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FOREST RECLAMATION OF THE POST-MINING DUMPS. II. NITROGEN FERTILIZATION AS A KEY FOR SUCCESSFUL MIOCENE STRIP-MINE DUMPS RECLAMATION

Key words: forest recultivation, dumps reclamation, nitrogen in recultivation

S u m m a r y

The post-mining area in the Łęknica vicinity is covered with Miocene sediments, mainly loamy sands containing pyrite. As part of the reclamation process, described area have been afforested, mainly with Scotch pine. The recultivation results were in many places highly unsatisfactory, because of nutrients deficiency on the trees appearance. A field experiment applying combinations of N, P and K with each element applied at different rates (N - 100, 200, 400 kg·ha^{-1}, K – 160, 320 kg·ha^{-1}, P – 70, 140 kg·ha^{-1}) was carried out. After four years it was clear, that the growth of pine seedlings depends mainly from nitrogen application, which 100 kg N·ha^{-1} yearly sufficient to achieve good growth. During the first year after additional fertilizer application the soil surface between pine seedlings rows was covered fully with grass and other plant species. The pine needles became dark green color and were longer and heavier. In the following 3 years the annual growth of fertilized trees was much higher. The N-content in the pine needles increased proportionally to needle weight and N fertilization, from 1,2-1,3% N in the "0" combination to over 2,0% N in the heavily fertilized plots. The elevated doses of K and P did not change the P and K content of the needles. Also the Ca and Mg concentration in the needles were not dependent from the fertilization level. The heavy metal concentration was typical for clean areas, although the soil became a quite large amount of these elements with the waste lime from zinc smelter.

Introduction

The brown coal strip-mine in Łęknica was closed in 1974, left dumped material consisting mainly of Miocene, pyrite-containing loamy sands. These

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sands have a very low amount of plant nutrients, and very low pH (2-3) [Greinert 1988].

According to the reclamation plan all possible area was taken for afforestation. The land was leveled and the following fertilizer amounts added:

- magnesium limestone, from 35 Mg to 50 Mg·ha^{-1}, calculated on the basis of hydrolitic acidity,
- nitrogen in the form of nitro-chalk – 50 kg N·ha^{-1} before planting and 25 kg N·ha^{-1} after one year,
- potassium as a 60% potassium salt, 90 kg K_2O·ha^{-1},
- phosphorus, 70 kg P_2O_5·ha^{-1}, in the form of ground phosphate rock.

The fertilization measures did not yield satisfactory results. The pine seedlings were small. Nutrient deficiency symptoms appeared on the needles (needles were yellow). However, soil erosion damaged the young forest stand.

Bender [1983] took a good results making similar experiment with heavy fertilized deciduous trees at the Experimental Station in Konin, so we set up an experiment with relatively high doses of NPK.

Material and methods

Two plots, planted with Scotch pine (*Pinus silvestris* L.) were chosen for the fertilizer experiment:

plot "A" – 6 years old stand,
plot "B" – 1 year old stand.

The NPK and lime treatments are presented in table 1. The lime addition was used to check the influence of liming on the growth of pine trees. Each plot consists of 300 m^2, and was subdivided to the rows – 10 rows pro plot. For statistical tendencies description, occurred during experiment, each of measurements was 5-times repeated (using material from 2 rows pro 1 mixed sample). The lime was added one, at the beginning of the experiment and NPK fertilizer each year in the spring of 1987, 1988 and 1989. Each year the morphological measurements and the needles and soil samples were taken. For morphological and chemical analyses the needles from 1- and 2-years branches were taken. Also trees height was measured for yield description. Soil sampling was described in first part of paper. All of measurements were statistically worked out, using variation analysis module of "Statistica for Windows" software.

