Bulgarian Journal of Agricultural Science, 22 (No 6) 2016, 912–920
Agricultural Academy

GROWER AND REPRODUCED BEHAVIOR OF TOMATOES ON SUBSTRATES FOR SOIL RECLAMATION

I. MITOVA[*], M. BANOV[**] and L. NENOVA
Agricultural Academy, Institute of Soil Science, Agrotechnologies and Plant Protection „Nikola Pushkarov", BG-1331 Sofia, Bulgaria

Abstract

MITOVA, I., M. BANOV and L. NENOVA, 2016. Grower and reproduced behavior of tomatoes on substrates for soil reclamation. *Bulg. J. Agric. Sci.*, 22: 912–920

The experiment is based on four reclamation substrates, taken from technically and biologically reclaimed dumps built during the extraction of iron ore (Lokorsko) and coal (Moshino). The purpose of this study was to determine the effects of fertilization and elevated levels of heavy metals on the growth, development and fruiting of tomatoes on the researched substrates and terrains. It was found that the surveyed areas are suitable for agricultural production. The positive effect of the application of N, P and K fertilization on the tested reclamation substrates is convincingly proved by the increment of tomato plants. In the early stages of tomato vegetation, the height and mass of plants fertilized with $(NH_4)_2SO_4$ are greater than those of plants with NH_4NO_3 in all three Samples. As vegetation advances and reaches fruiting phase, plants fertilized with NH_4NO_3 achieve greater vegetative mass than those fertilized with $(NH_4)_2SO_4$. In all three reclamation substrates, plants fertilized with NH_4NO_3 formed more and larger fruits than those fertilized with $(NH_4)_2SO_4$. The total yield of fruit from plants fertilized with ammonium sulfate and ammonium nitrate was highest from the reclamation substrate of organically reclaimed dump built during iron ore extraction, horizon 0–30 cm

Key words: soil destruction, soil reclamation, heavy metals, tomatoes

Introduction

With the development and expansion of industrial production the risk of environmental pollution with industrial waste increases. Lands disturbed by industrial activities are unsuitable for further use. In order to fully return them as part of the country's agricultural land it is mandatory to implement radical methods to restore and improve their physical, physico-chemical, agrochemical and microbiological characteristics. To assess the suitability of reclaimed agricultural lands different vegetation types can be used as test crops depending on the purpose of testing.

The choice of tomatoes as test crop in this research is based on the fact that they are extremely adaptable and tolerant to various abiotic stress factors and do not accumulate toxic substances (Mitova, 2007; Gorbanov, 2010). The argument may be further indicated by the fact that the reclamation substrates used in the experiments are from the lands of towns and villages where this crop is important for the self-sufficiency with fresh vegetable production.

Purpose of the research: Effects of fertilization and elevated levels of heavy metals on the growth, development and fruiting of tomatoes, grown on reclamation substrates of technically and biologically reclaimed land.

Materials and Methods

The research is conducted on four reclamation substrates taken from technically and biologically reclaimed dumps built from iron ore extraction (village Lokorsko) and coal extraction

E-mail: [*]smolyanovci@abv.bg, [**]banovm@abv.bg

(village Moshino) activities. For convenience, the materials used in the experiment will be marked as:

Object 1 – reclamation substrata from biologically reclaimed dump in the Moshino region, horizon 0-30 cm;

Object 2 – reclamation substrata from technically reclaimed dump in the Moshino region;

Object 3 – reclamation substrata from biologically reclaimed dump in the Lokorsko region, horizon 0-30 cm;

Object 4 – reclamation substrata from technically reclaimed dump in the Lokorsko region;.

Table 1 presents the values of the agro-chemical indices, characterizing the soil substrates included in the research. The soil acid-base reaction in Object 1, 2, and 3 is slightly acidic – pH_{KCl} changes from 6.8 to – 7.0. The content of humus in Object 1 is average – 3.99%, while in Objects 2 (0.93%) and 3 (1.14%) it is relatively low. The content of mineral nitrogen in Object 1 is average – 53.9 $mg.kg^{-1}$, while in Objects 2 (28.4 $mg.kg^{-1}$) and 3 (14.5 $mg.kg^{-1}$) it is low. The content of mobile phosphorus in Object 2 is low, while in Objects 1 and 3 – medium. Regarding the content of K_2O all three Objects show very good deposits.

According to their mechanical composition the investigated substrates are from heavy sandy-clay to lightly clay (Table 2).

The content of trace elements and heavy metals (Table 3) is within the permissible under the provisions of Regulation № 3 for limit values of concentration of harmful substances in soil, with the exception of the high levels of concentration in terms of lead and copper in Object 4 (Nikolov and Zlatareva, 1999; Zlatareva and Nikolov, 1999).

A sample with hybrid tomatos "Nikolina-F1" was planted during the first ten days of April on all four Samples. Containers holding 4 kg of soil were used for the purposes of the research, with each sample containing four repetitions.

