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AGROBIOLOGICAL ASSESSMENT OF APPLICATION OPPORTUNITIES OF NATURAL HUMATES AND PYROLYSIS RESIDUE IN THE PRODUCTION OF APPLE ROOTSTOCKS

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Abstract

Two products are applied as supplements in soil - natural humates and pyrolisis residue - during shoot production of apple rootstock MM106 in stool bed.
Chemical analysis of the experimental supplements shows high levels of organic substances, as well as a supply of macro and micro elements.
Some growth manifestations of shoots are analysed. There are several combinations of shoots: covered by soil with supplements in different doses and without supplements. The improved values of some of the monitored growth indicators are observed in the combinations with soil with supplements, especially the ones with a higher supplement dose. Among the monitored growth indicators, improved plant development is achieved in respect to length, thickness, feathering and rooting which aligns with the standard norms.

Key words*: apple rootstocks, natural humates, pyrolysis residue.*

INTRODUCTION

Adequate supply of nutritional substances, water and air in soil are important determinants for achieving high productivity of root shoots in stool bed plants participating in the development of apple clonal rootstocks (Stamatov et al., 1982; Stojanowska, 1987; Licznar and Licznar, 2004).
There are different methods for improving the performance of productivity determinants. Dobrevska et al., (2015a), Dobrevska et al., (2015b), Popova et al. (2014) experiment with organic supplements in stool bed and find positive results regarding soil substrate and rootstock quality.
Popova et al. (2016) and Dobrevska et al. (unpublished) apply moisture absorbent in the soil covering layer of apple stool bed and report improved values regarding growth and soil indicators in respect to the combinations containing moisture absorbent in different doses. They also show an improved ecological assessment of future soil and conduct an economic evaluation of results when the supplement is applied.
In the context of intensive fruit growing, the effective production process is based on the use of high-quality seedlings. In this respect, it is not only necessary to supply air and water in soil, but also deliver sufficient organic substances due to their important role in the process of apple rootstock production in stool bed. Nowadays, there are various alternative methods to improve organic substance supply in soil which slowly and surely become popular in different fields of agriculture. One of them is the application of natural humates containing some moisture-absorbing crystals and pressed organic substances, the use of which dramatically reduces the demand for water and fertilizers (http://www.terawet.com). Another alternative approach is pyrolisis residue which is derived from the use of biogenic fuels for greenhouse heating. Pyrolisis residue has not been studied before in the field of fruit growing and it deserves research attention (Brezin et al., 2013).
The latter explains the main goal of the study. It accomplishment requires an evaluation of the influence of natural humates and pyrolisis residue as a supplement in the covering soil layer in a stool bed of the MM106 rootstock.
To what extent, the application of natural humates and pyrolisis residue are likely to alter soil conditions and lead to the production of

high-quality shoots from the apple rootstock MM106 - this is the main goal of the current study.

MATERIALS AND METHODS

The stool bed plant is developed from root shoots of the MM106 rootstock.

The experiment is conducted with four replicates for each combination by following the block method of Fisher (Zapryanov and Marinkov, 1978).

Plants are cultivated according to conventional stool bed technology (Trachev et al., 1975). The method includes plant protection measures and multiple soil treatments. The latter are performed with specialized equipment for shallow treatments and soil covering in orchards (Todorov, 1966; Todorov et al., 1974; Trachev et al., 1975). The inter-row strips are managed with the black fallow system. Having said this, there were several shallow inter-row soil treatments leading to improved nutrition supply, water and air regime, as well as, destruction of weeds. There was also a deep inter-row autumn soil ploughing at a depth of 18-20 cm. During the vegetation period, three additional soil covering procedures were performed on the basis of the experimental plants; thereby, contributing to their better rooting.

The supplement of humate tablets (HT) and pyrolisis residue (PR) are delivered to soil at the end of the winter dormancy period. Three combinations were created during the HT experiment: 1st combination - no natural humates; 2nd combination - natural humates equal to 25 kg/dka and 3rd combination - natural humates equal to 50 kg/dka. Three combinations were created during the PR experiment: 1st combination - no pyrolisis residue; 2nd combination - pyrolisis residue equal to 250 kg/dka and 3rd combination - pyrolisis residue equal to 500 kg/dka.

Chemical analysis of the applied supplements – HT and PR - was applied. Findings indicated:

1. Organic substance, % - BSS ISO 14235:2002;
2. Total N, mg/kg - BSS EN 13654-1:2004;
3. Total P, mg/kg - BSS EN 13650:2003;
4. Total K, mg/kg - BSS EN 13650:2003.

