NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 30, 2013
Print ISSN 1222-4227; Online ISSN 2067-5720

THE INFLUENCE OF CROPS, FERTILIZATION AND PHASE OF EXPLOITATION ON THE PRODUCTIVITY OF FORAGE ON THE RECULTIVATED LAND COAL PIT

Verica Živković[1], Savo Vučković[2], Gorica Cvijanović[3], Drago Cvijanović[4], Gojko Duronić[5]

[1]RB “Kolubara”, Sveti Sava 1, Lazarevac, Serbia, ver.zivkovic@gmail.com

[2]Faculty of Agriculture, Nemanjina 6, 11080 Zemun-Belgrade, Serbia, savovuck@agrif.bg.ac.rs

[3]Faculty of Biofarming, Maršala Tita 39, 24 300 Bačka Topola, Serbia

[4]Institute of Agricultural Economics, Volgina 15, 11 000 Belgrade, Serbia

[5] „Kopeks” Novi Sad, Serbia

ABSTRACT

Mining Basin "Kolubara" is the open pit coal (lignite), which covers about 550 km^2, and is the most important in Serbia. For the purpose of expanding its occupied and agricultural land, so far about 1300 ha were recultivated. After completions of mining activities in the „Kolubara”, large areas of degraded land remain, which should be returned to its original state as possible. Recultivation process is lengthy and very complex, and in that period, in addition to repairing the physical and chemical properties of the soil, it should be economically used. Cultivation of fodder crops in recultivated areas is one way to use them. The aim of this study was to determine the productivity of fodder crops, depending on different crops, the exploitation phases and the different types of fertilizers nutrition. Results demonstrated that the production of forage crops can be successfully organized on recultivated land, but the yields obtained are lower than the yield obtained on arable land, by 15-30% depending on the crop. The level of forage yield very significantly depended on forage species, the exploitation phase and their interaction.

Key words: "Kolubara", land recultivation, forage crops, productivity.

INTRODUCTION

Surface coal mining humanize work, but at the same time, large amounts of overburden excavation and their redeposit harms the environment, destroying fertile land and almost all forms of life. Mining Basin "Kolubara", the open pit coal (lignite) which covers about 550 km^2, is located 50 km southwest of Belgrade. By degree of utilization of lignite reserves and the application of modern equipment and technology, it is the most important in Serbia. Agricultural land was used for open pit mine expansion and so far about 1300 ha were recultivated. The total degradation of natural and man-made environment in the zones of influence of production-technological system in large basins of mining today is a limiting factor for their further development (Spasic et al., 2009a). Taking up space for exploitation and processing of lignite, can basically be regarded as temporary, given the fact that the degraded area of land, after mining, can be recultivated in order to re-use it (Spasic et al., 2009b).

Recultivation includes a complex of mining, engineering and agricultural measures undertaken to restore and even improve biological productivity and the value of agricultural fields damaged by surface exploitation (Pavlovic, 2000). Recultivation creates a natural habitat of plants and animals, which have the technical, environmental, economic and aesthetic function in our environment (Bauer, 2006). The main aim of recultivation is linked to the restoration of damaged natural reproductive potential, restoration of disturbed ecosystems, restoration of damaged areas and other useful purposes (Spasic et al., 2005). Recultivated areas have great potential, and their use allows the development of agriculture and other productive and service activities, to ensure

Received 25 November 2011; accepted 06 September 2012. First online: 20 December 2012. DII 2067-5720 RAR-125

optimal use of available resources in accordance with the principles of sustainable development. One possible way of exploiting these areas is growing forage crops.

Developed farming requires rationally organized production and forage quality. Adequately resolved forage base is one of the main factors which affect the profitability of livestock production. Animal husbandry and crop farming are the main branches of agriculture and their coordinated development is a prerequisite for agricultural development and successful accomplishment of tasks relating to the human nutrition, development of processing industry and exports of agricultural products (Aleksic et al., 2009). The possibility to produce green fodder is determined by the varieties of forage crops, which should have: high yield, good quality, short vegetation, high power of regeneration, the ability to use different edaphic-climatic conditions, growing in several periods during the year, etc. The most important agro-technical measure in crop production is the proper system of fertilization, which has the highest impact on increasing the yield, provided that fertilizers are used rationally and in sufficient quantity (Tollenar, 1991; Starcevic and Latkovic, 2005). The yield of green fodder depends on phase of the development of fodder crops, and using the earlier stages, inevitably leads to a decrease in yield but it often improves forage quality (Vuckovic, 1999).

