SOIL ANALYSIS AND INTERPRETATION FOR ESTABLISHING TOMATO CROP

POPESCU C.V.[1], MARIA DINU[2*]

[1]University of Craiova, Faculty of Agriculture, The Department of Agricultural and Forestry Technology, 19 Libertăţii Street no 19, 200583, Craiova, Romania;

[2]University of Craiova, The Faculty Horticulture, The Department of Horticulture and Food Science, 13 A.I. Cuza Street,200858, Craiova, Romania:

Coressponding author: dinumariana@hotmail.com

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ABSTRACT

Tomatoes (Solanum lycopersicum L.), are one of the most consumed species in the world. Their fruits have a high vitamin, mineral salts and oligoelements content, as a good human health support. Can be consumed as fresh products or processed as juice, sauce or ketchup. Due to these properties, the way their harvests are obtained have to be managed properly. The study aimed to emphasize the importance of the soil analysis in order to establish an open field tomato crop. Thee trial was established in 2018 in Hanu Conachi, Galați department (45°35'8"N 27°36'12"E). There are presented observations and measurements on the soil content of the available macro- and micronutrients compared to the total nutrient content, for the establishment of the tomato crop. It can be observed that, for weak alkaline soils, the total phosphorous content versus the available phosphorous is 25 - 30 times higher, due to the blockages with the soil cations. The analysis of the soil's texture showed variations within the same plot designated for the establishment of the tomato crop.

INTRODUCTION

Tomatoes *(Lycopersicon esculentum* Mill.), are one of the most consumed species worldwide due to the fact that they are the main important phytonutrients' supplier for the human consumption, playing as well, an important role in human health (Willcox et al., 2003). At global scale, the annual fresh tomato production reaches an approximate of 160 million tons (FAO, 2017).

Despite this, about a quarter are industrial tomatoes, thus ranking tomatoes as one of the most important vegetable for industrialization in the world. As for the daily fresh consumption, tomatoes are offering to humans 40% from the daily recommended C vitamin level, 20% from the daily A vitamin level, important quantities of potassium, calcium and small iron, magnesium, thiamine, riboflavin, niacin quantities, at only about 35 calories (Dinu et al., 2017).

Tomatoes are an important species due to their major contribution in carotenoids, phenols, C vitamin, E vitamin delivered to the daily nutrition ratio of the globe's population (Khachik et al., 2002).

Numerous studies have shown that tomatoes and their sub products can determine a protective effect on various forms of prostate cancer and cardiovascular diseases (Maria Dinu et al., 2015).

During ripening and storage important changes in the pigment synthesis occur. Giovanelli et al., (1999) have reported an increase in the ascorbic acid content during ripening, sustaining that the main antioxidants from tomatoes are the carotenoids, the ascorbic acid and the phenolic compounds.

The entire antioxidative activity in tomatoes is varying considerably according to the variety, genetical background, maturity stage and cropping conditions (Leonardi et al. 2000). There is a big variation of the C vitamin content within the tomato varieties (Maria Dinu et al., 2017).

The carotene content is very much influenced by the cropping type (Zoran et al., 2014) and by the fertilizing during the vegetation period. Fertilizer rates to be applied should be based on the annual soil testing results.

Soil analysis is crucial for obtaining a qualitative superior tomato, due to the fact that many of the factors affecting negatively the development and quality of the tomato yields are nonbiological and caused by an improper nutrition.

For optimal growth of the tomato, a balanced fertilisation is required - *balanced fertilization does not mean a balanced fertilizer formula.*

The right fertilizer has to be applied at the right time, according to the growth stages of the tomato plant - vegetative stage, flowering, fruit-set, fruit growth / maturity. Also, the fertilizer schedule has to be adjusted according to these stages.

Nutrients are better applied using a combination of base application and fertigation - fertilizer properties, such as solubility and compatibility have to be considered. The application frequency of the fertilizer within each growing stage of the tomato, depends on the soil's/substrate's properties and their water holding capacity.

The yield's level and quality are realized during the vegetation period and can be maintained or improved by respecting the correct technological steps. This can be realized by a qualitative genotypes' selection and, most important, by a comprehensive set of biochemical analysis on the soil before the crop establishment and during the vegetation period.

For this reason, the study was initiated to fill-in the information deficit by evaluating the available soil nutrients focusing on the phosphorous availability before a tomato crop establishment.

The involvement of phosphorus in the plant's metabolism is essential. Phosphorus acts as a fundamental support in all phenological development stages of the crops, becomes essential in the formation and development of the radicular system especially in the early vegetative stages, being the most important element for plant development and the accumulation of reserve substances.