Scheme of the samples

Control sample – non-fertilized

Sample background$P_{600}K_{757}$ + $N_{400+400}$ – $(NH_4)_2SO_4$

Sample background$P_{600}K_{757}$ + $N_{400+400}$ – NH_4NO_3

The research scheme includes:

1. Control sample (w/o fertilizers) and samples 2 and 3 with application of mineral fertilizers. The nitrogen in Sample 2 has been applied at levels of 800 mg N/kg soil in the form of $(NH_4)_2SO_4$. The nitrogen fertilization in Sample 3 is at the same levels, but in the form of NH_4NO_3. The phosphorus and potassium fertilization in the research is background and is made by depositing KH_2PO_4 while preparing the soil substrates used for filling the containers at levels of 600 mg R/kg soil and

Table 1
Agrochemical characteristic of substrates for reclamation

Object	pH		NH_4N+NO_3-N	P_2O_5	K_2O	Humus
	H_2O	KCl	$mg.kg^{-1}$	$mg.100g^{-1}$		%
Object 1	7.2	6.8	53.9	7.5	61.4	3.99
Object 2	7.7	7.0	28.4	1.3	57.5	0.93
Object 3	8.1	7.0	14.5	5.6	36.8	1.14
Object 4	8.1	7.5	26.1	11.4	29.1	0.47

Table 2
Mechanical composition of substrates for reclamation

Object	Particle size in mm							
	Sum > 1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	Sum <0.01
Object 1	0.0	9.37	8.76	12.37	10.05	16.29	43.16	69.50
Object 2	0.0	7.94	17.47	7.36	8.71	24.0	34.52	67.23
Object 3	0.0	5.63	10.42	12.84	14.05	6.65	50.41	71.11
Object 4	0.0	27.04	15.53	9.30	3.36	8.32	36.45	48.13

Table 3
Outgoing content of microelements and heavy metals in substrates for reclamation

Object	Cu	Ni	Pb	Zn	Cd	Fe
	$mg.kg^{-1}$					%
Object 1	47.0	38.5	49.0	53.5	0	38700
Object 2	45.5	8.0	97.5	73.0	0	21400
Object 3	49.5	20.0	51.5	84.0	0	37000
Object 4	535.0	34.0	2575.0	312.5	0	88200

757 mg K/kg soil. The nitrogen levels are covered twice – 400 mg N/kg soil during the preparation of soil substrates along with thee phosphorus and potassium fertilization. The other half of the nitrogen is applied one week after planting the plants in pots (Gorbanov, 2010; Mengel and Kirkby, 1982).

Four tomato plants, in phase 1–2 true leaf stage (phase “crossover”) were planted in each container. With Sample 4 (reclamation substrate from technically recultivated dump near Lokorsko), despite repeated replanting of the seedlings in containers, the plants did not survive in any of the versions and the sample was dropped from the research.

The research includes biometrical parameters characterizing the growth and reproductive activities of plants in terms of Samples 1, 2 and 3. During key phases of the tomato development (phase 5–7th leaf, phase 1–2nd inflorescence and fruit ripening) the following statistics are taken into account: plant height (cm), number of plants in a container, number of leaves and leaf and stems weight (g), stem diameter (cm), number and weight of fruits (g).

The results were statistically processed by statistical package Statgraphics (Anova).

Results

Influence of reclamation substrates and fertilization on the development of tomato plants in Phase 5–7th leaf (Table 4)

In early phase 5–7th leaf, the height difference between non-fertilized and fertilized plants is statistically proven with high confidence level ($P \geq 99\%$). The plants from the different sites, fertilized with ammonium sulphate are between 1.81 and 2.36 times higher than the non-fertilized ones. If ammonium – nitrate fertilizer is applied, then these height differences compared to the control sample are between 1.76 and 2.30 times.

Plants fertilized with ammonium sulphate showed more rapid growth than those fertilized with ammonium nitrate, but these differences were not proven statistically. During the phenological observation made in this phase – 15 days after planting, plants from the non-fertilized samples at all three sites were weak, with brittle stems, in Phase 3 – 4th leaf. At site 2 the leaf textures were twisted on the inside around the central nerve. Despite that the height of the plants fertilized with ammonium sulfate were higher than those with ammonium nitrate at all three sites, at sites 1 and 3 plants with ammonium – nitrate nutrition visually look best developed, with equal growth, fresh with normal turgor and typical coloring corresponding to the species and variety.

There are no proven differences between plants fertilized with different nitrogen fertilizers (Table 4). In contrast, the height of the plants from Site 3 are the least-leaved – 6.0 leaves per plant on average.

Table 4
Effect of reclamation substrates and applied fertilization on the biometric indicators of tomatoes, phase 5–7 leaf

Object	Variant	Height of plants – h (cm)	Number of plants	Number of leaves on plant	Weight of plant (g)
Object 1	1. checking	13.90	3.3	4.0	6.05
	2. $(NH_4)_2SO_4$	25.10	3.0	7.33	14.43
	3. NH_4NO_3	24.47	3.0	7.67	10.20
	SPD P≥95 %	5.52	0.6	1.50	2.74
	SPD P≥99 %	8.37	1.0	2.26	4.15
Object 2	1. checking	13.1	4.0	4.67	5.91
	2. $(NH_4)_2SO_4$	29.07	4.0	7.33	22.45
	3. NH_4NO_3	25.63	3.0	7.33	10.33
	SPD P≥95 %	4.81	0.3	2.31	3.14
	SPD ≥99 %	7.29	0.6	3.50	4.26
Object 3	1. checking	13.47	4.3	4.67	6.19
	2. $(NH_4)_2SO_4$	31.80	3.3	7.0	17.68
	3. NH_4NO_3	30.91	4.0	6.33	23.69
	SPD P≥95 %	2.86	1.5	1.49	4.77
	SPD P≥99 %	4.33	2.3	2.26	7.23

As a statistical indicator the plants’ mass gives the most accurate picture of the impact of applied substances. At all three sites, there is a high statistically proven difference in mass between the control and fertilized samples, as well as between the different fertilized samples (Table 4). Masses of plants fertilized with $(NH_4)_2SO_4$ are between 2.39 and 2.86 times higher than those of control plants. The differences between samples fertilized with NH_4NO_3 non- fertilized ones are between 1.68 and 3.83 times in favor of fertilization.