MATERIALS AND METHODS

A 3-year investigation was carried out at recultivated land RB "Kolubara". The total area with tracks was 7185.2 m^2 (253 x 28.4 m). The experiment was placed in a block design with three replications, with experimental plots sized 84 m^2 (15 x 5.6 m). Area of one replication was 2357.2 m^2 (83 x 28.4 m).

The following crops were used:

1. Maize (*Zea mays* L.) - sown at a distance of 70 × 25 cm at a depth of 5 cm (57,000 plants ha^{-1});
2. Sorghum (*Sorghum bicolor* L.) - sown at 70 × 5.8 cm at a depth of 4 cm (246,000 plants ha^{-1});
3. Soybean (*Glycine hispida*) - sown at a distance of 70 × 3.1cm at a depth of 4 cm (460,000 plants ha^{-1});
4. Sunflower (*Helianthus annuus* L.) - sown at a distance of 70 × 25 cm at a depth of 4 cm (57,000 plants ha^{-1}).

Cultivars of domestic origin and seed with high germination produced at the Institute of Field and Vegetable Crops in Novi Sad were used.

The different types of fertilizer applied on the experiment were:

1. Celuflora (organic fertilizer) was used on an area of 2304 m^2 for the three replications in quantities of 40 t ha^{-1};

2. Manure was used on an area of 2304 m^2 for the three replications in quantities of 40 t ha^{-1};

3. Mineral fertilizer - was used on an area of 2304 m^2 for the three replications as nitrogen fertilizer AN (34.5% pure nitrogen) equivalent to 200 kg ha^{-1};

4. Microbiological fertilizer was used on an area of 2304 m^2 for the three replications the inoculation of all species was done just before sowing with specific bacteria that are able to fix atmospheric nitrogen, as follows:

a) symbiotic nitrogen fixers-Bradyrhizobim japonicum for soybean;

b) associative nitrogen fixers-*Azotobacter chroococcum, Azotobacter vineland* for maize, sorghum and sunflower.

5. Phosphorus, potassium, and nitrogen were applied on the whole area (600 kg ha^{-1} of 15-15-15 fertilizer NPK).

The trial was established in 2008 and this paper includes three-year results for the period 2008-2010.

Laboratory methods used for determining the chemical properties of soil were those from the practicum Agrochemistry (Pantović et al., 1989) and Pedology (Korunović and Stojanovic, 1989), as follows:

- Soil reaction - pH meter with glass electrode;
- Humus - Kotzman's method;
- Total Nitrogen - Kjeldahl's method;
- Easily accessible K_2O - Al method according to Egner-Riehm (photometric);

- Easily accessible P_2O_5 - Al method according to Egner-Riehm-in (colorimetric).

The yield of green forage was measured in the three utilization phases, which were defined for each crop as follows:

1. Maize: phase I – before tassel formation;
   phase II- the formation of cob and grain;
   phase III - waxy ripeness;
2. Sorghum: phase I - before tassel formation;
   phase II - the formation of grain and tassel;
   phase III - waxy ripeness;
3. Soybean: phase I - early formation of pods;
   phase II - intensive flowering and formation a half of pods number;
   phase III - the end of flowering and the formation of 2 / 3 of pods number;
4. Sunflower: phase I - before head formation;
   phase II – beginning of head formation;
   phase III - the formation of seeds in the head.

RESULTS

Table 1 presents the results of soil chemical analysis from samples taken before sowing. The soil had slightly acid to slightly alkaline reaction, basically appropriate and especially suitable for living organisms. The level of the basic parameters of productive capacity, soil fertility - humus and total nitrogen, were very low. Also small amounts of nitrogen forms (NH_4, NO^3-N) were detected.

However, their quantity was also very variable in relatively short intervals, at the starting point, before fertilization. The relationship C/N is very important as an indicator of nitrogen mineralization intensity. The ratio C/N was narrow, reflecting the rapid mineralization of nitrogen, which is compatible with the results obtained for mineral forms of nitrogen. The levels of phosphorus and potassium in the soil were different. The levels of 5.41 mg P_2O_5/100 are very low and indicate that the soil requires a high amount of fertilizer, even 130-150% higher than that established based on the yield of crops. The soil was well supplied with potassium.