Phosphorus balances the growth alongside with the nitrogen and potassium, essential for the development of the radicular system and for the stability and quality of the yield.

In addition to its low mobility on the soil's profile, phosphorus that is applied from the conventional fertilisers will be limited once it reaches the soil - the possibility of being more or less absorbed by the plant is depending on the soil's reaction and its compounds - up to 75% becomes insoluble / unavailable. In acid soils, the phosphorus forms insoluble complexes with the iron hydroxide and aluminium (Iron phosphates and AL) and in basic soils, rich in calcareous, it reacts with Calcium turning into Dicalcium phosphate or Tricalcium phosphate (through retrogradation), and in both cases, the phosphorus is no longer available for the crop.

MATERIALS AND METHODS

The studied tomato variety to be established is *San Marzano*, used mainly for industrialization and also for fresh consumption. The location for the crop to be established in 2019 is Hanu Conachi, Galați department

(45°35′8″N 27°36′12″E), through direct seeding.

The establishing scheme: lines of 2 rows (50 cm width between the rows), 100 cm between the lines of rows and 15 cm between the plants / row, resulting in 90.000 plants / ha.

There were collected manually five soil samples according to the standard soil sampling methodologies, covering the designated area – five hectares. Soil analysis was performed using the laboratory methodologies (table 1).

As for the nitrogen analysis, the samples have been analysed for available nitrate (NO_3) and ammonia (NH_3) nitrogen which are quoted in parts per million (ppm). These figures have been used to calculate the level of soil mineral nitrogen in kg/ha in the profile submitted.

Previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications.

RESEARCH RESULTS

The tomato crop has to get an adequate supply of all the essential nutrients - the critical nutritional requirements of the tomato plants according to the growth and development stages are represented by the calcium, boron, magnesium and potassium elements, along with the continuous supply with nitrogen and phosphorous – as mentioned, up to 75% of the phosphorous applied from conventional fertilisers becomes insoluble / unavailable to crops.

Table 1

Laboratory soil analysis methods

pH	Water	pH electrode/meter
Nitrogen	Sulphuric/orthophosphoric acid digestion OR DUMAS METHOD	Kjeldhal distillation CNS analyser
Nitrate	Water or calcium sulphate	Ion specific electrode for nitrate
Phosphorus	OLSEN (sodium hydrogen carbonate)	Solution spectrophotometry after complexing with ammonium molydate
Potassium	1 M Ammonium nitrate	Flame emmission spectrometry or ICP
Calcium	1 M Ammonium nitrate	Atomic Absorption or ICP
Magnesium	1 M Ammonium nitrate	Atomic Absorption or ICP
Manganese	1 M Ammonium acetate with 2 g/l quinol	Atomic Absorption or ICP
Boron	Hot water (80°C)	Solution spectrophotometry after complexing with azomethine or ICP
Copper	0.05 M EDTA disodium salt	Atomic Absorption or ICP
Molybenum	Ammonium acetate (24.9 g/l) + oxalic acid (12.6 g/l)	Atomic Absorption with nitrous oxide or ICP
Iron	0.05 M EDTA disodium salt	Atomic Absorption or ICP
Zinc	0.05 M EDTA disodium salt	Atomic Absorption or ICP
Sulphur	Calcium tetrahydrogen Diorthophosphate	Solution spectrophotometry of precipitated barium sulphate or ICP
Organic Matter	WALKLEY BLACK (oxidation of organic matter with potassium dichromate + sulphuric acid) OR DUMAS METHOD	Spectrophotometry CNS analyser
CEC Cation Exchange capacity	Leached with 1 M ammonium acetate followed by 10% potassium chloride	Ion specific electrode

I.C.P. Inductively Coupled Plasma Analyser
CNS Carbon/nitrogen/sulphur combustion analyser

It is well recognized within most of the crop nutritional programs that the tomato crop requires about 30% of the nitrogen to be applied along with 100% of the required phosphorous and 30-70% of the required potassium at the crop's establishment / preplant stage, mainly using various NPK grade fertilizers.

During the vegetative growth, tomatoes require about 20% of the nitrogen and an equal amount of potassium.

During flowering / fruit set there is an increased demand of nitrogen along with potassium (about 30% of the requirements / consumption for nitrogen and 20% for the potassium).

During the fruit ripening stage and maturity there is a 20% requirement from the total equilibrated between the nitrogen and the potassium.