At Sites 1 and 2 plants fertilized with ammonium sulfate formed larger vegetative mass than those fertilized with ammonium nitrate, while at Site 3 the differences are in favor of plants with ammonium nitrate nutrition. The mass of tomato plants fertilized with ammonium sulphate at sites 1 and 2 is 1.42 and 2.17 times greater than that of tomatoes fertilized with ammonium nitrate. The mass of plants fertilized with ammonium nitrate at Site 3 is 1.34 times greater than that of fertilized with ammonium sulphate.

Influence of reclamation substrates and fertilization on the development of tomato plants in Phase 1–2nd inflorescence (Table 5)

In Phase 1–2nd inflorescence, the height differences between non-fertilized and fertilized plants in all three Sites are statistically proven (Table 5). It is also the case, as in the previous phase, that plants fertilized with ammonium sulphate are 1.89 to 2.86 times taller than the non-fertilized ones. For samples with ammonium nitrate the differences in favor of fertilized plants are smaller and range from 1.72 to 2.58 times.

The stem diameter is an important morphological characteristic of plants, taking into account the peculiarities of the growing manifestations of the given species. There are statistically proven differences between non-fertilized and fertilized plants from all sites. There are statistically proven differences between the thickness of stems of fertilized plants in Sites 2 and 3. At Sites 1 and 2, plants fertilized with ammonium sulphate have thicker stems than samples with ammonium nitrate nutrition, while at Site 3 plants from this sample have noticeably thin stems, and the high proportion – plant height/diameter of the stem shows abnormal plant growth.

The average number of leaves for one plant in Phase 1-2nd inflorescence shows the same values at Sites 1 and 3 – 8.89 leaves per plant and similar value – 8.22 per plant at Site 2. In this phase, the highest growth was observed in Site 3 – from 6 leaves per plant in phase 5 – 7th leaf up to 8.89. Statistically proven differences between non fertilized and fertilized plants were recorded only at Sites 1 and 2. The samples at Site 3 demonstrated no differences in the number of leaves per plant.

There are proven differences between the masses of leaves of non fertilized and fertilized plants at all three sites. At Sites 2 and 3 are recorded differences in the leaf mass even between the fertilized samples. Plants fertilized with ammonium sulfate have proven to have higher leaf mass than those fertilized with ammonium nitrate. The same pattern is also observed at Site 1, but it is not statistically proven. The highest average leaf mass is at Site 3 – 16.92 grams per plant. At Site 1, it is 15.63 grams per plant, and at Object 2 – 11.64 grams per plant.

Comparing the different reclamation substrates shows that there is no difference in the leaf mass between the control samples at the different sites. There are proven differences in the leaf mass of plants fertilized with ammonium sulphate (at $P \geq 95\%$, SPD = 7.97) between Sites 2 and 3. The samples fertilized with ammonium nitrate show no evidence of differences between the different sites.

Influence of recultivation substrates and fertilization on plant growth in phase ripening of the tomatoes

In the final phase, the samples with highest average plant height are those from Site 3 – 73.51 cm/plant. At Sites 1 and 2, the average height of the plants is almost identical – 67.11 cm/plant and 67.79 cm/plant. Plants fertilized with ammonium sulphate from the three sites are with 1.35 to 2 times taller stems than the non-fertilized ones. The samples, fertilized with ammonium nitrate show differences compared to the non-fertilized samples of 1.32 to 2.15 in favor of fertilization.

In all three reclamation substrates differences in the height of the plants are proven only between fertilized and non-fertilized plants. The height of the plants fertilized with ammonium sulfate and ammonium nitrate shows no statistically proven differences. In the first and third sites the trend, fertilized with ammonium sulphate plants to be taller than those fertilized with ammonium nitrate, is retained.

Table 5
Effect of reclamation substrates and applied fertilization on the biometric indicators of tomatoes, phase 1st- 2nd raceme

Object	Variant	Height of plants – h (cm)	Diameter of stem – d (cm)	Correlation h/d	Number of leaves on plant	Weight of leaves (g)	Weight of stems (g)
Object 1	1. checking	24.84	0.29	85.66	4.33	2.09	1.55
	2. $(NH_4)_2SO_4$	47.03	0.60	78.38	11.67	24.94	8.44
	3. NH_4NO_3	42.73	0.55	77.69	10.67	19.86	11.41
	SPD P≥95 %	9.22	0.06		2.58	8.43	2.83
	SPD P≥99 %	13.96	0.10		3.91	12.77	4.29
Object 2	1. checking	16.13	0.20	80.65	4.67	0.87	0.73
	2. $(NH_4)_2SO_4$	46.07	0.57	80.82	10.0	18.53	9.13
	3. NH_4NO_3	41.67	0.49	85.04	10.0	15.51	7.33
	SPD P≥95 %	5.71	0.07		2.40	3.00	1.82
	SPD P≥99 %	8.66	0.11		3.64	6.08	2.85
Object 3	1. checking	22.07	0.36	61.31	7.67	3.25	2.53
	2. $(NH_4)_2SO_4$	49.57	0.47	105.47	9.67	28.77	15.53
	3. NH_4NO_3	43.97	0.70	62.81	9.33	18.75	9.04
	SPD P≥95 %	4.06	0.10		3.05	4.89	2.25
	SPD P≥99 %	6.15	0.15		4.62	7.41	3.41

There is evidence of differences in the diameters of the stems between fertilized and non-fertilized plants in all 3 sites, at Site 1 there is also evidence of a difference in the stem thickness between the two types of fertilization.

