

Reducing the rate of nitrogen fertilization for growing of early tomatoes, cv. “Dar”, using modified fertilizing granules

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Growing early tomatoes, cv. “Dar” on alluvial meadow soil (Calcaric Fluvisol) in non-heated greenhouses in the period 2008 – 2009, the nitrogen fertilization was optimized, thank to introduction of modified granules, containing ammonium nitrate, deep water Black Sea sediments (sapropels) and water swelling polymer. In variant I, using granules coated with a polymeric layer of partially acetylated (20 %) polyvinyl alcohol (PVA-M), the early yield increased with 12.4 %, and the total standard yield increased with 11.9 % in comparison to control. Due to reduced fertilization rate and once introduced modified granules, was realized economy of 12.5 % ammonium fertilizer. Ecological effect is expected, due to decreased pollution of groundwater and tomato fruits with nitrates.

Keywords: Black Sea sediments, yield, modified granules, polymeric membrane, modified polyvinyl alcohol.

Abbreviations: SAS – surface active substances (surfactants)

PVA - polyvinyl alcohol,

PVA-M - modified PVA/ ,

M_m – median molecular mass

INTRODUCTION

The traditional methods of nitrogen nutrition in many cases lead to number of unfavourable on the environment phenomena. According to Koteva [1] the long standing mineral fertilizing leads to increasing of soil acidity, destruction of soil structure and lower humus content, especially by using of ammonium nitrate. A part of ammonium nitrogen can not be assimilated, due to evaporation by decomposition of salt in the soil. According to European Environment Agency the presence of nitrates is a common problem for many European regions. In many cities groundwater are contaminated with nitrates. In regions with intensive agricultural activities, nitrate content is higher than the allowable 50 mg/l [2]. According to Revich [3] the intensive feeding with nitrogen deteriorates the quality of plant production, related to changes in population health.

In recent decades, the Black Sea sapropels are subject of special research, because of possibility for their application in various aspects of agriculture, related to increase of soil fertility. Their origin according Dimitrov et al. [4], have started after an ecological cataclysm.

As a consequence the more from the available flora and fauna perished and formed 1-2 m sediments on the sea bottom. An important motive for studying of sapropels according to Bmins [5]

in agreement with Dimitrov et al., [6] and Shnukov et al [7] is the favorable macro- and micro- componential composition of sapropels. Georgiev [8] has established that they improve the agrotechnical properties of soils and stimulate the growth of plants. According to Cholakov et al [9], tomatoes do not tolerate high nitrogen fertilization rates. Overdosing especially those fertilizers with acidic character as ammonium nitrate, ammonium sulphate, calcium nitrate etc. have a negative environmental impact on soil and plant production. It is recommended feeding to be realized by parts - before planting the seedlings and twice during the vegetation, According to Terziev et al [10] the use of chemical fertilizers with acidic character leads to progressive acidification of soils with poor buffering capacity. Parallel to this is getting worse their structure, leading to reduction in yields and nitrate accumulation in plant production over allowable concentrations.

As SAS many water-soluble and amphiphilic polymers in the form of solutions are widely used in the practice. The limited solubility of some amphiphilic polymers in water make them suitable for certain specific applications, such as adhesives, coatings with membrane properties etc

According to Nikolov et al. [11] the Black sea sapropels represent complex organic-mineral fertilizer and ameliorant for various type of soils. Thank to their buffering ability they can be used to control acidity by soils with pH less 5.5. Using fertilizing agents with acidic reaction the

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introduction of spropels regulate the soil medium, which is favorable, especially by sensitive to acidic reaction crops.

The aim of present work was to reduce the rate of nitrogen fertilization by growing of early tomatoes, cv.Dar, using modified fertilizer granules, containing polymers and Black sea sediments (spropels).