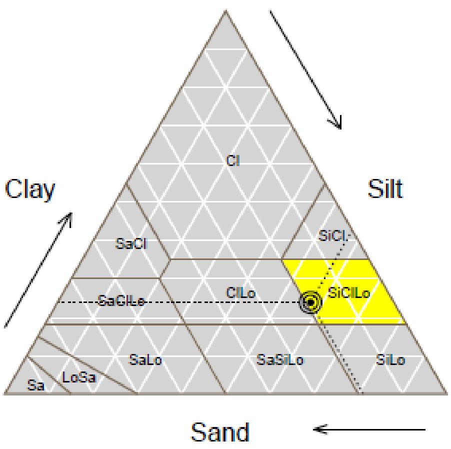
There were analysed the main macro and micronutrients along with the soil's particle size - results are presented in tables 2 and 3.

The analysis of the soil's particle size showed variations within the same plot designated for the establishment of the tomato crop – silty clay loam vs clay loam – there is almost double the sand content in sample 4 versus sample 2, which is influencing both the nutritional and the irrigation schemes that have to be adapted accordingly.

Table 2.

Soil's particle size analysis

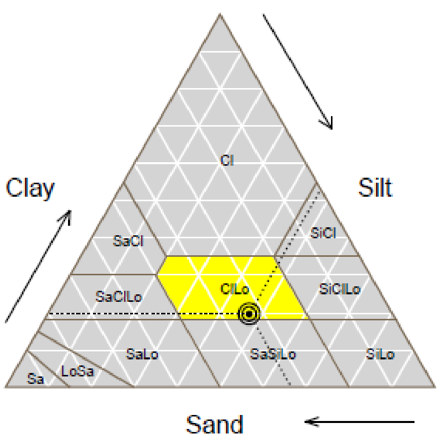
Particle size analysis – sample no. 2



Analysis	Result (%)
Sand	18.87
Silt	57.24
Clay	23.89
Very Fine Sand	14.32
Fine Sand	4.47
Medium Sand	0.09
Coarse Sand	< 0.01
Very Coarse Sand	< 0.01
Stones >2mm	0.20
Soil Type	SiClLo Silty Clay Loam

Property	Assessment
Available Water	High to Medium
Drainage Rate	Medium
Inherent Fertility	Medium
Potential C.E.C.	Medium
Leaching Risk	Moderate
Warming Rate	Rapid to Medium

Particle size analysis – sample no. 4



Analysis	Result (%)
Sand	33.39
Silt	46.93
Clay	19.68
Very Fine Sand	17.58
Fine Sand	10.74
Medium Sand	4.49
Coarse Sand	0.58
Very Coarse Sand	< 0.01
Stones >2mm	< 0.01
Soil Type	ClLo Clay Loam

Property	Assessment
Available Water	Medium to High
Drainage Rate	Medium to Slow
Inherent Fertility	Medium to High
Potential C.E.C.	Medium to High
Leaching Risk	Moderate to Low
Warming Rate	Medium

Table 3

Soil available vs. total nutrient content analysis

Analysis / Type / Sample no.	**1**	**2**		**3**	**4**		**5**
		Available nutrients	**TOTAL**		**Available nutrients**	**TOTAL**	
pH	7,5	**7,7**		**7,3**	7,7		7,6
Nitrogen (Kg/ha)	**18**	**60**	***1133***	42	28	***1313***	39
Ammonium N (ppm)	2,0	2,4		3,2	2,1		2,6
Nitrate N (ppm)	3,9	17,6		10,8	7,1		10,3
Phosphorus (ppm)	**14**	**15**	***378***	**22**	**15**	***437***	**21**
Potassium (ppm)	218	234	***5720***	299	219	***5693***	294
Magnesium (ppm)	431	374	***4633***	255	364	***4626***	268
Calcium (ppm)	3935	3912	***7442***	3783	3821	***11386***	4910
Manganese (ppm)	175	171	***592***	183	171	***592***	176
Sulphur (ppm)	1	1	***156***	1	1	***182***	1
Copper (ppm)	30,2	19,4	***35.7***	24,3	25,1	***45.2***	23,4
Boron (ppm)	1,59	1,52	***22.2***	1,56	1,59	***21.4***	1,59
Zinc (ppm)	2,4	**2,2**	***48.6***	**3,4**	2,5	***49.1***	3,2
Molybdenum (ppm)	0,10	0,10	***0.45***	0,07	0,11	***0.41***	0,09
Iron (ppm)	198	210	***1372***	**251**	176	***13508***	215
Sodium (ppm)	27	23	***227***	22	19	***252***	25
C.E.C. (meq/100g)	19,9	19,4		21,8	18,9		27,6
Organic Matter (%)	3,3	**2,8**		**3,4**	3,1		**3,4**

