RECLAMATION ON LAND DISTURBED BY SURFACE MINING IN ROMANIA[1]

Elisabeta Dumitru [2] and Agatha Popescu

Abstract: Within the Oltenia surface mining region of Romania, 14,890 ha have been disturbed and only 1,002 ha have been reclaimed. The majority of this disturbance has involved agricultural land (12,208 ha), of which only a small amount has been reclaimed (552 ha). Forest land disturbed by surface mining in this region amounted to 2,682 ha, of which only 450 ha have been reclaimed. Therefore, huge land areas remain unreclaimed. Two experiments for the recultivation of sterile dumps were conducted: one without fertile soil covering on Garla dump and another one on Cicani dump which was covered by 30-40 cm of fertile soil. The study took into account 10 crops: Lolium perenne, alfalfa, Lotus corniculatus, winter wheat, maize, soybean, pea, mixture of barley or oats with a leguminous plant, sunflower, and sorghum. Three fertilization levels were applied: $N_0P_0K_0$, $N_{100}P_{80}K_{60,}$ and $N_{200}P_{160}K_{120}$. Yield gains obtained in the case of fertilization with $N_{100}P_{80}K_{60}$ on the Garla non-covered sterile dumps were 48% Lolium perenne, 22% alfalfa, 200% winter wheat, 300% maize, 50% soyabean, 80% pea, 122% mixture of barley or oats with a leguminous plant, 60% sunflower, and 164% sorghum. Higher yield gains were obtained with $N_{200}P_{160}K_{120}$ on the Garla non-covered sterile dumps (74% Lolium perenn, 37% alfalfa, 46% Lotus corniculatus, 264% winter wheat, 366% maize, 75% soyabean, 150% pea, 146% mixture of barley or oats with leguminous plant, 180% sunflower and 252% sorghum). The yield gains obtained on the Cicani dump which was covered with 30-40 cm of fertile soil with $N_{100}P_{80}K_{60}$ were 60% Lolium perenne, 30% alfalfa, 19% Lotus corniculatus, 171% winter wheat, 550% maize, 50% soyabean, 58% pea, 117% mixture of barley or oats with a leguminous plant, 83% sunflower, and 118% sorghum. High yield gains were obtained by applying high rates of fertilizers on the Cicani dump. The highest yield gains were obtained for maize, sorghum, sunflower, winter wheat, pea, and mixture of barley or oats with a leguminous plant, and the lowest yield gains were obtained for alfalfa and Lotus corniculatus. In both cases, the first crops do not change their order, the best results being obtained with the mixture of barley or oats with a leguminous plant, alfalfa, Lotus corniculatus, winter wheat, and maize. In all cases, the highest yield was obtained when the highest fertlization rate was applied.

Additional Key words: stockpile, reclamation, demonstrative experiments, organic and mineral fertilizers, agricultural crops.

---

[1] Paper was presented at the 2002 National Meetings of the American Society of Mining and Reclamation, Lexington KY, June 9-13, 2002. Published by ASMR, 3134 Montavesta Rd. Lexington, KY 40502

[2] Elisabeta Dumitru, Research Institute of Soil Science and Agrochemistry, Bucharest Romania, Blvd. Marasti 61, Sector 1, Code 71331 E-mail mdumitru@icpa.ro
Agatha Popescu, University of Agricultural Sciences and Veterinary Medicine, Bucharest Romania, Blvd. Marasti 59, Sector 1, Code 71331, E- Mail: agatha_popescu@hotmail.com
Proceedings America Society of Mining and Reclamation, 2002 pp 115-129
DOI: 10.21000/JASMR02010115

https://doi.org/10.21000/JASMR02010115

Intoduction

The total area of Romania is about 237,500 square kilometers, of which about 62% is agricultural land, about 28% are forests, about 4% are waters and pools, about 3% are areas disturbed by construction, about 2% are roads and railways, and about 1% are other areas. Agricultural areas assure 0.65 hectare per capita. Arable land represents 39.4% of the total area, providing 0.41 hectare per capita. The total area used for agricultural in Romania is 14,730,700 hectares. Agricultural land is divided into 9,358,100 hectares of arable land; 3,322,800 hectares of pastures; 1,512,000 hectares of meadows; 281,100 hectares of vineyards and nurseries; and, 256,700 hectares of orchards and nurseries. The average contribution of agriculture for the last seven years to the Romanian Gross Domestic Product is 17.68%.