The obtained values of the ratio height / diameter of the stem (h/d), with the exception of the control sample of Site 3, where the plants are weak and lying, are in the range indicated as optimal for the growth and development of tomato plants (Boteva and Cholakov, 2011).

In the phase of ripening fruits, the plants from Site 3 have the highest average count of leaves per plant – 46.11 pc/plant and at Sites 1 and 2 the numbers are close – 40.43 pc/plant at Site 1 and 41.0 units/plant at Site 2.

Similar to the plant height, the samples fertilized with ammonium sulfate at sites 1 and 3 have formed a greater number of leaves compared to plants fertilized with ammonium nitrate.

The greatest leaf mass have the plants from Site 1 – 88,49 gr/plant, at Site 3 it is 85,95 gr/plant and at Site 2 – the lowest 68.20 gr/plant. Leaf mass of samples fertilized with ammonium sulfate is greater than this of plants fertilized with ammonium nitrate at all three sites.

At the end of the research, in all three tested samples (control, ammonium sulfate and ammonium nitrate) the mass of leaves was lowest at site 2, which was proven with high levels of reliability (with control P ≥ 95%, and in the other two versions P ≥ 99%).

Masses of stems, similarly to leaf masses are highest in Site 1 – 56.71 g/plant, Site 2 had an average weight of plants of 55.09 g/plant and Site 3 – 46.66 g/plant. The aerial vegetative mass of plants fertilized with ammonium sulphate are 9.08 to 19.36 times higher than those of non fertilized plants and those of plants fertilized with ammonium nitrate are from 7.93 to 26.64 times greater compared to the control samples.

The control samples of all three sites have statistically proven differences in the stem masses (at P ≥ 99%, SPD = 3.32). Samples fertilized with ammonium sulfate have demonstrated differences in the stem mass between sites 2 and 3 and 1 and 2 (at P ≥ 99%, SPD = 24.26). Samples fertilized with ammonium nitrate lack proven differences in the stem mass between all three sites.

At Sites 1 and 3 there is a proven difference only between fertilized and non fertilized plants. There is no difference be-

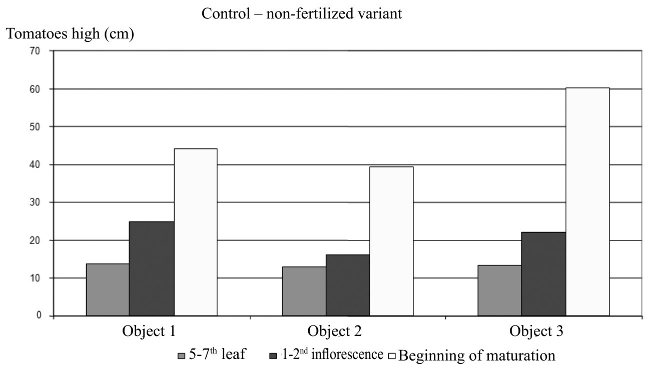

Fig. 1 A. Effect of reclamation substrates on the heights of non-fertilized tomato plants

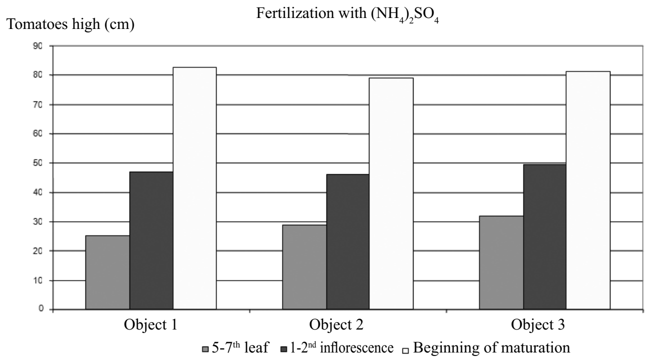

Fig. 1 B. Effect of reclamation substrates and fertilization with $(NH_4)_2SO_4$ on the heights of tomato plants

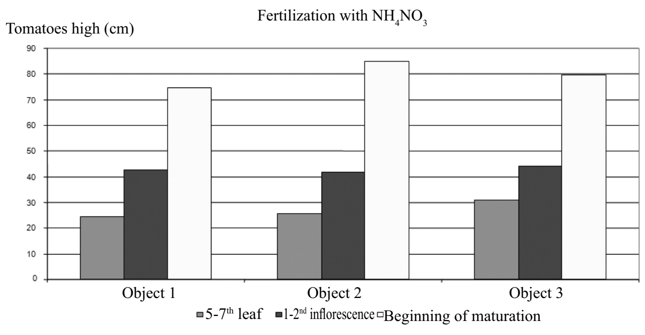

Fig. 1 C. Effect of reclamation substrates and fertilization with NH_4NO_3 on the heights of tomato plants