MATERIALS AND METHODS

1. Elemental analysis

The content of some micro- and macro nutrients was determined in sample spropels, taken from a depth 1200 m. K, P, Si, Ti, Al, Ca, Na, as well as some micronutrients as Fe, Mn, Mg, Cr, Mo, Zn, Mn, Cu, Ni and the heavy metal Pb was determined, (calculated in the form of oxides) The content of the main nutrient nutrients N, P, K, Ca and Mg (ppm) in the alluvial meadow soil was determined. The inductively coupled emission spectrometry (Jobni Yvon Emission - JY 38 S. France) was used. The quantitative measures were carried out with apparatus ICP. The humus content of sample pure spropels was determined by the method of Turin (Trendafilov et al., 2007)

2. Determination of pH and EC (mS/cm)

pH values (H₂O) of the tested alluvial meadow soil (Calcaric Fluvisol) was determined using pH meter, model OP-211/1, (ISO 10390). Additionally was determined electrical conductivity (EC) of the tested soil (mS/cm) by EC meter, model SOPs.

3. Preparation of modified granules

For the purpose of the field experiment modified granules tomatoes cv."Dar" with the following composition were prepared:

- 440 g/kg ammonium nitrate in the form of classical granules,
- 300 g/kg Black sea spropels and 1,3 g/kg polymer PVA-M
- 258.7 g/kg kaolin, (IUPAC Standard InChI, with formula Al₂O₇Si₂ and molecular weight 222.13).

The filler and spropels were pre-screened through a sieve of 1.0 mm.

The granulation was carried out by mixing and injection (pressing), by using aqueous solution of PVA-M with concentration 5 g/kg as an adhesive. PVA-M represents partially acetylated PVA with a rate of acetylating 20%. The starting PVA was with $M_m = 73\ 000$. After 24 h drying at room temperature granules obtained were additionally coated with a polymeric layer by immersion in aqueous solution of the same polymer with concentration 20 g/kg. The size of granules was in

borders 9-10 mm (Fig.1). After drying they were used for fertilizing of tomato plants at variant 1.

4. Greenhouse experiment

The two years experiment was carried out in unheated greenhouse. Tomato plants cv."Dar" were planted at the 6th of April in two variants, every of them in four replications as follows:

1. Variant 1 - fertilizing with modified granules containing spropels
2. Control - traditional fertilizing with ammonium nitrate

The total number of tomato plants in the both variants was 80, as every replication contained 10 plants. The four trial replications were separated from both sides with 2 guardian plants, or for the both variants - 16 plants. Planting of tomato seedlings was conducted in two-roll band in scheme 90 +60 x30 cm. The plants were grown by technology for early production. For irrigation was used drop irrigation system.

The soil used was alluvial meadow (Calcaric Fluvisol). Fertilization of the test plot with superphosphate and potassium sulphate was done with the last treatment at doses backing respectively 18 and 12 kg/da active substance.

Tomato plants were formed to one stem in phase "Five wrist". Fertilization at variant 1 was made once during the planting of seedlings by introducing of modified granules. There was applied a reduced fertilization rate - 12 g ammonium nitrate for plant, corresponding to 48 kg/da, calculated for 4 000 plants/da. In the control feeding was performed three times with 15 g total amount ammonium nitrate for plant, conforming to the 60 kg/da, as follows:

1. First feeding - a week after planting of seedlings
2. Second feeding - at the 15th of May in phase flowering.
3. hird feeding - at the 5th of June, by an appearance of the first red tomatoes.

Two weeks after transplanting as a preventive measure against attack of plant pathogens was made treatment at variant 1 and control plants with fungicide preparation "Ridomil Gold". Both variants have grown under the same irrigation regime by using drop irrigation system, with placed nozzle at each tomato plant, including the guardian plants.

5. Statistical analysis.

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

Table.1. Agrochemical analysis of Alluvial meadow soil, (*Calcaric Fluvisol*) , water extract and recommended fertilization rates

pH deep horizon 0-40cm	EC mS/cm	Nutrient elements, ppm					Recommended fertilizers, kg/da		
		N	P	K	Ca	Mg	NH ₄ NO ₃	Ca(H ₂ PO ₄) ₂ .H ₂ O triple superphosphate	K ₂ SO ₄