At the end of 1999, the labor force working in agriculture represented 40.6% of the total active population. Approximately 45.1% of the population lives in rural areas. The slight increase in the rural population after 1990 (from 3,055,000 in 1990 to 3,419,000 in 1999) is related to the industry restructuring process. This process is expected to continue in the coming 2-3 years, emphasizing the real need of protecting the active population involved in agriculture. The Land Capability Classification system indicates that only 2.8% (411,000 hectares) of the agricultural land in Romania belongs to the first class with only very few limitations, 24.7% (3,656,000 hectares) with a few limitations, 20.8% (3,086,000 hectares) with some limitations, 24.4% (3,613,000 hectares) with severe limitations, and 27.3% (4,036,000 hectares) having very severe limitations. The inventory carried out within the Romanian National Soil Quality Monitoring System shows that of the 14 million hectares of agricultural land, 7.5 million hectares of arable land were affected by one or several limitations. Different restrictive factors have a negative influence upon soil functions; particularly the bio-productive capacity as well as the crop yields quantity, quality and food security with severe consequences on the environment and standard of living. The main restrictive factors are: frequent drought affecting about 7,100,000 hectares; periodic water-logging affecting about 3,781,000 hectares; water soil erosion on about 6,300,000 hectares (of which about 702,000 hectares are affected by landslides and about 378,000 hectares are affected by wind erosion); salinity on about 614,000 hectares; moderate and high acidity on about 3,424,000 hectares; low available phosphorus content on about 6,330,000 hectares; low humus content on about 7,485,000 hectares; low nitrogen content on about 5,110,000 hectares; low available potassium content about 787,000 hectares, zinc deficiency on about 1,500,000 hectares; chemical soil pollution on about 900,000 hectares; pollution with oil and brine on about 50,000 hectares; disturbed by various works on about 30,000 hectares; and, solid wastes covered an area of about 18,000 hectares. Surface mining activity affects over 25,000 hectares in Romania. The majority of the disturbances are found in the Oltenia region where 14,890 hectares of disturbed surface mine land exist. In Oltenia, 12,208 hectares of agricultural land and 2,682 hectares of forestlands have been disturbed. Of this area, only 1,002 hectares has been reclaimed up to now (552 hectares of agricultural land and 450 hectares of forest land). Surface mining operations are one of the most aggressive forms of land degradation in Romania, and therefore, huge efforts are required on such areas in order to achieve proper reclamation.

The present structure of land ownership in Romania is represented by 71% with less than 3 hectares per family, 18% with 3-5 hectares per family, and 11% with more than 5 hectares per family (1). The average family farm size is 2.3 hectares. In the mining region, part of the typical family farm is usually adversely affected by the mining activities. At present, many mining operations are closed and the mineworkers are obliged to return to farming the land. Therefore, it is imperative that we reclaim the sterile dumps that are the result of surface mining activities and return them as close to the original productivity as possible for the landowners. The goal of our research programs on the sterile dumps located in the Oltenia region is to look for the proper agricultural management for revegetation with different crops. In Romania, the revegetation of mined land with agricultural crops is considered the primary goal of most mined land reclamation programs.

Material and methods

Over the years, many long-term revegetation experiments with various soil amendments have been conducted on the sterile dumps in the Oltenia mining region. Recently, three (3) new field demonstrations were conducted. In this paper, data on the main crop yields are presented.

- A. Cicani Dump – This was the first field demonstration and experiment. It involved covering the Cirani dump with a fertile soil and applying three mineral fertilization doses: $N_0P_0K_0$; $N_{100}P_{80}K_{60}$; $N_{200}P_{100}K_{120}$. On the Cicani Dump, the following ten (10) agricultural crops were tested: Lolium perenne, Lotus corniculatus, alfalfa, winter wheat, corn, soybean, pea, barley and pea mixture, sunflower, and sorghum.