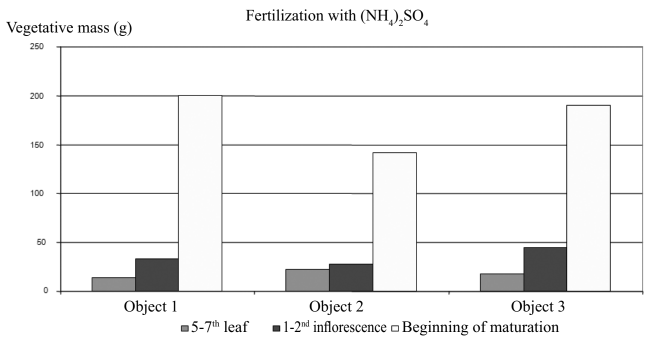

Fig. 1 D. Effect of reclamation substrates and fertilization on the heights of tomato plants

tween plants fertilized with different nitrogen fertilizers. At Site 2, however, there were proven differences between plants fertilized with ammonium sulfate and those fertilized with ammonium nitrate at $P \geq 99\%$.

Effect of reclamation substrates and applied fertilization on plant growth and the dynamics in the accumulation of vegetative mass

Figure 1A presents the dynamics in plant growth in all three data collection phases. It is recorded that the control samples with the highest growth rate at the end of the research are those from Site 3, despite the fact that in the previous phase the plants from Site 2 were taller.

The trends with plants fertilized with ammonium sulfate (Figure 1B) are reversed. Despite the fact that the start for plants from Site 3 was better, at the end of the research Site 1 has the tallest plants. On Site 3 plants fertilized with ammonium nitrate (Figure 1C) are higher than those of Site 1 during all three data collection phases. At Site 2 the height of the plants fertilized with ammonium nitrate was greatest at the end of the research.

Plant tomatoes grown without fertilizers, as well as those fertilized with ammonium sulphate from Site 1 are taller than those grown on Site 2 – geological materials.

The masses of the aerial parts of the plants in the control sample (Figure 2A) at Site 1 have shown the highest readings at the end of the research. The same goes for plants fertilized with ammonium sulfate (Figure 2B). The mass of plants in samples fertilized with ammonium nitrate (Figure 2C) at Site 3 is the greatest at the end of the study. With both the control and fertilized samples, however, plants grown on Site 1 have larger mass than those on Site 2.

During the conducted research samples without fertilization are lacking fruit formation, due to the weak and depressed plant growth in all three sites the fruits were aborted and did not form ovaries. The first ripe fruits were reported in plants fertilized with ammonium nitrate from Site 1. On Site 1 plants fertilized with ammonium sulphate have not formed fruit. The mass of tomato fruits collected on Site 2 averaged 13.07 g/plant, and from Site 3 7.5 g/plant. Plants fertilized with ammonium nitrate formed more and larger fruits at all three soil substrates compared to those fertilized with ammonium sulphate. Among the plants fertilized with ammonium nitrate the highest total fruit

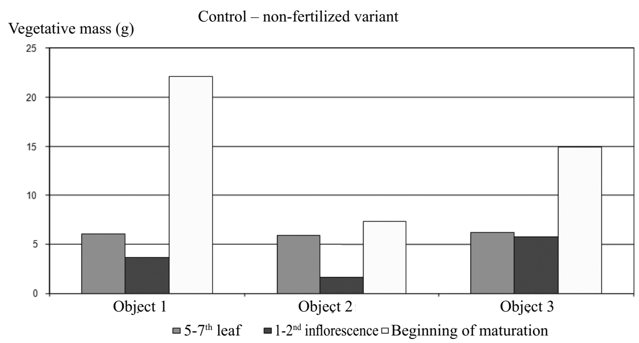

Fig. 2 A. Effect of reclamation substrates on the forming biomass from non-fertilized tomato plants

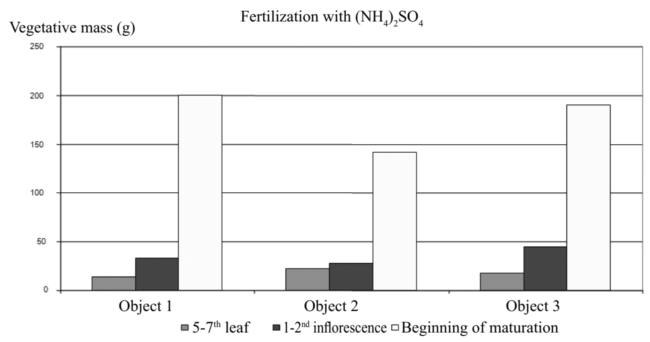

Fig. 2 B. Effect of reclamation substrates and fertilization with $(NH_4)_2SO_4$ on the forming biomass from tomato plants

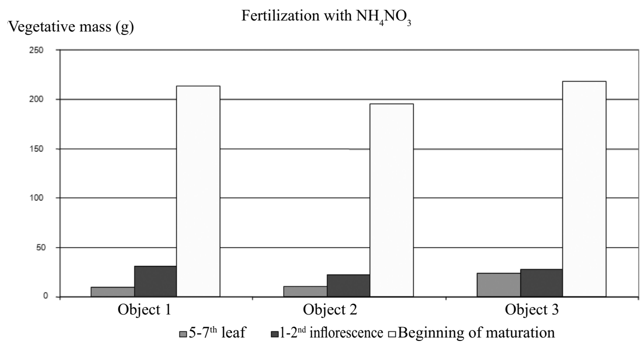

Fig. 2 C. Effect of reclamation substrates and fertilization with NH_4NO_3 on the forming biomass from tomato plants