Chemical analysis of soil was conducted, as well. The accessed results were recorded at the end of the initial vegetation phase, as well as in the beginning of plants winter dormancy.

Two indicators were monitored, as follows:

1. pH - potentiometric in water solution;
2. Organic substance, % - according to Turin's method

After the end of the vegetation period, the following growth indicators were analyzed in respect to the experimental shoots:

1. Average number of shoots per plant;
2. Average length of shoot, cm;
3. Average thickness of shoot, mm;
4. Average number of feathers per shoot, units;
5. Average length of feathers, cm;
6. Average number of roots per shoot, units;
7. Leaf area, cm^2.

The data from the monitored indicators are statistically processed by following the analysis of variance (ANOVA) method.

RESULTS AND DISCUSSIONS

Chemical analysis shows improved levels of organic substances in both products (Table 1). In the case of humate tablets, organic substances account for 64.54%, whereas their share reaches 78.43% when pyrolisis residue is taken into consideration. The organic substance in both products has a different origin (Filcheva, 2007; Yaneva et al., 2013). In humate tablets, it is plant-based. Hence, humic acids account for 39.03%. They quickly bind with Mg and Ca in soil and develop humates which are easily absorbed by plants. The organic substance in pyrolisis residue contains fulvic acids which are a product of wood. They are very mobile and can be easily washed away from soil (Yaneva et al., 2013). Perhaps, that fact positively influenced the improved performance of experimental plants during the initial year of observations in the combination with humate tablets, despite the larger content of organic substance in pyrolisis residue (Tables 4 and 5).

The chemical analyses of humate tablets showed content of Ca, Mf, Fe and Mn. Respectively, they achieved values of 1.13%, 0.22%, 0.90% and 0.026%. N, P and K are present in both products, as well.

Table 1. Chemical analysis of applied supplements

Name of the characteristic	Humate tablets	Pyrolysis residue
Organic substance, %	64.54	78.43
Total N, mg/kg	2.61	0.29
Total P, mg/kg	0.06	0.16
Total K, mg/kg	2.51	0.25

The conducted analysis of soil with added humate tablets in the covering layer into doses of 25 kg/dka and 50 kg/dka, the organic substance, which enters soil, is 16.135 kg/dka and 32.270 kg/dka, respectively. In the combination with pyrolisis residue into doses of 250 kg/dka and 500 kg/dka, the organic substance is 196.075 kg/dka and 39.150 kg/dka, respectively.

Soil analysis results are presented in Tables 2 and 3. Assessments are performed at the end of the initial vegetation phase and at the beginning of winter dormancy.

The measured pH level in the covering layer in respect to the different combinations determines soil reaction as neutral or slightly alkaline (7.0-7.7).

Table 2. Soil physicochemical properties during initial growth

Samples	pH (H_2O)	Organic substance, %
Soil with humate tablets - 50 kg/dka	7.7	3.79
Soil with humate tablets - 25 kg/dka	7.1	3.03
Soil free of supplements	7.3	2.44
Soil with pyrolisis residue - 500 kg/dka	7.5	3.90
Soil with pyrolisis residue - 250 kg/dka	7.0	3.42
Soil free of supplements	7.2	2.39

Table 3. Physicochemical properties of soil during initial winter dormancy

Samples	pH (H_2O)	Organic substance, %
Soil with humate tablets - 50 kg/dka	7.6	2.49
Soil with humate tablets - 25 kg/dka	7.0	2.11
Soil free of supplements	7.0	1.87
Soil with pyrolisis residue - 500 kg/dka	7.2	2.93
Soil with pyrolisis residue - 250 kg/dka	7.0	2.79
Soil free of supplements	7.1	1.75

In relation to organic substance, the first measurement of organic substance in soils with humate tablets into a dose of 50 kg/dka is 1.3% higher in comparison to the value from the second measurement. The introduction of 32.270 kg/dka (3.79%) of organic matter and a measured residue of 21.201 kg/dka (2.49%) leads to a difference of organic matter equal to 11.069 kg/dka (1.3%). In the case with a dose of 25 kg/dka, the measured organic content is 0.92% higher than the second measurement. With other words, the introduction of organic content equal to 16.135 kg/dka (3.03%) and measured residual of 11.236 kg/dka (2.11%) leads to a difference of 4.899 kg/dka. There is a difference in soil without supplements - 0.57% better values during the first measurement (Tables 2 and 3). Similar tendency, although weaker, is noted during the second experiment with pyrolisis residue supplement. The differences in this case are the following: with a dose of 500 kg/dka - 0.97% better values during the first measurement. Or, when introducing 390 kg/dka of organic matter and measured residual of 293 kg/dka (2.93%), the difference of organic substance is 97 kg/dka (0.97%). Under the scenario with a dose of 250 kg/dka, there are 0.63% more organic substances during the first measurement. The introduction of 195 kg/dka (3.42%) and measured residual of measured residual of 35.921 kg/dka (0.63%) leads to a difference of organic substance content equal to 159.079 kg/dka (2.79). The difference in soils without supplements is 0.64% in favor of the first measurement.

