Bulgarian Chemical Communications, Volume 46, Special issue B (pp. 112 – 115) 2014

Application of Black Sea sapropels for increasing of grain beans yield cv. "Smiljan", cultivated on cinnamonic pseudopodzolic soil (Planosol)

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Received June 15, 2014; accepted December 25, 2014

In the period 2012 – 2013 was studied the effect of application of deep water Black Sea sediments (sapropels) for recultivation of acidic cinnamonic pseudopodzolic soil (Planosol) [CPS (Planosol)], used for growing of beans for grain, cv. "Smiljan". The results obtained showed that in an amount 20 g/kg, the sapropels (Variant 1) neutralize the acidity of CPS (Planosol) from 4.53 to pH 6.87 after incubation period of a month and to pH 7.05, 7.12 and 7.27 respectively after 2, 3 and 4 months incubation. The sapropels increase the content of humus in the used soil from 6.7 to 11.2 g/kg and the content of $CaCO_3$ from 0.22 to 1.46 g/kg. At Variant 1 the grain yield was 33.2 % more higher, compared to Control. The content of crude protein increases with 12.8 % and the content of phosphorus in the grain – with 1.1 % more, in comparison to Control.

Keywords: *Organic-mineral sediments, soil acidity, crude protein, dry matter*

INTRODUCTION

The grain legumes collections are the richest group in plant world, with their economic value and dissemination they take second place after cereals. They supply about 20 % of total fund of plant protein. The seeds are 2 to 5 richest of proteins compared to cereals, and most of them consists between 20 – 35 % crude protein. Beans (Phaseolus vulgaris) according to Terziev et al. [1] as a cultural plant is well known since ancient times. Mature seeds of beans are valuable food for humans because of its high content of protein, amino acids, carbohydrates, minerals, vitamins B, C and others. Beans is a strategic food because its seeds can be stored for years without losing their nutritional value. The legumes are for a big importance for agriculture as trench culture, because they enrich the soil with nitrogen. According to Crepon [2] bean protein is easily assimilated by the human body, unlike those of meat foods for which the degradation toxic products cause pathological changes in human organism. Bean seeds are a source of valuable amino acids for the human body. Beans is included in the diet of people suffering from various diseases - cardiovascular, diabetes, etc.

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In our country areas and production of beans are concentrated mainly in northeastern Bulgaria, but is also is grown in other areas, including on acid soils that are not favorably for its cultivation. The optimum soil pH lies in neutral and weakly alkaline medium. So that is needed the acidic soils to be neutralized with appropriate ameliorants. As such, currently are used various lime ashes, lime cream, calcium carbonate and others. A disadvantage of these ameliorants according to Dimitrov et al. [3] may indicate that they do not provide long-term stabilization of pH, because of an absence of buffering capacity.

According to Koteva et al [4] from about 46 millions da cultivated agriculture lands in Bulgaria, 3.5 millions are classified as strong acidic (pH 4.1 - 4.6), and 4.6 - 5.0 millions – as acidic soils (pH 4.6 - 6.0) as a consequence of long standing using of nitrogen fertilizers, acidic rains, waterlogging related to reduction processes etc., leading to destruction of the soil structure and low yields. In fact more than 8 millions decares lands need a chemical recultivation.

The Black Sea organic-mineral sediments (sapropels) according to Dimitrov et al. [5] in agreement with Bmins [6] represent an unique natural phenomena, having no analogue between the sediments found in other watersheds on earth. During last years they are a subject of special research, because of the opportunity for application in several aspects of agriculture. The soil fertility according to Petrova [7] depends on the content of

nutrients, pH of the soil solution, the soil structure, irrigation regime etc. According to Nikolov et al. [8] the introducing of sapropels in acidic soils leads to increasing of soil buffering capacity and enriching of exhausted soils with useful for the plants nutrients and organic matter. The sapropels are widespread on the Sea bottom at a depths 1200 – 2000 m and in fact are practically inexhaustible. An important their advantage according to Shnukov et al [9] in agreement with Dimitrov [10] is that they are completely sterile, because of their forming in non-living hydrogen sulphide zone on the sea bottom.