- B. Garla Dump – This second field demonstration and experiment involved no fertile soil covering but with the same three mineral fertilization applications: $N_0P_0K_0$; $N_{100}P_{80}K_{60}$; $N_{200}P_{100}K_{120.}$ This experiment on the Garla Dump also tested for the establishment of the same ten (10) agricultural crops as on the Cicani Dump (Lolium perenne, Lotus corniculatus, alfalfa, winter wheat, corn, soybean, pea, barley and pea mixture, sunflower, and sorghum).

- C. Balta Uncheasului Dump – This third field demonstration and experiment involved an application of a fertile soil covering over the Balta Uncheasului Dump with additional mineral and organic fertilization, involving different doses and types. The following four (4) agricultural crops were tested: sweet sorghum, rye, pea, and winter wheat. This experiment had two main levels: organic and mineral fertilization. For organic fertilization we used 50 t/ha untreated cattle manure; 100 t/ha cattle manure; 10 t/ha winter wheat straw; 20 t/ha sorghum stems, and 20 t/ha corn stalks. For mineral fertilization we used: $N_0P_0K_0$; $N_{100}P_{80}K_{60}$; $N_{150}P_{120}K_{120}$ (active substance). In total there were 24 plots in 4 replicates in randomized block design.

Tillage, bedding, sowing, maintenance, and harvesting were applied according to the local conditions, keeping as much as possible the optimum state for crop development and improvement and preserving fertility and environment. All demonstrative fields were organized in the same area under similar climate and substrate conditions.

<u>The climate conditions</u>

From a climatic point of view (Table 1), this first experimental year (1999-2000) was an unfavorable one for the agricultural crops in that area. Annual average temperature increased by 1.9° C in comparison with the average multi-annual temperature during the last 60 years; every month, the average temperature was higher than the multi-annual monthly temperature, except September. The maximum temperature (40.6° C) was registered in August and the minimum in January (-17° C). The maximum temperature registered on the soil surface was 65.2° C in June, July, and August. This year was considered one of the hottest during the last decade. The average multi-annual rainfall for the last 60 years is 753 mm. But for this experimental year only 598 mm was registered. This was 155 mm less than the normal conditions. After germination, a deficit of 140 mm rainfall was registered, relative to normal local conditions. During this agricultural year, one of the worst droughts in the last decade was experienced in this area. The annual relative air humidity after germination was much lower than the multi-annual average. In May, June, July, and August the relative air humidity decreased to 29.8%, 17.6%, 14.9% and 15.3 % respectively, due to the high temperature and low rainfall. During the period of growth there were many days without any rainfall. Also, in the summer season the soil water content decreased in the first 20 cm of soil, bringing the crops close to the wilting point.

Site

Post mining land use has two important stages: technical and biological, both having an important role in the reclamation program. In the first stage salvage, stockpiling and replacement activities require a special amount of time, many operations, large equipment and investments in money and attention. The stabilized stockpiles on which the field demonstrations were conducted were previously vegetated. A large range of values for different properties (table 2) characterized the anthropic protosoil. The ranges of values, i.e. confidence intervals for main properties, are as follows: pH $_{(H20)}$ 7.2 - 8.5; organic carbon (%) 0.9 – 17.3; total Nitrogen (%) 0.06 - 0.50; mobile phosphorus (ppm) 24 - 84; mobile potassium (ppm) 336 - 630. The content of heavy metals was somewhat higher than in normal soil but was within permissible levels by international standards. Further, the pH values were higher than 7.00. Therefore, there should be no problems concerning crop quality due to the availability of the heavy metals. Coal residue in the soil resulted in a high value of organic carbon. The use of large equipment in the stripping process resulted in the coal residue and the occasional mixing of different thin soil layers during the mining process.