Microelements are essential in the nutrition of plants, and mostly originate from the parent substrate. The content of microelements was not a limiting factor for the plants to complete their vegetative and reproductive stages of their life cycle. The amounts of heavy metals in soil samples were lower than the maximum allowed for unpolluted soil (Table 1a), except for Ni, but this amount would have no adverse effects on plants and animals (Eikmann et Kloke, 1993).

Table 1. Agrochemical properties of the soil ready for recultivation

pH		Humus	Total N	C/N	NH_4^+-N	NO_3-N	Ca	Mg	P_2O_5	K_2O
H_2O	KCl	%	%		mg.kg^{-1}		mg.kg^{-1}		mg.kg^{-1}	
7.56	6.70	1.4	0.14	5/1	12.6	10.2	4800	76.2	5.41	22.2

Table 1a. The content of microelements and heavy metals in the soil

Fe	Mn	Cu	Zn	Mo	Cr	Cd	Pb	Ni	As	Hg
%	mg.kg^{-1}									
2.25	791	20.1	27.2	13.5	37.3	0.51	37.3	62.1	2.6	<0.1

The table 2 present average value daily temperature and the average monthly precipitation during the vegetation period 2008-2010.

Table 2. The average monthly temperature and precipitations during the vegetation period (2008-2010)

Year	Temperature (ºC)								Average
	March	April	May	June	July	August	September	October	
2008	8.4	13.3	18.6	22.4	23.1	23.4	16.4	14.1	17.4
2009	8.1	15.2	19.2	20.6	23.5	23.4	20.7	14.9	18.2
2010	8.1	13.4	17.5	20.9	22.1	23.1	17.7	12.6	19.9
Average	8.2	13.9	18.4	21.3	22.9	23.3	18.3	13.9	
	Precipitations (mm)								
2008	30	14	22	20	21	11	23	7	148
2009	24	6	11	57	27	15	3	38	181
2010	20	18	34	66	27	19	24	22	230
Average	25	13	22	48	25	15	17	22	

During the research period 2008-2010, the average temperature was 17.5°C and average precipitation was 23 mm. The warmest year was 2010, with an average temperature of 19.9°C. The coldest year was 2009, with an average temperature of 17.4°C. The highest temperatures were in the summer months, when the most intense development of vegetative and generative organs of plants takes place. The highest level of precipitation was recorded in 2010 (the highest level of precipitation was recorded in June of that year - 66 mm). Sum of precipitation during the vegetation period was highest in 2010, and amounted to 231 mm, and lowest was in 2008, only 148 mm.

Table 3. The influence of crops, fertilizers and exploitation phase of the green forage (t.ha^{-1}) in 2008

A-crop	B-types of fertilizers	C- exploitation phase			AB
		C_1	C_2	C_3	
A_1 soybean	B_1 - NH_4NO_3 + NPK	4.41	9.58	15.81	9.93
	B_2 - celuflora + NPK	5.97	15.11	22.00	14.36
	B_3 - manure + NPK	10.33	14.92	22.89	16.05
	B_4 - microbiological + NPK + NPK	7.11	17.56	18.77	14.48
	B_5 - NPK	7.89	11.78	13.33	11.00
A_1	AC	7.14	13.79	18.56	13.16
A_2 maize	B_1 - NH_4NO_3 + NPK	11.41	24.67	35.83	23.97
	B_2 - celuflora + NPK	19.67	26.00	28.20	24.62
	B_3 - manure + NPK	15.30	17.92	27.00	20.07
	B_4 - microbiological + NPK + NPK	20.20	23.74	25.89	23.28
	B_5 - NPK	14.89	19.30	21.44	18.54
A_2	AC	16.29	22.33	27.67	22.10
A_3 sunflower	B_1 - NH_4NO_3 + NPK	15.59	34.17	38.89	29.55
	B_2 - celuflora + NPK	22.94	33.11	34.94	30.33
	B_3 - manure + NPK	17.81	30.25	37.00	28.35
	B_4 - microbiological + NPK + NPK	16.33	35.14	41.26	30.91
	B_5 - NPK	17.86	25.10	34.85	25.94
A_3	AC	18.11	31.55	37.39	29.02
A_4 sorghum	B_1 - NH_4NO_3 + NPK	11.90	16.67	27.11	18.56
	B_2 - celuflora + NPK	16.90	22.89	26.97	22.25
	B_3 - manure + NPK	11.30	22.50	26.33	20.04
	B_4 - microbiological + NPK + NPK	9.30	20.30	22.81	17.47
	B_5 - NPK	11.10	19.52	23.81	18.14
A_4	AC	12.10	20.38	25.41	19.29