Results

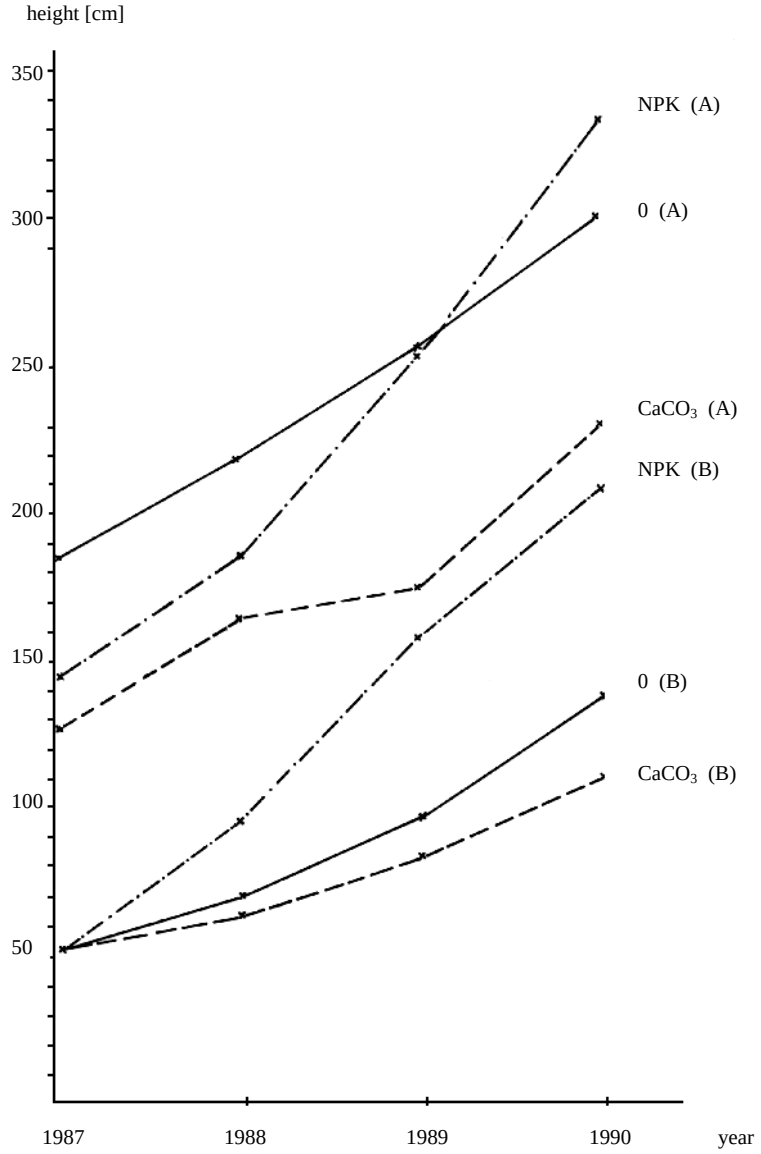
During the first year after the fertilizer application the soil surface between the rows of pine trees was covered with grass and other plant species. Before the fertilization it was bare soil. As a result the effects of erosion by water was almost eliminated. The pine needles became a dark green color, they were longer and much heavier. In the next 3 years annual growth of fertilized trees has increased considerably. Also the N content of pine needles was higher. The results are presented in tables 2-4. Figure 1 shows the growth changes between treatment "O", limed and NPK-fertilized combinations.

The higher doses of K and P did not change the K and P content of needles. Also the other elements seems to be independent from nitrogen fertilization [Greinert 1966]. Although nitrogen is the limiting factor for most of the recultivation areas, there are cases, on which other factors are more important (per example by the recultivation of alluvial soils on sandpits the limiting factors can be the physical properties [Drab 1998]).

Tab. 1. Experimental design of the field plot experiment

Treatment No	N	P_2O_5	K_2O	Lime (oxide)
1	0	0	0	0
2	0	0	0	8Mg
3	+	+	0	0
4	+	0	+	0
5	+	+	+	0
6	++	++	++	0
6a	++++	++	++	0
7	+	+	0	8Mg
8	+	0	+	8Mg
9	+	+	+	8Mg
10	++	++	++	8Mg
10a	++++	++	++	8Mg

Commentary: + 100kg N, 70kg P_2O_5, 160kg K_2O per hectar,
++ 200kg N, 140kg P_2O_5, 320kg K_2O per hectar,
+++ 400kg N, 140kg P_2O_5, 320kg K_2O per hectar.