Table 1 Data on climatic characteristics in the first experimental year comparing to the average data recorded during the last 60 years

Characteristic/year and month	**1999**			**2000**									**Multiannual average**
	X	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	
Average temperature (^{O}C)	11.9	5.3	7.9	-2.4	1.3	5.6	13.8	17.0	22.1	22.9	24.0	16.2	**12.1**
Multiannual average temperature (^{O}C)	11.0	4.9	-0.1	-2.9	-0.4	4.9	10.8	15.9	19.4	21.6	20.7	16.9	**10.2**
Maximum temperature (^{O}C)	27.0	22.0	15.0	11.4	10.6	20.8	27.5	29.4	37.0	40.6	39.2	30.6	
Minimum temperature (^{O}C)	3.0	-5.5	-11.0	-17.0	-7.1	-7.1	-1.6	0.8	5.0	9.5	8.2	1.2	
Air average relative humidity (%)	78	80	84	80	82	70	71	74	58	58	54	77	**72**
Air average humidity (%)	77	82	85	82	81	72	66	66	65	62	63	68	**72**
Average rainfall in the experimental year (mm)	112.4	1.2	83.0	40.1	46.1	45.5	61.4	66.4	5.3	44.5	11.4	81.1	
Multi annual average rainfall (mm)	59.6	63.9	59.9	52.8	48.9	47.7	64.7	81.3	88.4	61.1	59.8	54.9	
Rainfall difference	42.8	-62.7	23.1	-12.7	-2.9	-2.2	-3.3	-14.9	-83.1	-16.6	-48.4	26.2	

Table 2. Main chemical characteristics of the Anthropic Protosoil cultivated with different crops.

Characteristic	pH (H_2O)	Nt (%)	P (ppm)	K (ppm)	C(org) (%)	Cu (ppm)	Zn (ppm)	Pb (ppm)	Co (ppm)	Ni (ppm)	Mn ppm)	Cr (ppm)	Cd (ppm)
Average	7.8	0.288	47	428	5.3	48	71	27	21	55	182	115	2.1
Median line	8.1	0.155	46	434	4.6	51	63	28	22	54	188	117	1.5
Standard deviation	1.1	0.524	18	105	3.8	13	30	7	4	14	53	25	2.5
Minimum value	7.2	0.060	24	336	0.9	34	49	17	14	38	117	85	1.0
Maximum value	8.5	0.500	84	630	17.3	68	159	43	27	77	278	156	2.3

Results and Discussion

A. Data obtained in the experiment with fertile soil covering Cicani Dump

Table 3 presents crop yield and fertilization levels in tons per hectare and in relative units (percentages). The reduced yields of all the crops tested under all treatments applied relate to the particular climatic conditions in that year. However, as a consequence of the application of mineral fertilization, an evident increase in measured crop yields were noticed. Also as a result of the mineral fertilization, the crop canopy of all tested crops was visually observed to be clearly improved regarding their health in spite of the unfavorable weather conditions. Under the applied medium doses, the yield increased by: 60 % for Lolium perenne; 30 % for alfalfa; 19 % for Lotus corniculatus; 171 % for winter wheat; 550 % for corn; 50 % for soybean; 58 % for pea; 117 % for barley with pea; 83 % for sunflower and 118 % for sorghum.

Under the applied high doses, the yield increased by with: 90 % for Lolium perenne; 48 % for alfalfa; 48 % for Lotus corniculatus; 300 % for winter wheat; 650 % for corn; 100 % for soybean; 125 % for pea; 184 % for barley with pea; 200 % for sunflower and 202 % for sorghum. Even in that particularly droughty year, which did not allow the complete use of the applied mineral fertilizers, high yield gains were obtained by applying high rates of fertilizers ($N_{200}P_{160}K_{120}$), such as: Lolium perenne 90%, alfalfa 48 %, Lotus corniculatus *48* %, winter wheat 300%, corn 650 %, soybean 100 %, pea 125 %, barley and pea mixture 184%, sunflower 200%, and sorghum 202%. The highest yield increases were obtained under corn, sorghum, sunflower, winter wheat, pea, and mixture barley with pea, and the lowest yield increases were obtained for alfalfa and Lotus corniculatus. The highest biomass amount (root is not included) was obtained when barley was cultivated together with pea as a forage crop, and it had also provided the highest nutritive units. If we consider the nutritive units obtained with winter wheat in the control plot (non-fertilized) as a reference level, then the most important yield increases were obtained in the following order with: alfalfa, mixture between barley and pea, Lotus corniculatus, sunflower, sorghum, and soybean.