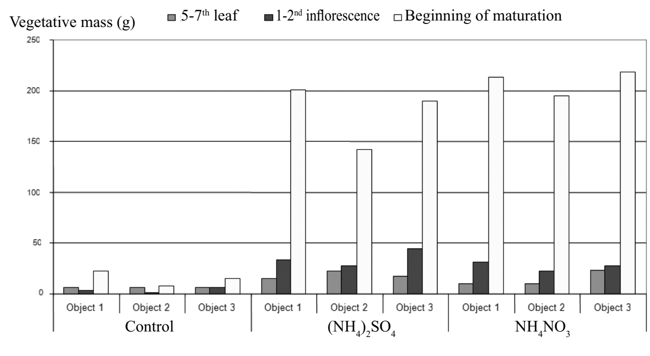

Fig. 2 D. Effect of reclamation substrates and fertilization on the forming biomass from tomato plants

mass is recorded at Site 3 – 66.53 g/plant, 59.63 g/plant from Site 1 and 38.21 g/plant from Site 2.

Discussion

The terrains, from which the recultivation substrates, which are used for carrying out the research, are extracted, are close to populated areas. This determined the choice of the experimental culture, i.e. plant of economic and agricultural importance to farmers in the regions. Traditionally, tomatoes are the most widespread culture in Bulgaria (Mitova, 2007). Many studies have proven the extremely wide adaptability and tolerance of tomatoes to a variety of stress factors (Dinev et al., 2006). Despite the great adaptability to various growing conditions in order to have optimal development, tomatoes requires a certain range of parameters ensuring high yields and quality. The input pH and nutrient content in the soil substrates showed that the soil parameters are unfavorable for normal growth and development of tomatoes. The contents of organic matter, with the exception of Site 1 is low, the contents of P_2O_5 is also low. Plants have low to medium access to mineral nitrogen. Only the potassium levels in all sites are high. It is obvious, as evidenced by the poor development of the plants in the control samples at all three objects that the nutrient contents creates conditions not only for nutritional deficiency, but also for an unbalanced absorption of elements. The choice of N, P, K fertilization rates is consistent with the deposits of these elements in the soil substrates and plants' need them (Boteva and Cholakov, 2010; Gorbanov, 2010; Mitova, 2007).

The soil reaction at all sites is alkaline, having in mind that the optimal medium for tomatoes is slightly acidic – pH out water from 6.0 to 6.5. This determined the choice of nitrogen fertilizers – $(NH_4)_2SO_4$ – physiologically-acidic fertilizers, where nitrogen is in the form of ammonium (NH_4^+). Regarding NH_4NO_3 – physiologically neutral fertilizer, nitrogen is in ammonium and nitrate forms (NH_4 + and NO_3^-). Both nitrate and ammonium nitrogen is absorbed and metabolized in plants (Gorbanov, 2010; Mengel and Kirkby, 1982; Mitova et al., 2005; Mitova, 2007). In neutral medium (sand, water plants) it is considered the tomatoes grow best on a mixed nitrogen source, at a certain ratio between NH_4^+ and NO_3^-, in which the proportion of nitrates reaches 80% (Merkel, 1973). In terms soil conditions, however, the picture is much more complex. In many cases, nitrates are the preferred nitrogen source for crop growth, but it depends on many factors: species and varietal characteristics, the plant carbohydrate regime, pH, soil temperature, light conditions, etc. (Mengel and Kirkby, 1982; Mitova, 2007).

The number and weight of leaves are important indicators, characterizing the overall development of the plants and have a direct impact on the photosynthetic potential and respectively, on the plants productivity. At all sites the fertilized samples have more leaves than the control ones. Statistically proved differences in all three sites are recorded only between the control and fertilized samples (Table 4).

The trend, plants fertilized with ammonium sulphate to be taller than those fertilized with ammonium nitrate, is persistent at all three sites, and in phase 1st-2nd inflorescence. Proven statistical differences between the two fertilized samples are recorded only at Site 3 (at $P \geq 95\%$, SPD = 4.06). Plants from Site 3 appear to be the highest at this stage too, with average height of 38.54 cm. With a height of 38.2 cm the plants from Site 3 are almost equal to those of the samples from Site 3. At Site 2 the average plant height is the lowest – 34.62 cm.

Taking into account the influence of soil substrates on the formation of vegetative mass in this phase, no differences were statistically proven differences (at $P \geq 95\%$, SPD = 1.44) between the control samples at the different sites. In terms of plants fertilized with ammonium sulfate (at $P \geq 95\%$, SPD = 6.45) statistical evidence of a difference in the mass of plants is recorded between Sites 1 and 2. However, among the masses of plants fertilized with ammonium nitrate, the differences between sites 1 and 3 and sites 2 and 3 are proven even at $P \geq 99\%$ (SPD = 6.83).

In the early phase of its development 5th – 7th leaf, when the plants are weak and not well rooted, the acidifying effect of ammonium sulfate had a noticeably better effect on the growth performance compared to the ammonium nitrate (Table 4). As a result of nitrification NH_4^+ from $(NH_4)_2SO_4$ is oxidized to nitrite and then to nitrate. This process is associated with the release of H^+, which in turn leads to acidification of the soil. As a result, the changes in soil reaction create favorable conditions for the development of tomatoes, according to their physiological requirements.