Continued table 3

BC	B_1	10.83	21.27	29.41	20.50
	B_2	16.37	24.28	28.03	22.89
	B_3	13.69	21.40	28.31	21.13
	B_4	13.24	24.19	27.18	21.53
	B_5	12.94	18.93	23.36	18.41
C		13.41	22.01	27.26	20.89

	Level	A	B	C	AB	AC	BC	ABC
F-test		**	ns	**	ns	**	ns	ns
LSD	5%	4.1	3.9	1.9	9.1	4.2	4.8	14.2
	1%	5.4	5.2	2.6	13.1	5.9	6.8	25.9

*significance level P<5%;
**significance level P<1%; ns - no statistical significance.

The yield of green forage (t ha^{-1}) in 2008 depended on the type of forage crops and exploitation phase. Differences were statistically highly significant (the lowest yield soybean was achieved in the first phase of exploitation and the highest sunflower yield was obtained in the third stage). The influence of fertilizers on yields was not statistically significant. The only significant interaction between two factors was that between the type of crops and the exploitation phase.

Table 4. The influence of crops, fertilizers and exploitation phase of the green forage (t.ha^{-1}) in 2009

A-crop	B-types of fertilizers	C- exploitation phase			AB
		C_1	C_2	C_3	
A_1 soybean	B_1 - NH_4NO_3 + NPK	2.56	7.10	13.50	7.72
	B_2 - celuflora + NPK	3.10	8.50	19.10	10.23
	B_3 - manure + NPK	5.70	10.80	18.50	11.67
	B_4 - microbiological + NPK	4.90	11.10	16.00	10.67
	B_5 - NPK	3.00	7.10	10.90	7.00
A_1	AC	3.85	8.92	15.60	9.46
A_2 maize	B_1 - NH_4NO_3 + NPK	15.10	27.89	35.00	26.00
	B_2 - celuflora + NPK	18.67	29.44	31.33	26.48
	B_3 - manure + NPK	18.90	29.67	32.11	26.89
	B_4 - microbiological + NPK + NPK	15.67	21.22	25.33	20.74
	B_5 - NPK	13.67	22.67	27.89	21.41
A_2	AC	16.40	26.18	30.33	24.30
A_3 sunflower	B_1 - NH_4NO_3 + NPK	19.33	34.22	44.10	32.55
	B_2 - celuflora + NPK	20.22	29.56	39.67	29.82
	B_3 - manure + NPK	19.44	31.44	37.33	29.40
	B_4 - microbiological + NPK + NPK	21.11	30.77	36.11	29.33
	B_5 - NPK	18.89	21.88	29.44	23.40
A_3	AC	19.80	29.57	37.33	28.90
A_4 sorghum	B_1 - NH_4NO_3 + NPK	10.20	27.22	29.89	22.44
	B_2 - celuflora + NPK	7.22	17.44	21.00	15.22
	B_3 - manure + NPK	9.22	17.00	22.33	16.18
	B_4 - microbiological + NPK + NPK	8.33	15.33	20.00	14.55
	B_5 - NPK	5.22	11.00	17.67	11.30
A_4	AC	8.04	17.60	22.18	15.94

Continued table 4

BC	B_1	11.80	24.11	30.62	22.18
	B_2	12.30	21.24	27.78	20.44
	B_3	13.32	22.23	27.57	21.04
	B_4	12.50	19.61	24.36	18.82
	B_5	10.20	15.66	21.48	15.78
C		12.02	20.57	26.36	19.65

	Nivo	A	B	C	AB	AC	BC	ABC
F-test		**	*	**	ns	*	ns	*
LSD	5%	5.9	3.1	1.6	7.0	3.4	3.9	11.4
	1%	7.7	4.0	2.1	10.1	4.7	5.5	20.9

*significance level P<5%; **significance level P<1%; ns - no statistical significance.