B. Data obtained in the demonstrative experimental field on non-covered Garla Dump

Exactly the same treatments, with fertilizers and agricultural crops, were applied on a stockpile not covered with fertile soil. Crop yield data are presented in Table 4 and they show the same trends as in the first case. Under the medium fertilization level ($N_{100}P_{80}K_{60}$) the crop yield increases by: 22% for alfalfa, 48 % for Lolium perenne, 50% for soybean, 60% for sunflower, 80% for pea, 122% for barley and pea mixture, 164% for sorghum, 200% for winter wheat and 300% for corn. Under the maximum fertilization level ($N_{200}P_{160}K_{120}$), the crop yield increases by: 37 % for alfalfa, 46% for Lotus corniculatus, 74% for Lolium perenne, 75 % for soybean, 180 % for sunflower, 80 % for pea, 146 % for mixture between barley and pea, 252 % for sorghum, 264 % for winter wheat and 366 %for corn. For 1 kg of active chemical fertilizer, the yield gain was lower than under the maximum rate applied, rather than medium rate.

Comparing the data presented in these two tables, we noticed only some small differences between them. This could be explained by the quality of the stockpiles, which are not so different between the two research areas. The small differences in the data between the two tables could also be explained by the particular climatic conditions in that year, mainly due to the excessive drought, which did not allow for a high efficiency of the two fertilizer levels.

Related to the nutritive units (calculated both for the main and secondary yield) per hectare, the following crop order could be established for the Cicani dump experiment where fertile soil was used as a covering: the mixture between barley and pea, alfalfa, *Lotus corniculatus*, winter wheat, corn, pea, *Lolium perenne*, sunflower, sorghum, soybean. In the experiment on the Garla Dump without a fertile soil covering: the mixture between barley and pea, alfalfa, *Lotus corniculatus*, winter wheat, corn, *Lolium perenne*, pea, soybean, sorghum, and sunflower.

For both field demonstrations, the best results were obtained for the mixture between barley and pea, alfalfa, *Lotus corniculatus*, winter wheat and corn. Therefore, the crops in that order could be recommended on a larger area under similar conditions especially in the droughty years. But, there is also the opinion that these dumps could be mainly used as a forage source. Under such a land use, problems such as erosion can be better controlled and the conditions for improving the physical, chemical, and biological properties can be ensured. A low fertility level of any dump can be improved by using proper agricultural management, including a high fertilization rate.

Table 3. Main crop yields (at the standard water content) related to fertilization levels on the Cicani covered dump

Cultivated crop	Fertilization level	Average Yield			
		t/ha^{-1}	Nutritive Unit/ha*	%	
				Main Yield	Nutritive Units
Lolium perenne	$N_0P_0K_0$	2.0	1860	100	89
	$N_{100}P_{80}K_{60}$	3.2	2976	160	142
	$N_{200}P_{160}K_{120}$	3.8	3534	190	168
Alfalfa	$N_0P_0K_0$	11.5	10350	100	493
	$N_{100}P_{80}K_{60}$	15.0	13500	130	642
	$N_{200}P_{160}K_{120}$	17.0	15300	148	728
Lotus corniculatus	$N_0P_0K_0$	10.5	7245	100	345
	$N_{100}P_{80}K_{60}$	12.5	8625	119	411
	$N_{200}P_{160}K_{120}$	15.5	10695	148	509
Winter wheat	$N_0P_0K_0$	1.4	2100	100	100
	$N_{100}P_{80}K_{60}$	3.8	5700	271	272
	$N_{200}P_{160}K_{120}$	4.2	6300	300	300
Corn	$N_0P_0K_0$	0.4	816	100	39
	$N_{100}P_{80}K_{60}$	2.6	5304	650	253
	$N_{200}P_{160}K_{120}$	3.0	6120	750	291
Soybean	$N_0P_0K_0$	0.6	1164	100	55
	$N_{100}P_{80}K_{60}$	0.9	1746	150	83
	$N_{200}P_{160}K_{120}$	1.2	2328	200	111
Pea	$N_0P_0K_0$	1.2	1752	100	83
	$N_{100}P_{80}K_{60}$	1.9	2774	158	132
	$N_{200}P_{160}K_{120}$	2.7	3942	225	188
Mixture between barley and pea	$N_0P_0K_0$	10.4	14144	100	674
	$N_{100}P_{80}K_{60}$	22.6	30736	217	146
	$N_{200}P_{160}K_{120}$	29.5	40120	284	192
Sunflower	$N_0P_0K_0$	0.6	948	100	45
	$N_{100}P_{80}K_{60}$	1.1	1738	183	83
	$N_{200}P_{160}K_{120}$	1.8	2844	300	135
Sorghum	$N_0P_0K_0$	0.62	874	100	49
	$N_{100}P_{80}K_{60}$	1.35	1904	218	91
	$N_{200}P_{160}K_{120}$	1.87	2637	302	126