Table 2. Chemical composition of sapropels. Content of N, P and micronutrients

№	Chemical composition of sample Black sea sapropels								
1	Cr ₂ O ₃ g/t	MoO ₃ g/t	ZnO g/t	MnO g/t	PbO ₂ g/t	CuO g/t	NiO g/t	P g/kg	N g/kg
2	50.0	36.4	65.8	383.4	28.2	36.6	49.8	9.6	25.4

Table 3. Chemical composition of sapropels. Content of humus, micro- and macronutrients

№	Chemical composition of sample Black sea sapropels, g/kg									Humus /g/kg/
1	SiO ₂	TiO ₂	Al ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	
2	397.6	7.0	117	45.6	0.40	26.8	154.6	21.3	18.3	68.6

RESULTS AND DISCUSSIONS

The data for the agrochemical analysis of water extract of Alluvial meadow soil used show that pH value - 6.72 (neutral medium) is favorable for growing of tomatoes. The insignificant content of mobile forms of N (15 ppm), P (4.1 ppm) and K (32 ppm) requires the soil used to be enriched additionally with ammonium nitrate, triple superphosphate and potassium sulphate (Table 1).

The data analysis for macro- and micronutrients (Tables 2, 3) showed that some of contents in the sapropels composition are more, than in soils and substrates used for seedlings production of vegetable crops. The content of macro- and micronutrients was established, calculated as oxides. The data show that for some important for the crops vegetation micronutrients, such as Cr, Mo, Fe, Mn, their content in sapropelles exceeds many times the same in soils. The presence of CaO is 154,6 g/kg, which is over the limits in comparison to most soil types. The content of K₂O - 1,83 g/kg, MgO – 26,8 g/kg and some other nutrients determine the deep water marine sapropels as a natural micro- and macro fertilizer. The lost by heating at 1273 K, (table 2) is 199,7 g/kg, because of organic matter and carbonates. Humus content according to Koteva et al (1983) is an important factor for the soil fertility because it improves the nitrogen assimilation from the plants. Sample used sapropels contains 68,6 g/kg humus. The content of heavy metals Zn, Ni, Pb is in admissible borders (Table 2).

Fig.1 represents modified granules, containing NH₄NO₃, kaolin, sapropels and PVA-M as adhesive and film-forming substance on the granule surface. The result obtained showed that the use of granules coated with polymer membrane has a



Fig.1. Modified nitrogen fertilizer granules with PVA-M membrane

significant impact on economic productivity of tomato plants. This effect was better pronounced in the early yield of tomato fruit (Table 4). The increase compared to control was 24.4% as reported differences has good statistical reliability. Data from Table 4 show significant change in the proportion of early yield compared to the total standard yield. Quantity obtained in the first three harvest standard production was 40.5% of the total amount harvested to the end of the harvest period. Reliable method to include scheduled nitrogen fertilizer in granules coated with PVA-M significantly increase the total amount of the resulting standard yield – with 12.0% compared to control, although the application rate of fertilizer was reduced to 48 kg/da NH₄NO₃, compared to control - 60 kg/da. The results obtained for the early and total standard yields were well warranted. 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 indices of legumes, which are sensitive to acidic soil reaction.

Table.4. Early and Total Yield of Standard Tomato Fruits, cv."Dar"

Variants	Early yield of standard fruits 2008-2009				Total yield of standard fruits 2008-2009			
	kg /da	% to control	+D	rate	kg /da	% to control	+D	rate
	1.Control	2704	100.0	0	4	7417	100.0	0
2,Variant 1	3365	124.4	+661	1	8308	112.0	+891	1
GD 5%	108.1				404.1			
GD 1%	156.5				584.3			
GD 0.1 %	234.8				876.5			