Commentary: A. 10 years old trees, B. 5 years old trees

Fig. 1. Changes in the Scotch pine trees height 1987-90

Tab. 2. The nitrogen concentration in pine needles, the weight of 100 needles and the average length. Experimental field "A" (needles 1 and 2 years old)

Treatment No	N [% d.m.]		Weight of 100 needles [g]		Average length of needle [cm]	
	1-year	2-years	1-year	2-years	1-year	2-years
1	1,21	0,51	1,99	1,29	5,08	4,66
2	1,23	0,49	1,84	1,16	3,82	4,20
3	1,42	0,54	3,23	2,43	5,95	6,89
4	1,98	0,52	2,86	3,57	5,85	7,34
5	1,64	0,71	3,56	3,81	6,10	8,73
6	1,75	0,71	3,92	2,14	6,40	6,60
6a	2,46	0,89	3,46	4,00	5,78	8,83
7	1,49	0,40	4,16	3,44	8,15	8,19
8	1,42	0,60	3,36	2,70	6,10	7,60
9	1,60	0,34	3,14	2,22	6,02	6,34
10	1,90	0,45	3,70	2,61	6,47	6,92
10a	1,83	0,86	3,87	2,61	5,45	5,39

Tab. 3. The nitrogen concentration in pine needles, the weight of 100 needles and the average length. Experimental field "B" (needles 1 and 2 years old)

Treatment No	N [% d.m.]		Weight of 100 needles [g]		Average length of needle [cm]	
	1-year	2-years	1-year	2-years	1-year	2-years
1	1,34	0,40	2,26	2,17	6,19	7,22
2	1,52	0,59	1,60	0,95	5,39	3,86
3	1,42	0,37	3,59	3,55	6,52	8,39
4	1,34	0,60	3,44	3,70	6,88	8,09
5	1,38	0,45	3,03	3,66	5,55	7,71
6	1,87	0,75	4,20	4,32	7,51	9,29
6a	1,79	0,64	4,50	3,22	7,60	9,21
7	1,53	0,37	3,35	3,38	6,40	8,46
8	1,49	0,56	3,15	2,88	5,80	8,10
9	1,53	0,37	3,68	3,18	6,85	8,02
10	1,89	0,73	3,45	3,06	6,35	7,41
10a	2,57	0,93	2,56	3,98	5,34	9,20

Tab. 4. The growth of pine trees on experimental field "B"

Treat-ment No	The average heights [cm]				The average annual top growth [cm]			
	1987	1988	1989	1990[x]	1987	1988	1989	1990[x]
1	52,6	69,8	95,6	136,0	30,7	20,7	26,5	21,2
2	45,8	63,3	82,3	109,1	23,6	16,9	21,3	16,6
3	53,9	93,4	148,0	208,0	27,3	41,0	58,8	32,8
4	52,7	89,4	141,0	207,2	32,0	39,5	59,2	32,3
5	52,1	95,3	157,6	205,2	28,1	42,6	61,2	33,3
6	50,0	88,4	148,9	210,1	27,2	39,8	56,1	40,3
6a	46,1	88,8	144,1	197,7	25,3	39,5	56,2	40,5
7	41,5	83,8	143,0	202,0	21,8	41,4	59,7	35,1
8	46,7	83,2	134,7	181,0	27,3	35,7	83,6	30,9
9	41,0	74,8	123,4	180,2	22,7	31,2	51,3	36,5
10	42,4	72,6	128,9	137,1	25,0	31,6	49,9	26,7
10a	36,2	61,9	111,5	130,0	21,1	27,2	42,1	24,7

[x] – no fertilizer applied

Discussion

The dump material do not contain real humus, only admixtures of brown coal particles and dusts. The C:N ratio of soil-forming rocks (in average about 40:1) is to wide for the proper plants growth. For the fields with similar C:N, a large amount of nitrogen is necessary. This is the explanation of good results in the cases of high N doses on the pine growth. Even very high nitrogen doses did not have negative influence. Similar conclusion made Bender [1983] and Gilewska for brown coal strip-mines dump material from Konin locality. Also Nilsen and Abrahamsen [1995] in Norway obtained similar results – the nitrogen was still most limiting factor for pine trees growth.