The aim of present work was to study the opportunity to use Black Sea sapropels for increasing the grain yield of beans cv. "Smiljan", cultivated on the acidic soil CPS (Planosol).

EXPERIMENTAL

Elemental analysis

Sample sapropels, taken from a depth 1200 m was analysed for a content of Si, K, P, Ti, Al, Ca, Na, as well as some micronutrients, as Fe, Mn, Mg, Cr, Mo, Cu, and heavy metals Zn, Ni, Pb. They were determined in the form of oxides. An inductively coupled emission spectrometry (Jobni Yvon Emission - JY38S, France) was used. The quantitative measuring was carried out with apparatus ICP.

Neutralization of Planosol.

For preparing of the trial parcels, acidic CPS (Planosol) from the area of Zlatosel village (Plovdiv district), taken from deep horizon 0 - 40 cm was mixed with sapropels at amounts 20 g/kg. After pouring on with water, samples were left for incubation. The samples were periodically filled up with water and mixed. Parallel was prepared two control parcels with CPS. During a month of incubation period, the beads were closed to avoid an access of atmospheric air. After incubation period of 1, 2, 3 and 4 months at a temperature 303 K were determined pH of the detached varieties in water medium by pH-meter, model OP-211/1 (ISO 10390). Parallely were established the pH value of sample sapropels.

Determination of exchange ions, humus content and calcium carbonate.

The content of exchange ions - Ca^{2+}, Mg^{2+}, Al^{3+} and H^{+} was determined by standard method[11] in extract of 1n KCI. The humus content of CPS (Planosol) in the soil horizon 0 - 40 cm, as well as in the soil-sapropels mixtures and in sample pure sapropels was determined by the method of Turin. The content of active calcium carbonate was established by the method of Druino and Gale [11].

Field experiment.

Bean seeds were sown on the 15th of April in four replications of 12 plants in two trial parcels, every of them with surface 1 m^2. Parralely were sown bean seeds in four replications on the two control parcels with the same surface. There were made all necessary agro technical activities. Feeding with NH_4NO_3 in the both variants was made twice at a dose 4 g for a plant, as the first was at the 30th of April in a phase 3th - 4th leave and the second - at the 15th of June in phase flowering. The beans plants at Control and Variant 1 were grown by the same irrigation regime. For the normal development of bean plants was used wire structure with a height 3 m. Picking of grain harvest for the two investigated years was made at the 15th of November.

Analysis of beans grain

After the end of vegetation were determined the following indicators of beans grain: absolute dry matter by the weight method, weight of 100 bean grains, total yield of grain, kg/da. The content of crude protein was calculated on the base of nitrogen content, multiplied by coefficient 6.25. The content of nitrogen was determined by Kjeldhal method with apparatus "VELP UDK 132" (Jones 1991).

Statistical data analysis

The statistical processing of the obtained experimental data from the two investigated years was made with the program "BIOSTAT".

RESULTS AND DISCUSSION

The data from the elemental analysis of sapropels are shown at Tables 1 and 2. The content of macro- and micronutrients was established, calculated as oxides. The data show that content of calcium – 154.6 g/kg, calculated as CaO is more than its content in the most soil types. The content of some other basic nutrients as Mg, Mn, Fe exceeds their content in soils too. The rich content of macro- and micronutrients as well as of organic matter determines sapropels as a complex organic-mineral fertilizer.

The experimental data for the content of exchange ions in the samples are shown in Table 3. It was established that the neutralizing ability of sapropels used was most significant after the first month of incubation – from 4.53 to pH 6.87 and after that changes weakly reaching pH 7.27 in the.

Table 1. Chemical composition of sapropels. Content of N, P and micronutrients.

Content of nutrients in sample Black Sea sapropels								
Cr_2O_3	MoO_3	ZnO	MnO	PbO_2	CuO	NiO	P	N
g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/kg	g/kg
50	36.4	65.8	383.4	28.2	36.6	49.8	9.6	25.4

Table 2. Chemical composition of sapropels. Content of humus, micro- and macronutrients.