(green)	*Normal*	(red)	*Very low*	(yellow)	*Low / Slightly low*	(orange)	*High / Very high*

It can be observed from table 3 that:

- soil is slightly to medium alkaline - pH values are between 7,3 – 7,7 - which can determine possible interferences on availability of P, K, Mn, B, Cu, Zn and Fe;

- available nitrogen content is different considering that there were cultivated field crops in the area, which were fertilized with different amounts of fertilizers - the soil mineral nitrogen figures should not be used in isolation as there are a number of factors outside the control of the laboratory which will affect the accuracy of assessing the soil nitrogen supply. Previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications;

- for these weak alkaline soils, **the total phosphorous content versus the available phosphorous is 25 - 30 times higher**, due to the blockages with the soil cations. There is compulsory to adapt phosphorous nutrition schemes by using fertilizers containing phosphorous protection technologies – coated with new generation of polymers and other technologies or by using beneficial microbes (phosphate solubilizing bacteria). As an example of quality phosphate fertilizers available in Romania, the **AMESAL** product range marketed by CiCh Năvodari is including **AMESAL 200N**, an unique polymer with a high capacity for exchanging cations (its molecular structure enhances phosphorous absorption by doubling its efficiency when coated onto phosphate fertilizers - due to its phosphorus enhancement technology, the phosphorus no longer gets blocked into the soils, regardless of the soil's reaction) – 50 to 75 kg/P_2O_5 should be applied from quality fertilisers to supply the tomato requirements in this case;

- potassium content is slightly low – 40 – 50 kg K_2O as maintenance dose needs to be applied according also to the crop's requirements and soil's further analysis which is recommended to be done yearly in case of intensive cropping;

- generally speaking for this plot, magnesium, calcium and manganese will not present deficiencies but leaf analysis will be required further during the vegetation period to determine their level – as in the case of other nutrients, leaf analysis is one of the most important tools to determine crop's deficiencies and prevent them using combinations of base and foliar treatments;

- high copper values can determine possible interference with the availability of Manganese;

- boron is slightly low – an appropriate quality boron fertiliser can be used in the nutritional schemes considering its requirements and avoiding high doses;

- zinc application should be considered after foliar analysis like in the case of other deficient micronutrients;

- sodium level is not an issue for this plot for the moment;

- cation exchange capacity levels are showing good nutrient holding capacities and the organic matter content should be increased by using appropriate organic fertilizers.

CONCLUSIONS

The tomato crop has to get an adequate supply of all the essential nutrients - the critical nutritional requirements of the tomato plants according to the growth and development stages are represented by the calcium, boron, magnesium and potassium elements, along with the continuous supply with nitrogen and phosphorous.

The analysis of the soil's particle size showed variations within the same plot designated for the establishment of the tomato crop – silty clay loam vs clay loam – there is almost double the sand content between the samples analysed, which is supposed to influence further both the nutritional and the irrigation schemes, that have to be adapted accordingly.

The analysis of the macro and micronutrients, along with the cation exchange capacity and organic matter, are showing that:

- weak alkaline soils are causing interferences on the availability of nutrients, especially on phosphorous, potassium, zinc and iron – good quality fertilisers are required (*the total phosphorous content versus the available phosphorous is 25 - 30 times higher, due to the blockages with the soil cations)*. **AMESAL 200N**, is a unique polymer with a high capacity for exchanging cations (its molecular structure enhances phosphorous absorption by doubling its efficiency when coated onto phosphate fertilizers - due to its phosphorus enhancement technology, the phosphorus no longer gets blocked into the soils, regardless of the soil's reaction) – 50 to 75 kg/P_2O_5 should be applied to supply the tomato requirements in this case;

- the soil mineral nitrogen figures should not be used in isolation as there are a number of factors outside the control of the laboratory which will affect the accuracy of assessing the soil nitrogen supply. Previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications;

- leaf analysis will be required further during the vegetation period to determine the nutrients' level – leaf analysis is one of the most important tools to determine crop's deficiencies and prevent them using combinations of base and foliar treatments;

- although the cation exchange capacity levels are showing good nutrient holding capacities, the organic matter content should be increased by using appropriate organic fertilizers.

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