From the results in table 4 we can see, that 3 years of fertilizer application was not enough to obtain a normal N nutrient status of the soil. After ending of the NPK fertilization in 1989, growth of the pine trees was lower than in previous years. Nevertheless, from the ecological point of view, growth-speed after heaviest fertilizing (in mentioned above dozes) is enough for soil protection and forest habitat formatting. To stable reclamation effects achieve, fertilizer applying has to be used in longer time period – to about 5-7 years.

Conclusions

- Nitrogen was the limiting factor for successful forest recultivation on strip-mine dumps in Łęknica locality.
- The amount of 100 kg N/ha yearly is enough high to achieve good growth rates of pine trees.
- For achieve a stable nitrogen uptake condition in the soil more than 3 year of fertilizer application is necessary.

References

1. BENDER J.: *Theoretical base of industrial landscape recultivation*. "Recultivation of technogenous areas" Ed. Szegi. Matraalja Coal Mining Co. Győngyős: 113-118. 1983
2. DRAB M.: *Przyczyny niskiej produktywności mad przekształconych przez przemysł wydobywczy kruszywa budowlanego w Dobroszowie Wielkim (The causes of low productivity of the alluvial soils in Dobroszów Wielki transformed by the exploitation of sand and gravel aggregate*. The 1st International Conference: "Protection and Recultivation of the Odra-Basin areas. Zielona Góra: 213-218. 1998
3. GILEWSKA M.: *Rekultywacja biologiczna gruntów pogórniczych na przykładzie KWB "Konin"*. Roczniki Akademii Rolniczej w Poznaniu. Rozprawy Naukowe. Nr 211. 1991
4. GREINERT H.: *Rekultywacja leśna utworów pokopalnianych w rejonie Łęknicy (The reforestation of the surface mine area in the Łęknica vicinity)* Politechnika Zielonogórska. Zeszyty Naukowe nr 114. Inżynieria Środowiska 6: 91-111. 1996
5. NILSEN P., ABRAHAMSEN G.: *Nutrient balance in Scots pine (Pinus silvestris L.) forest. V. Tree growth in a field plot experiment*. Water, Air and Soil Pollution 85: 1143-1148. 1995

REKULTYWACJA LEŚNA HAŁD POKOPALNIANYCH. II. NAWOŻENIE AZOTOWE JAKO KLUCZ DO REKULTYWACJI MIOCEŃSKICH GRUNTÓW POKOPALNIANYCH

Słowa kluczowe: rekultywacja leśna, rekultywacja hałd, azot w rekultywacji

S t r e s z c z e n i e

Powydobywcze hałdy w okolicy Łęknicy pokryte są utworami mioceńskimi, o składzie piasków gliniastych, zawierającymi piryt. Rekultywację hałd prowadzono w kierunku leśnym, z użyciem sosny zwyczajnej jako wiodącego gatunku. Zastosowana technologia rekultywacyjna okazała się nie satysfakcjonującą, z uwagi na pojawienie się silnych deficytów składników pokarmowych dla roślin. Przeprowadzono pilotażowe doświadczenie polowe z różnymi dawkami N, P i K (N - 100, 200, 400 kg·ha^{-1}, K – 160, 320 kg·ha^{-1}, P – 70, 140 kg·ha^{-1}). Już po czterech latach stało się jasnym, że wzrost I rozwój sosny zależy przede wszystkim od nawożenia azotowego, a dawka 100 kg N·ha^{-1} rocznie wydała się wystarczającą. Zaobserwowano przy tym w pierwszym roku doświadczenia pokrycie całego obszaru nawożonego azotem roślinnością zielną. Sadzonki sosny stały się mocniejsze, ciemno zielone i miały lepsze przyrosty. Następne trzy lata jeszcze istotniej zróżnicowały poletka na korzyść nawożonych azotem. Zwiększyła się też zawartość N w igłach, z 1,2-1,3% N w kombinacji "0" do ponad 2,0% N przy maksymalnej dawce azotu. Wzrost nawożenia PK nie wpłynął na pobieranie P i K przez rośliny. Także w odniesieniu do Ca i Mg zaobserwowano podobny brak reakcji. Zawartość w materiale roślinnym metali ciężkich była typowa dla roślin czystych obszarów, pomimo wniesienia do gruntu znaczących ich ilości z wapnem odpadowym.