* to calculate nutritive units/ha, the secondary production was also included

Table 4. Main crop yield (at the standard water content) related to fertilization levels on the Garla non-covered dump

Agricultural crop	**Fertilization level**	**Average Yield**			
		t/ha^{-1}	Nutritive Units/ha*	%	
				Main Yield	Nutrition Units
Lolium perenne	$N_0P_0K_0$	2.3	2139	100	130
	$N_{100}P_{80}K_{60}$	3.4	3162	148	192
	$N_{200}P_{160}K_{120}$	4.0	3720	174	225
Alfalfa	$N_0P_0K_0$	13.5	12150	100	736
	$N_{100}P_{80}K_{60}$	16.5	14850	122	900
	$N_{200}P_{160}K_{120}$	18.5	16650	137	1009
Lotus corniculatus	$N_0P_0K_0$	12.0	8280	100	502
	$N_{100}P_{80}K_{60}$	15.0	10350	125	627
	$N_{200}P_{160}K_{120}$	17.5	12075	146	732
Winter wheat	$N_0P_0K_0$	1.1	1650	100	100
	$N_{100}P_{80}K_{60}$	3.3	4950	300	300
	$N_{200}P_{160}K_{120}$	4.0	6000	364	364
Corn	$N_0P_0K_0$	0.6	1224	100	74
	$N_{100}P_{80}K_{60}$	2.4	4896	400	297
	$N_{200}P_{160}K_{120}$	2.8	5712	466	346
Soybean	$N_0P_0K_0$	0.8	1552	100	94
	$N_{100}P_{80}K_{60}$	1.2	2328	150	141
	$N_{200}P_{160}K_{120}$	1.4	2716	175	165
Pea	$N_0P_0K_0$	1.0	1460	100	88
	$N_{100}P_{80}K_{60}$	1.8	2628	180	159
	$N_{200}P_{160}K_{120}$	2.5	3650	250	221
Mixture between barley and pea	$N_0P_0K_0$	9.2	12880	100	78
	$N_{100}P_{80}K_{60}$	20.4	28560	222	173
	$N_{200}P_{160}K_{120}$	22.6	31640	246	192
Sunflower	$N_0P_0K_0$	0.5	790	100	48
	$N_{100}P_{80}K_{60}$	0.8	1264	160	77
	$N_{200}P_{160}K_{120}$	1.4	2212	280	134
Sorghum	$N_0P_0K_0$	0.5	755	100	46
	$N_{100}P_{80}K_{60}$	1.3	1993	264	121
	$N_{200}P_{160}K_{120}$	1.8	2658	352	161

* To calculate nutritive units/ha, the secondary production was also included

C. Influence of organic and mineral fertilization upon crops cultivated on Balta Uncheasului Dump

Data are presented in Tables 5 and 6 for sweet sorghum, rye, winter wheat, and pea for different fertilization levels. The yield obtained on this stockpile for the agricultural crops tested, under all fertilization treatments applied, was very small due to the weather conditions. Therefore, the consequences of any fertilization type or rate upon crop development and yield were very reduced, even if there are significant differences among applied treatments.