There is a high degree of proved differences ($P \geq 99\%$) between the masses of stems in the different samples from Sites 1, 2 and 3. The average mass of stems shows the same patterns as the leaves. The highest weights of stems – 9.03 grams per plant were measured at Site 3, and the lowest, 5.73 grams per plant – at Site 2. There are no differences in the stem mass between the non fertilized plants from all three sites. Similarly to the leaf masses, the masses of stems fertilized with ammonium sulphate have proven differences between the three sites. On the contrary, plants fertilized with ammonium nitrate showed no evidence of differences in the masses of stems between the different Sites.

It is noteworthy that the reported plants' mass of the control samples in phase 1–2nd inflorescence at the 3 sites are lower than this of plants in stage 5–7th leaf (Table 5). The reason for this is the serious attack on the samples by mildew, regardless of the plant-protection measures taken during the whole experiment,

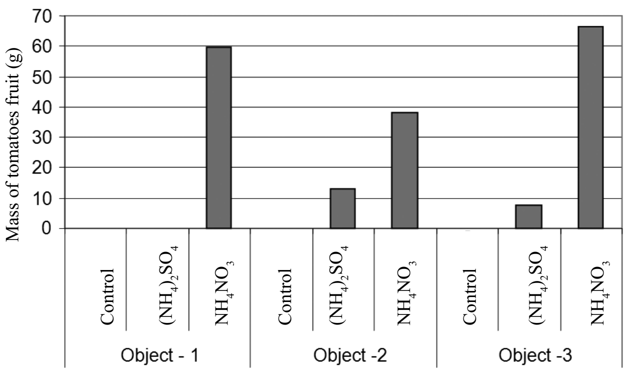

Fig. 3. Effect of reclamation substrates and fertilization on the weight of tomato harvest

plants from these samples were stressed and affected the accumulated mass. Plants fertilized with ammonium sulfate, compared to the control samples, showed differences in the range of 7.66 and 17.29 times greater, while the samples fertilized with ammonium nitrate – in the range of 4.81 and 14.28 times in favor of fertilized plants.

The reported highest weight of harvested fruit at Site 3 for samples fertilized with ammonium nitrate corresponds to the received highest aerial vegetative mass in this research (Figure 3). The vegetative mass (213.0 g/plant) and fruit 59.63 g/plant of samples with ammonium nitrate at Site 1 are larger than those at Site 2 – 195.33 g/plant vegetative mass and 38.21 g/plant fruits. In terms of plants fertilized with ammonium nitrate a strong correlation between vegetative mass and fruits – R = 99.9 was established. There are no proven correlations regarding plants fertilized with ammonium sulphate at all sites. The total mass of fruit harvested from plants fertilized with ammonium sulfate and ammonium nitrate was highest at Site 3 – 74.03 g/plant, and again the amount of tomatoes from Site 1 (59.63 g/plant) was higher than that of site 2 (51.28 g/plant).

As vegetation advances and soil and air temperatures increases, the absorption of nitrogen from the nitrate form is enhanced (Table 6). So far, nitrogen in ammonium form is used for plants fertilized with ammonium nitrate. As medium acidification increases, the absorption of nitrogen from NO3$^-$ also increases. It is known (Mengel and Kirkby, 1982) that the reduction NO_3^- to NH_3 requires energy, which is saved through the introduction of NH_4^+. Thus the presence of NH_4^+ acts in synergy and stimulates the absorption and reduction of nitrate by tomato plants (Table 6).

Compared to many agricultural crops, tomatoes are less sensitive to soil contamination with heavy metals and trace elements (Dinev et al., 2006). During the conducted research, no evidence was found of visual symptoms of depression on the plants as a result of the high, albeit within regulated levels, contents of heavy metals in the recultivation substrates.

The disturbances in the development and formation of vegetative masses in non-fertilized plants from all three sites for Phase 1st – 2nd inflorescence is due to the serious attack on

Table 6

Effect of reclamation substrates and applied fertilization on the biometric indicators of tomatoes, phase beginning of ripening

Object	Variant	Height of plants – h (cm)	Diameter of stem – d (cm)	Correlation h/d	Number of leaves on plant	Weight of leaves (g)	Weight of stems (g)
Object 1	1. checking	44.17	0.57	77.49	10.0	6.62	15.47
	2. $(NH_4)_2SO_4$	82.70	1.05	78.76	61.0	115.73	84.78
	3. NH_4NO_3	74.47	0.88	84.63	50.3	143.11	69.89
	SPD P≥95 %	15.80	0.16		10.530	19.451	16.594
	SPD P≥99 %	23.94	0.24		15.954	29.472	25.142
Object 2	1. checking	39.43	0.43	91.70	9.0	3.25	4.08
	2. $(NH_4)_2SO_4$	79.03	0.85	92.98	46.0	88.20	53.72
	3. NH_4NO_3	84.90	0.87	97.59	68.0	113.14	82.19
	SPD P≥95 %	15.00	0.21		15.303	16.219	8.036
	SPD P≥99 %	22.73	0.32		23.186	24.575	12.176
Object 3	1. checking	60.03	0.53	113.26	10.33	5.0	9.93
	2. $(NH_4)_2SO_4$	81.0	0.98	82.65	64.67	113.0	76.64
	3. NH_4NO_3	79.51	0.89	89.33	63.33	139.85	78.71
	SPD P≥95 %	14.78	0.20		10.572	17.404	7.243
	SPD P≥99 %	22.40	0.30		16.018	26.369	10.975

the samples by mildew. Due to its general underdevelopment, regardless of the plant-protection measures taken during the whole experiment, plants from the control samples recovered more slowly and incompletely.