In 2009, a lower average yield was recorded compared to 2008, by 6.3% (from 20.89 t.ha-1 to 19.65 t.ha-1). The yield of green forage significantly depended on all three factors tested. The interaction of all three factors and interaction between crop and exploitation phase had a significant impact on the yield of green fodder.

Table 5. The influence of crops, fertilizers and exploitation phase of the green matter yield (t.ha^{-1}) in 2010

A-crop	B-types of fertilizers	C- exploitation phase			AB
		C_1	C_2	C_3	
A_1 soybean	B_1 - NH_4NO_3 + NPK	3.67	6.67	13.10	7.81
	B_2 - celuflora + NPK	2.78	9.67	15.20	9.22
	B_3 - manure + NPK	8.83	12.44	16,10	12.46
	B_4 - microbiological +NPK + NPK	6.83	14.00	17.80	12.88
	B_5 - NPK	5.67	9.56	12.90	9.38
A_1	AC	5.56	10.47	15.02	10.35
A_2 maize	B_1 - NH_4NO_3 + NPK	17.89	21.00	29.00	22.63
	B_2 - celuflora + NPK	15.67	18.44	25.56	19.89
	B_3 - manure + NPK	15.67	17.89	22.89	18.82
	B_4 - microbiological +NPK + NPK	17.44	23.11	25.33	21.96
	B_5 - NPK	12.44	15.78	20.45	16.22
A_2	AC	15.82	19.24	24.65	19.90
A_3 sunflower	B_1 - NH_4NO_3 + NPK	13.00	27.20	31.10	23.77
	B_2 - celuflora + NPK	10.20	16.11	26.00	17.44
	B_3 - manure + NPK	19.67	25.00	30.10	24.92
	B_4 - microbiological + NPK + NPK	11.78	27.89	33.20	24.29
	B_5 -NPK	12.44	20.11	28.00	20.18
A_3	AC	13.42	23.26	29.68	22.12
A_4 sorghum	B_1 - NH_4NO_3 + NPK	11.67	21,56	29.89	21.04
	B_2 - celuflora + NPK	17.00	20.89	22.32	20.07
	B_3 - manure + NPK	14.11	21.36	24.99	20.15
	B_4 - microbiological +NPK + NPK	16.56	20.55	22.65	19.92
	B_5 - NPK	13.00	19.12	21.69	17.94
A_4	AC	14.47	20.70	24.31	19.82

Continued table 5

BC	B_1	11.56	19.11	25.77	18.81
	B_2	11.41	16.28	22.27	16.65
	B_3	14.57	19.17	23.52	19.09
	B_4	13.15	21,39	24.75	19.76
	B_5	10.89	16.14	20.76	15.93
C		12.32	18.42	23.41	18.05

	Nivo	A	B	C	AB	AC	BC	ABC
F-test		**	ns	**	ns	**	ns	ns
LSD	5%	3.4	2.6	1.4	6.1	3.2	3.6	10.7
	1%	4.4	3.5	1.9	8.7	4.4	5.1	19.6

*significance level P<5%; **significance level P<1%; ns - no statistical significance.

The trend of yield reduction (-8.8%) continued in the year 2010, which may be the result of agrometeorological conditions (2009 was a dry year and 2010 a rainy one). The yields were very significantly influenced by crop species, exploitation phase, and their interaction.

The yield of grain on the recultivated land are presented in table 6. The average yield on the arable land in the similar condition for soybean was 2-2.5 t.ha^{-1}; maize 5-5.5 t.ha^{-1}; sunflower 2.5-2.8 t.ha^{-1} and sorghum 3-3.4 t.ha^{-1}.