Among other things, all differences in soil samples are due to the absorbed organic substances by plants during the vegetation period.

The monitoring of the vegetative manifes-tations of experimental plants shows no differences between combinations with respect to the average number of shoots per plant. Findings refer to the first experiment where humate tablets are used into two doses as a supplement in the soil covering layer (Table 4). When the “average length of shoots” indicator is taken into consideration, there is a significant difference between the control and the combination which contains a soil supplement of 50 kg/dka. The supplemented combination has the highest value (Table 4).

Table 4. Growth manifestations of plants cultivated in soil with humate tablets (HT) and with no supplements.

Samples \ Indicators	Number of shoots per plant	Shoot length, cm	Average thickness of shoots, mm	Number of feathers per shoot	Feather length, cm	Average number of roots per shoot	Leaf area, cm^2
Soil with humate tablets - 50 kg/dka	17,33	95,38	8,64	5,69	12,90	43,99	17,42
Soil with humate tablets - 25 kg/dka	17,00	82,69	8,38	5,93	6,49	42,33	17,34
Soil without supplements	16,32	69,37	8,09	5,43	4,21	31,18	16,11
GD 5%	2,09	25,98	0,52	0,52	8,67	10,55	1,99
1%	3,31	39,62	1,31	0,75	13,13	15,98	4,04
0,1%	5,26	64,38	2,11	1,28	21,11	25,68	5,11

Table 5. Growth manifestations of plants cultivated in soil with pyrolisis residue supplement and with no supplement.

Samples \ Indicators	Number of shoots per plant	Shoot length, cm	Average thickness of shoots, mm	Number of feathers per shoot	Feather length, cm	Average number of roots per shoot	Leaf area, cm^2
Soil with pyrolisis residue –500 kg/dka	17,88	85,49	8,40	4,98	7,92	37,29	16,12
Soil with pyrolisis residue –250 kg/dka	16,88	83,19	8,11	4,59	8,75	37,90	16,44
Soil without supplements	16,00	79,35	8,05	4,45	4,83	34,52	16,01
GD 5%	3,23	22,28	0,32	0,55	12,86	12,49	2,29
1%	4,71	31,22	1,29	0,73	19,48	18,93	4,64
0,1%	6,26	60,38	2,01	1,17	31,31	30,43	5,91

All plants were categorized as first-class quality because the measured thickness covered the required standards (Table 4). Statistically significant differences are shown between the combinations with a higher dose of humate tablets and those with no supplements.

Rootstock feathering at a specific height has a positive effect on their overall development. All shoots have branches without statistically significant differences. In respect to length, however, the combination with the highest content of humate tablets in soil is shown to have the longest branches. Respectively, the shortest branches are found in the combination without supplements (Table 4).

Good rooting is a major quality indicator of shoots. It is shown that the highest number of roots per shoots is observed in the combination with the highest content of humate tablets. Respectively, the lowest number of roots per shoot is found in the combination without supplements (Table 4).

The good development of leaf mass, including crown area, is an important indicator for the quality of rootstock photosynthesis process. There are no statistically significant differences in the leaf area of the different combinations (Table 4).

During the second experiment of using pyrolysis residue into two doses as a supplement in soil covering layer, there are no statistically significant differences among the combinations in relation to the indicators of average number of shoots per plant and average shoot length. Nevertheless, the thickest root shoots are shown in the combination with the highest supplement quantity, whereas the thinnest ones take place in the combination without supplements (Table 5).

All shoots have similar feathering without proved differences in respect to number and length of feathers (Table 5).

Identical results are found in respect to the indicators of “average number of roots” and “leaf area”, as well.

CONCLUSIONS

The study of soil content and development of apple clonal rootstocks in stool bed with different content of humate tablets and pyrolysis residue supplements suggests:

1. High levels of organic substances, macro and micro elements during the conducted chemical analysis of experimental supplements;
2. Improved values of some of the monitored growth indicators in soil combinations containing supplements, especially those with an increased amount of supplements. Among the monitored growth indicators, improved plant development is achieved in respect to length, thickness, feathering and rooting which aligns with the standard norms.

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