For sweet sorghum, only moderate and high rates of mineral fertilization have determined significant gains of yield. The application of the mineral fertilization in addition to the 50 t/ha of cattle manure did not result in yield increases. This means that this crop was not able to efficiently use the entire amount of nutrients. Comparing the crop yield obtained under 50 t/ha of cattle manure to the non-fertilized plot, no differences can be noticed between them, due to high water deficiency. Cattle manure, at the rate of 100 t/ha, determined a yield gain of 300 kg/ha, for sweet sorghum compared to the control plot, but this is not statistically ensured. Also, the association of the 100 t/ha cattle manure with $N_{150}P_{120}K_{120}$ did not ensure a statistically significant yield increase compared to the only mineral fertilization $N_{150}P_{120}K_{120}$. Using 10 t/ha of winter wheat straw and 20 t/ha of other corn and sorghum residual materials, we did not notice any significant change in crop yield, only a slight non-significant decrease compared to the control plot, because they were applied in the spring time, causing a nitrogen deficiency. Applying these kinds of materials in combination with mineral fertilization, the yield decrease is much lower due to some improvements in the nutrient balance. Anyhow, the yield obtained under different types and rates of residual crop material applied in combination or without mineral fertilizer remained under the level obtained with mineral or cattle manure fertilizers. More than that, sweet sorghum is a very demanding crop. It especially requires good seedbed preparation and it has a very low germination capacity and a slow seed emergence.

For rye, a more sensitive crop to the droughty conditions than sweet sorghum, the mineral and organic fertilization in such conditions does not have any significant practical or economical effect on the crop development or the yield obtained. This remains true even if the yields have significantly increased compared to the control plot. This is because the crops efficiently used a only a small part of the nutrients from the applied mineral and organic fertilizers.

Table 5. Influence of different organic fertilizer types and rates upon sweet sorghum and rye yield located on the Balta Unchiasului Dump.

Treatment	**Sweet Sorghum**				**Rye**			
	kg/ha	%	Difference (kg/ha)	Signif.	kg/ha	%	Difference (kg/ha)	Signif.
Control	1500	100	Control		280	100	Control	
$N_{50}P_{40}K_{40}$	1800	120	300		386	137	106	*
$N_{100}P_{80}K_{80}$	2400	160	900	***	640	226	360	***
$N_{150}P_{120}K_{120}$	2899	193	1399	***	800	285	520	***
50 t/ha cattle manure	1500	100	Control		252	100	Control	
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	1699	113	199		386	155	134	**
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	2100	140	600	**	506	200	254	***
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	2400	160	900	***	720	285	468	***
100 t/ha cattle manure	1800	100	Control		360	100	Control	
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	2100	116	300		493	170	133	**
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	2400	160	600	**	733	203	373	***
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	3000	166	1200	***	920	255	560	***
10 t/ha winter wheat straw	1290	100	Control		360	100	Control	
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	1500	116	210		413	114	53	
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	1899	147	609	**	733	203	393	***
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	2199	170	909	***	920	250	560	***
20 t/ha sorghum stems	1290	100	Control		320	100	Control	
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	1688	130	506	**	493	154	173	***
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	1888	146	598	**	573	179	253	***
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	2100	162	810	***	813	254	493	***
20 t/ha corn stalks	1290	100	Control		346	100	Control	
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	1800	139	510	**	426	123	80	
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	2499	193	1209	***	573	164	227	***
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	2700	209	1410	***	686	196	334	***
LSD 5%	309				94			
LSD 1%	453				126			
LSD 0.1%	653				168			

Table 6. Influence of different organic fertilizer types and mineral fertilizer rates on yield winter wheat and pea yield located at the Balta Unchiasului Dump.