Conclusions

The sites included in the research: Site 1 – reclamation substrata of organically recultivated dump near Moshino, horizon 0–30 cm; Site 2 – reclamation substrata from technically recultivated dump near Moshino and Site 3 – reclamation substrata of organically recultivated dump area of Lokorsko, horizon 0-30 cm, are suitable for agricultural production. The positive effect of the applied N, P and K fertilization on the tested reclamation substrates was conclusively proven by the growth of tomato plants. The heights of the plants fertilized with $(NH_4)_2SO_4$, from all three sites, during the various phases of vegetation are from 1.35 to 2.86 times greater than those of non fertilized plants. For samples with NH_4NO_3 this range is between 1.32 and 2.58 in favor of fertilized plants.

With Sample 4 (reclamation substrate from technically recultivated dump near Lokorsko), despite repeated replanting of the seedlings in containers, the plants did not survive in any of the versions. Possible reason for this is the high concentrations of lead and copper in the source substrate.

The aerial vegetative mass of plants from all three sites in samples fertilized with $(NH_4)_2SO_4$ during different phases of vegetation are 2.39 to 19.36 times greater than that of not fertilized plants. For samples with NH_4NO_3 this range is between 1.68 and 26.64 in favor of fertilized plants.

In the early stages of tomato vegetation the heights and masses of plants fertilized with $(NH_4)_2SO_4$ are larger than those of plants with NH_4NO_3 in all three sites. As advance of vegetation advances and fruiting starts to occur, plants with ammonium nitrate fertilization accumulate greater vegetative mass than those fertilized with $(NH_4)_2SO_4$.

Both non fertilized plants and those fertilized with $(NH_4)_2SO_4$ plants grown on recultivated substrates of biologically recultivated dump near Moshino at the end of the study have greater heights and weights than those of plants grown on the recultivated substrates obtained from technically recultivated dump from the same place.

Plants grown on all three recultivated substrates, fertilized with NH_4NO_3 formed more and larger fruits than those fertilized with $(NH_4)_2SO_4$. Among the plants with ammonium nitrate fertilizer the highest total mass have the fruits from Site 3 – 66.53 g/plant, 59.63 g/plant from Site 1 and 38.21 g/plant from Site 2.

Aggregate fruit harvest from plants fertilized with ammonium sulphate and ammonium nitrate is highest at Site 3 – 74.03 g/plant, and yet again more tomatoes were harvested from Site 1 (59.63 g/plant) that from Site 2 (51.28 g/plant).

It is necessary to conduct an experiment in field conditions to be specified fertilizer norms and agrotechnics of growing tomatoes.

We recommend to check the possibility of growing other crops on the reclamation substrate from technically recultivated dump near Lokorsko – Site 4.

References

Boteva, Hr. and T. Cholakov. 2010. Study on Influence of Biofertilizers for Growing of Tomato in Field Conditions. *Journal of International Scienctific Publications; Ecology&Safety*, **4**: pp. 153-161

Boteva, Hr. and T. Cholakov, 2011. Effectiveness of biofertilizers on vegetative and productive manifestations of Midearly Tomato. Scientific reports from the International Scientific Conference „100 years Soil Science in Bulgaria“, 16-20 May, Sofia, I part, pp. 461-465

Dinev, N., Iv. Mitova and V. Netcheva. 2006. Bio- indication of cadmium phytotoxicity on tomato plants depending on soil acidity. *Plant Science*, **43**: 377-382.

Gorbanov, S., 2010. Fertilization of Agricultural Plant. Sofia, 549 pp.

Mengel, K. and E. A. Kirkby, 1982. Principles of Plant Nutrition. *International Potash Institute Bern*, Switzerland, pp. 168-184.

Merkel, O., 1973. The influence of the NO_3: NH_4 ratio in the nutrient solution on yield and organic and inorganic contents in tomato. *Zeitsch Pfl. Ermahr u Bdakde*, 3: 236- 246.

Ministry of Environment and Water, **Ministry of Health, Ministry of Agriculture and Food**, 2008. **Regulation № 3**. regarding the maximum allowed values for harmful substances in soil.

Mitova I., 2007a. Dinamic of blooming and formation of Knos in tomatoes grown over Luvic Chernozem dnd in dependance of the form of nitrogen source. *Soil Science Agrochemistry and Ecology*, XLI (1): 44- 51.

Mitova, I., 2007b. Tomatoes – Breeding, Diseases and Enemies, Preservation. Sofia, pp. 110.

Mitova, I., K. Simeonov and V. Todorova, 2005. Dinamic of blooming and formation of knots in tomatoes grown over haplic luvisol and in dependence of the form of nitrogen source. *Ecologia and Industria*, 7: 209- 212.

Nikolov, N. and E. Zlatareva, 1999. Maximum acceptable concentration of Cd, Ni, Cr and Hg in agricultural soils depending on pH of the Soil. IVth International Meeting Red Mediterranean soils, Plovdiv, Bulgaria. *Bulgarian Journal of Agricultural Science*, 5: 166-170.

Zlatareva, E. and N. Nikolov, 1999. A Comparative study of methods for availability of Pb, Zn and Cd in polluted calcareous soils, IVth International Meeting Red Mediterranean Soils, Plovdiv, Bulgaria. *Bulgarian Journal of Agricultural Science*, 5: 171-177.

Received June, 5, 2016; accepted for printing November, 1, 2016