Content of humus and nutrients.in sample Black sea sapropels, g/kg										Humus /g/kg/
1	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	
2	397.6	7.0	117	45.6	0.4	26.8	154.6	21.3	18.3	68.6

Table 3. Exchange ions content and pH of CPS (Planosol) and soil-sapropels mixture.

Variants	Exchange ions after 1 month, mgeq/l				pH after months of incubation			
	Ca^{2+}	Mg^{2+}	$Ca^{2+}Mg^{2+}$	Al^{3+}, H^+	1	2	3	4
Variant I	41.7	227.3	65.4	-	6.87	7.05	7.12	7.27
Control	193.7	158.3	352.0	1012.3	4.53			

end of four months incubation period. Sapropel used has almost a neutral reaction – 7.28 pH units, but as the main reason for pH change should be noted the activation of exchange bases, in the marine sapropels. pH change depends on the content of humus and exchange ions. The presence of organic carbon in the form of humic acids salts immobilized in gel structures and exchange ions (Ca^{2+}, Mg^{2+}) in the sapropels composition, improve the buffer ability of the investigated CPS (Planosol).

The content of some nutrient nutrients and compositions changes after incubation of sapropels in the used CPS soil. The humus content increases from 6.70 to 11.20 g/kg and $CaCO_3$ – from 0.22 to 1.46 g/kg. The content of P and N changes insignificantly (Table 4).

Table 4. Content of humus, $CaCO_3$, N and P in CPS (Planosol). (Planosol), sapropels and soil-sapropels mixture.

№	Variants	Humus, /g/kg/	$CaCO_3$, /g/kg/	N, /g/kg/	P, /g/kg/
1	Variant 1	11.00	1.46	7.28	3.84
2	CPS	6.70	0.22	7.30	3.80
3	Sapropels	68.6	62.2	4.50	4.00

The yield in the four trial replications and the median value is represented on a Figure 1.

The most expressed difference was established in the grain yield of beans – with 33.2 % higher in Variant 1, compared to Control. At the second place increases the content of crude protein in the grain with 12.9 %, compared to Control, most probably due to the imported with the sapropels nutrients in the soil – macro-, micronutrients, humic substances etc. Another reason is the acidic soil medium which is not favorably for growing of legumes. There is not remarkable difference in weight of 100 grains and dry matter between variant 1 and Control – 1.02 % and 1.1 % (Table 5).

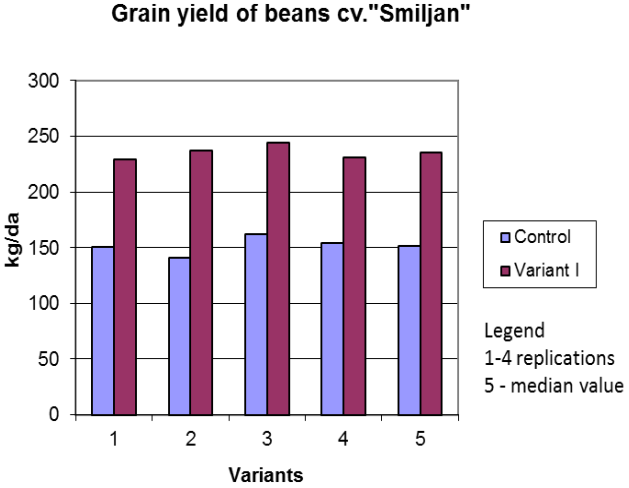

Fig. 1. Grain yield (kg/da) in replications and median value of beans, cv. "Smiljan".

The differences between the Control and Variant 1 in the total yield are well warranted (Table 6).

The marine sapropels neutralize the soil acidity of cinnamonic pseudopodzolic soil (Planosol) from 4.53 to neutral medium – pH 6.87 - 7.27 after 1 – 4 months incubation period by insignificant amount of sapropels - 20 g/kg. It influents positively on the final grain yield and the content of crude protein in the grain.