Analysis of results and the fact that despite the smaller quantity of fertilizer inputs, were obtained higher yields, give rise to claim that modified granules provide more effective assimilation of ammonium and nitrate nitrogen, which is an important factor for growth in all plant organs, including fruit. Formation of polymer membrane after swelling of the polymer coating, due to soil moisture, results in more even and prolonged releasing and assimilation of nitrogen in the soil nutrient solution. It reduces losses, due to decomposition of ammonium nitrate, associated with separation and departure of ammonia, as well as washing and removal of nitrate nitrogen in groundwater. The main reason for the losses is the dynamics of nitrates in the soil. They are highly mobile and pass faster the plow horizon to groundwater, thereby contaminate them. Second should be reported loss of ammonium nitrogen, due to hydrolysis of ammonium nitrate in the soil solution. Part of the nitrogen in the form of ammonia flies in the atmosphere during the decomposition of the ammonium base, which is perishable. Improved mineral nutrition of plants determines more higher yield of fruits. PVA-M as amphiphilic polymer formes stable polymer membrane, which is a prerequisite for more longer diffusion of nitrogen, associated with its more effective assimilation by plants. Should take into account the presence of marine sapropels. It is reasonable to assume that partly the established biological effect was due to additional introduction of macro-, microelements and organic matter in the soil medium.

CONCLUSIONS

1. Fertilization by modified granulates, containing ammonium nitrate, sapropels and amphiphilic water swelling polymer offers qualified new opportunities to improve nitrogen nutrition in tomato plants, cultivated in greenhouse conditions. The granules covered with

polymeric layer are stable in the soil medium and assure more evenly and prolonged action of nitrogen in soils.

2. The application of modified granules has significant economical effect, manifested in increased early and total standard yield of tomato fruit with 12.4% and 11.9% respectively by reduced nitrogen fertilizer dose with 20%.

3. The tested method of nutrition is recommended to sensitive of nitrates vegetable crops, thanks to regulating entry of nitrogen.

4. Expected is realizing of ecological effect, due to decreased pollution of plant production and groundwater with nitrates under the exposure limit 50 mg/l.

REFERENCES

1. V. Koteva, N. Artinova, *Soil Sci., Agrochem., Ecology*, **28**, 13 (1993) (in Bulgarian).
2. European Environment Agency Europe's Environment. The Third Assesment (Copenhagen: European Environment Agency), 172 (2003).
3. B. A. Revich. *Ecopolis*, Sofia, 44 (2000).
4. P. Dimitrov, V.Velev, *Oceanology*, Sofia, **17**, 92 (1988) (in Bulgarian).
5. T. Bmins, *OM GOR CNPM NAN*, 25 (1994).
6. 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)
7. E. Shnukov, S. Kleshchenko, T. Kukovskaya, *OM GOR NNPM NAN*, 12 (1999).
8. G. Georgiev. *News BAS, Sofia*, № 9825, **II**, 1 (2005). (in Bulgarian).
9. D. Cholakov, V. Petkova, D. Hristova. *Int. Conf. "Agro-Eco"*, Plovdiv Agr. Univ., Collect. Reports, b. 5 (2005).
10. Z. Terziev, H. Kirchev, N. Semkova. *Int. Conf. Timisoara Romania, Univ. Agric. Sci. Veter. Med.*, **I**, 93 (2007).
11. N. Nikolov, N. Artinova, D. Dimitrov, *Plovdiv Agriculture University*, **III**, **5**, 33 (2011) (in Bulgarian).

НАМАЛЯВАНЕТО НА НОРМАТА НА АЗОТНОТО ТОРЕНЕ ПРИ ОТГЛЕЖДАНЕ НА РАННИ ДОМАТИ, СОРТ "ДАР", С ИЗПОЛЗВАНЕ НА МОДИФИЦИРАНИ ТОРОВИ ГРАНУЛИ

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(Резюме)

При отглеждане на ранни домати сорт "Дар" върху алувиално ливадна почва (Calcaric Fluvisol) в неотопляеми оранжерии в периода 2008-2009 е оптимизирано азотното торене, благодарение въвеждането на модифицирани гранули съдържащи амониев нитрат, дълбоководни Черноморски утайки (сапропели) и водонабъбващ полимер. При вариант I, използващ гранули покрити с полимерен слой от частично ацеталиран (20%), поливинил алкохол (PVA-M), ранният стандартен добив се увеличава с 12,4% , а общият стандартен добив с 11.9% в сравнение с контролата. Благодарение на намалената торова норма и еднократно внесени модифицирани гранули се реализира 12.5% икономия на амониев тор. Очаква се реализиране на екологичен ефект, поради намалено замърсяване на подземните води и доматените плодове с нитрати.