Table 6. Average yield of crops depending on the type of fertilizer in the period 2008-2010

Year	Type of fertilizers					Average
	NH_4NO_3 + NPK	Celuflora + NPK	Manure + NPK	Microbial + NPK	NPK	
Yield of soybean (t.ha^{-1})						
2008	1.90	2.00	2.10	2.00	1.80	1.96
2009	1.50	1.60	1.60	1.50	1.40	1.52
2010	1.30	1.50	1.45	1.50	1.35	1.42
Average	1.57	1.70	1.72	1.67	1.52	
Yield of maize (t.ha^{-1})						
2008	5.20	5.10	5.00	510	5.00	5.08
2009	4.10	4.10	4.00	3.50	4.00	4.14
2010	3.90	3.50	4.00	3.50	3.60	3.70
Average	4.40	4.23	4.33	4.03	4.20	
Yield of sunflower (t.ha^{-1})						
2008	2.10	2.20	2.20	2.00	2.10	2.12
2009	2.00	2.00	1.90	1.65	1.85	1.88
2010	1.80	1.40	1.60	1.50	1.50	1.56
Average	1.96	1.87	1.90	1.72	1.82	
Yield of sorghum (t.ha^{-1})						
2008	3.00	1.90	3.00	3.10	3.00	2.80
2009	2.40	2.30	2.70	2.30	2.25	2.39
2010	2.00	2.10	2.10	2.20	2.00	2.08
Average	2.47	2.10	2.60	2.53	2.42	

Comparing the grain yields in recultivated land with yields obtained on the arable land, the yields achieved on the recultivated land were lower by 15-30% depending on the crop.

DISCUSSION

The benefits from the biological recultivation of degraded areas include several aspects (Stavretović, 2007):

- protection of groundwater;
- protection of soil contamination;
- protection of air pollution;
- protection of natural resources;
- preventing erosion;
- protection of human health;
- direct economic benefit.

There are a large possibilities of recultivation of degraded soil after the exploitation of coal was completed. Their utilization provides agricultural development and development of other production and service activities within rural areas, in order to improve the standard of living and quality of the population life.

The soil is a significant factor in productivity of forage plants. Improving fertility of recultivated soil is a slow process, based on regular application of NPK fertilizer, as well as the increased application of organic fertilizer, which in addition to providing part of the macro- and micronutrients for plant nutrition affects the creation and maintenance of favorable physical soil properties (Schulz, 1996). In the process of recultivation it is recommended to use microbiological inoculation, which may contain different types of beneficial microorganisms, which are often characterized as the bacteria that stimulate plant growth - PGPR (Plant Growth Promoting *Rhizobacteria*).

Environmental protection can be obtained through afforestation and grassing, but the economic effects of the recultivation would be far more significant if crops that are used as human or animal food could be grown in these areas (Antic-Mladenovic et al., 2004).

Soybean is a legume that has multiple usages, being used for the production of fodder in the form of green forage, silage and hay. The highest yield of green forage was achieved in the end stage of flowering and the formation of 2/3 pods on the plant for all variants of fertilization, which coincides with the optimal time to mow (Glamočlija, 2004). The highest yield was achieved in variants with the use of manure fertilization. Organic fertilizer - manure has an indirect role in the nutrition of soybean and its great importance is also reflected in a positive impact on the general condition of the soil. Soybean uses very well the extended effect of applied manure (Glamočlija, 2004).

Maize is an important crop, used as feed grain or as fodder. The highest yield of green forage during the experimental period was recorded in the phase of corn cob and grain formation, using mineral fertilizers (a higher level of combined two types of fertilizers). Complex mineral fertilizers have the most important role in the maize nutrition. It is also known that the number of plants per unit area has a major impact on maize green forage yield (Djukic et al., 2005).

Sunflower is an industrial oil plant, but also a valuable forage plant, which can be used as green fodder or silage. The highest yield of green fodder was obtained in the phase of seeds formation using NH_4NO_3 in combination with NPK. Sunflower has a great need in nutrients. The organic fertilizer also had favorable impact on the growth of sunflower, but highest yield was achieved by using increased amounts of mineral nutrients.

Forage sorghum is a plant from the group of grains with multiple uses. It is used as fodder in the form of green forage, silage, and, with the right technology for growing, also as early-cut hay. The highest yield of green forage in the period was achieved in the wax stage of ripeness, using mineral fertilizers (a higher level of combined two types of fertilizers). Thanks to the powerful and well-developed root system, sorghum can be grown on soils with low production characteristics.

CONCLUSIONS

Based on results presented in the tables, the production of forage crops can be successfully organized on recultivated land, but the yields obtained are lower than the yield obtained on arable land. The level of forage yield very significantly depends on forage species, the exploitation phase and their interaction.