The study show that marine sapropels could be used as ameliorant and complex organic-mineral fertilizer for acidic soils in order to optimize the

yield and biochemical indicators of legumes, which are sensitive to acidic soil reaction.

Table 5. Biochemical indicators and weight of 100 beans grains.

№	Variants	Dry matter, g/kg	Crude protein, g/kg	Weight of 100 grains, g	Total yield, kg/da	P, g/kg
1	Variant I	879.6	253.8	109	215.2	10.53
2	Control	864.3	198.8	99	161.8	9.6
3	Difference	1.02	12.8	1.1	33.2	1.1

Table 6. Total grain yield of beans, cv. "Smiljan".

Variants	Total yield, kg/da	± D	Rank
Control	152.05	0	IV
Variant 1	235.4	+ 83.35	I
GD 5 %	9,82		
GD 1 %	14.23		
GD 0.1 %	21.34		

REFERENCES

1. J. Terziev, Hr. Yancheva, Iv. Yanchev, T. Georgieva. B. Yankov, R. Ivanova, I. Dimitrov, T. Kolev. Plant Sci., Acad. Publ. House, Plovdiv Agric. Univ., p. 110 (2006) (in Bulgarian).
2. K. Crepon, Book of abstracts. 6th Eur. Conf. of Grain Legumes, 12–16 Nov., p. 5 (2007).
3. P. Dimitrov, N. Nikolov, N. Shaban, M. Kamburova, C. Moskova, P. Zapryanova, D. Dimitrov, D. Solakov. Amendment for soils and substrates, BG Patent № 63868, 3 (2000) (in Bulgarian).
4. V. Koteva, N. Artinova. *Soil Sci., Agrochem., Ecology*, **28**, 13 (1993) (in Bulgarian).
5. P. Dimitrov, V.Velev. *Oceanology*, **17**, 92 (1988) (in Bulgarian).
6. T. Bmins. OM GOR CNPM NAN, 258 (1994).
7. I. Petrova. "Physics-chemical valuation and recultivation of acidic soils", Dissertation, Sofia, (2008) (in Bulgarian).
8. N. Nikolov, N. Artinova, D. Dimitrov, *Plovdiv Agric. Univ.*, **III**, 33 (2011). (in Bulgarian)
9. E. Shnukov, S. Kleshchenko, T. Kukovskaya. OM GOR NNPM NAN, 34 (1999).
10. D. Dimitrov. Publ. House "Ongal", Varna, 184 (2010) (in Bulgarian).

ИЗПОЛЗВАНЕ НА ЧЕРНОМОРСКИ УТАЙКИ ЗА УВЕЛИЧАВАНЕ ДОБИВА НА ФАСУЛ ЗА ЗЪРНО, СОРТ „СМИЛЯН", КУЛТИВИРАН ВЪРХУ КАНЕЛЕНА ПСЕВДОПОДЗОЛИСТА ПОЧВА (Planosol)

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Постъпила на 15 юни, 2014 г.; приета на 25 декември, 2014 г.

(Резюме)

В периода 2012-2013 г. е изследван ефектът от прилагането на дълбоководни черноморски утайки (сапропели) за рекултивация на кисела канелена псевдоподзолиста почва (Planosol), използвана за отглеждане на фасул за зърно, сорт Смилянски. Получените резултати показват, че в количество 20 g/kg, сапропелите (вариант 1) неутрализират киселинността на канелената псевдоподзолиста почва (Planosol) от 4.53 до pH 6.87 след инкубационен период от един месец и до pH 7.05, 7.12 и 7.27 съответно след 2, 3 и 4 месеца инкубация. Сапропелите увеличават съдържанието на хумус в използваната почва от 6.7 g/kg до 11.2 g/kg и съдържанието на $CaCO_3$ от 0.22 g/kg до 1.46 g/kg. При Вариант 1 добивът на зърно е с 33.2 % по-висок, в сравнение с контролата . Съдържанието на суров протеин се увеличава с 12.8%, а съдържанието на фосфор в зърното - с 1.1% повече, в сравнение с контролата.