Treatment	Winter wheat				Pea			
	kg/ha	%	Difference (kg/ha)	Signif.	kg/ha	%	Difference (kg/ha)	Signif.
Control	400	100	Control		300	100	Control	
$N_{50}P_{40}K_{40}$	450	112	50		480	133	120	*
$N_{100}P_{80}K_{80}$	800	200	400	***	560	100	200	***
$N_{150}P_{120}K_{120}$	1050	262	650	***	720	200	360	***
50 t/ha cattle manure	350	100	Control		420	100	Control	
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	425	121	125		560	133	140	**
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	550	157	200	*	600	142	180	***
50 t/ha cattle manure + $N_{50}P_{40}K_{40}$	1000	285	650	**	780	185	360	***
100 t/ha cattle manure	450	100	Control		480	100	Control	
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	600	133	150		590	122	110	**
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	900	200	450	***	630	131	150	***
100 t/ha cattle manure + $N_{50}P_{40}K_{40}$	1100	244	650	***	840	175	360	***
10 t/ha winter wheat straw	500	100	Control		380	100	Control	
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	650	130	50		490	128	110	
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	950	190	400	***	570	150	190	***
10 t/ha winter wheat straw + $N_{50}P_{40}K_{40}$	1200	240	700	***	670	176	290	***
20 t/ha sorghum stems	400	100	Control		360	100	Control	
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	600	150	200	*	480	133	120	***
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	700	175	300	**	560	135	200	***
20 t/ha sorghum stems + $N_{50}P_{40}K_{40}$	1000	250	600	***	660	183	300	***
20 t/ha corn stalks	450	100	Control		390	100	Control	
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	500	125	50		516	166	126	
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	700	155	250	**	560	155	170	***
20 t/ha corn stalks + $N_{50}P_{40}K_{40}$	1000	222	550	***	660	183	270	***
LSD 5%	165				85			
LSD 1%	235				115			
LSD 0.1%	345				185			

For winter wheat, the yield obtained was 2-3 times lower compared to a normal year. This crop was also influenced by the climatic conditions. Nevertheless, the crop yield increased related to the mineral fertilization rate particularly for the maximum applied level. Any significant differences have not been recorded in relationship to the type and rate of the organic materials used in combination with mineral fertilization. This also can be explained by the water deficiency, which has affected the degradation and mineralization processes of the organic materials applied in the spring before seedbed preparation. In spite of the data obtained in this droughty year, we can use high rates of mineral fertilization to obtain better development of the winter wheat crop and a more economical result. We have to mention that winter wheat is the most important crop in this area for the local poor population`s survival. Therefore, even in droughty years these high fertilization levels can be taken into account by the landowners.

Peas were the other tested crop in the experiment. Because of its natural qualities to fix a significant amount of nitrogen usable by the subsequent crop, it is considered to be a good previous crop in the rotational system, mainly for sorghum, winter wheat, and rye. It may be chopped and incorporated into the soil as green manure; the nitrogen content of its modules will remain in the soil helping in the decay of vegetal residue without causing a nitrogen deficiency in the soil. Peas are a good nitrogen fixing crop, responding in general very well to the mineral fertilization. In this study, under droughty conditions, the development and yield of the pea crop were very much affected. In spite of this, some significant yield gains have been noticed under the fertilization treatments. In comparison with the control plot, the yield has significantly increased by using organic fertilization with 50 and 100 t/ha of cattle manure.

Conclusions

In Romania**,** agriculural land capability is affected by many restrictve factors with severe negative consequences on soil productivity and fertility as well as on environment, food security and living standard.

The productivity of Romania’s fertile and productive soils were annualy diminished, especially in the economically depressed regions such as Oltenia, by different causes including surface mining activities.

There is much need for significant investments in the proper reclamation of the land degraded by mining operations, particularly in the poor regions where the reclaimed land can be put back into production by the landowners.

Data obtained under this research program have shown that good agricultural management could assure incomes for the rural population in local areas.

The yield obtained for different agriculural crops on the reclaimed stockpile in the Oltenia region increased related to the mineral fertilization even under drouthy conditions, but the nutrients were not used very well due to high water deficit in the substrata.

Crop residues applied in the spring before site preparation were not properly functional due to the unbalanced nutritional system of the 'soil' and the slow decaying process for vegetable materials, even where it was used in association with mineral fertilizers.

REFERENCES

Bordanc Florica, 1996. "The spacial dimentions of agricultural in "Agriculture Restructuration and Rural Transition in Romania" Bucharest;

Dumitru M., Popescu I., Blaga Gh., Dumitru Elisabeta, 1999. "Recultivation of land disturbed by surface mining entereprises in Oltenia coal-bearing" Transilvania Press House.

Dumitru M., Blaga Gh., Popescu I., 1998. "Research concerning recultivation of the sterile dumps resulted from surface mining activities in Romania" in Soil Science Series III, 1-2, vol. XXXII;

**** National Institute for Statistics. Statistical Year Book, 2000.