REFERENCES

Aleksić, S., Pantelić, V., Radović, Č., 2009. *Livestock production – present situation and future development directions in Republic of Serbia.* Biotechnology in Animal Husbandry, 25 (5-6): 267-276.

Antić Mladenović, Svetlana, Ličina, V., Čanak, Nedić, Aleksandra, Kresović, Mirjana, Jakovljević, Miodrag, 2004. *Koncentracija teških metala u jalovinama kopa Kolubara i njihova akumulacija u biljkama.* Međunarodna naučno-stručna konferencija, ELECTRA III, Herceg Novi: 373-377.

Bauer, C., 2006. *Aspekte von Rekultivierungsmaßnahmen am Beispiel von Boden- und Vegetationsentwicklung.* BHM Berg- und Hüttenmännische Monatshefte, 151, 12: 495-498.

Eikmann, Th., Kloke, A., 1993. *Nutzungsmöglichkeiten und Sanierung belasteter Böden. 2. überarbeitete und erweiterte Auflage.* VDLUFA Schriftenreie 34, VDLUFA Verlag. Darmstadt.

Đukić, D. , Pejović, M., Stević, V., Maksimović, Livija, Itić, Olivera, 2005. *Prinos i kvalitet krme hibrida kukuruza iz postrne setve.* Traktori i pogonske mašine, 10, 2: 407-414.

Glamočlija, Đ., 2004. *Posebno ratarstvo-žita i zrnene mahunarke*. Draganić, Beograd.

Korunović, R.M., Stojanović, S.V., 1989. *Praktikum pedologije*. Beograd: Poljoprivredni fakultet.

Latković, Dragana, Jaćimović, G., Marinković, B., Malešević, M., Crnobarac, J., 2009. *Sistem đubrenja u funkciji prinosa kukuruza u monokulturi i dvopolju.* Letopis naučnih radova, 33, I: 77-84.

Ličina, V., Jovanović, Zorica, Antić Mladenović, Svetlana, Kresović, Mirjana, Nedić, M., 2004. *Primena organo-mineralnih materija i đubriva u rekultivaciji kolubarskih jalovina i njihov uticaj na produktivnost i mineralni sastav ratarskih kultura.* Međunarodna naučno-stručna konferencija, ELECTRA III, Herceg Novi: 475-480.

Vučković, S., 1999. *Krmno bilje*. Institut za istraživanja u poljoprivredi Srbija. Beograd.

Pavlović, V., 2000. *Rekultivacija površinskih kopova i odlagališta*. Beograd.

Pantović, M., Džamić, R., Petrović, M., Jakovljević, M., 1989. *Praktikum iz agrohemije*. Beograd: Naučna knjiga.

Stavretović, N., 2007. *Savremena iskustva biološke rekultivacije degradiranih površina*. Zbornik radova sa 2. Simpozijuma Reciklažne tehnologije i održivi razvoj: 34-48.

Schulz, D., 1996. *Recultivation of mining waste dumps in the Rhur area, Germany.* Water, Air and Soil Pollution, 91: 89-98.

Spasić, N., Stojanović, B., Nikolić, Marija, 2005. *Uticaj rudarstva na okruženje i revitalizacija degradiranog prostora.* Arhitektura i urbanizam., 16-17: 75-85.

Spasić, N., Džunić, Gordana, Đurđević, Jasmina, 2009a. *Uticaj proizvodnih sistema u velikim rudarskim basenima na planiranje razvoja, obnavljanje i uređenje prostora.* Arhitektura i urbanizam., 26: 67-76.

Spasić, N., Džunić, Gordana, Đurđević, Jasmina, 2009b. *Uticaj proizvodnih sistema u velikim rudarskim basenima na planiranje razvoja, obnavljanje i uređenje prostora.* Arhitektura i urbanizam., 27: 20-34.

Starčević, Lj., Latković, Dragana, 2005. *Prinos kukuruza u Vojvodini, 2004.godine bio je najviši u poslednjih 10 godina (5,88 tha-1). Da li je mogo biti više?* Da! Zbornik radova Naučnog instituta za ratarstvo i povrtarstvo, sv.41: 385-394.

Tollenar, M., 1991. *Physiological basis of the genetic improvement of maize hybrids in Ontario from 1959 to 1988.* Crop Science, Madison, 31, 1: 119-124.