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A research on the determination of productivity levels of tomato grown areas

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The research was conducted in tomato-growing lands of Lâpseki, Ezine, Bayramiç and Central districts of Çanakkale province, Turkey. The aim of the study is to check the suitability of the field for tomato farming and to produce a solution if there is a problem. Disturbed soil samples were taken from 114 points with certain coordinates, at a depth of 0 to 30 cm, and analyses were performed. In the soil samples, texture, soil reaction (pH; 1:2.5), calcium carbonate ($CaCO_3$%), phosphorus (P; kg.ha^{-1}), cation exchange capacity (CEC; meq.100 g^{-1}), iron (Fe; ppm), manganese (Mn; ppm), zinc (Zn; ppm), copper (Cu; ppm) and clay (%) analyses were conducted, and characteristic maps of the region were prepared according to the results of the analyses. Based on these results, the present condition and suitability of the soils were evaluated, and simple statistics along with correlations of the analyzed parameters were examined. For the problems of the area, in low pH areas, it was deemed necessary to apply calcium carbonate ($CaCO_3$) or calcium hydroxide [$Ca(OH)_2$] together with physiological alkaline fertilizers. As per the high pH areas, it was necessary to apply elemental sulfur together with physiological acid fertilizers. It was also concluded that Zn application was necessary for the 43.85% of the area with Zn deficiency.

Key words: Efficiency level, nutritional status, plant nutrition, tomato.

INTRODUCTION

There is a big question about whether conventional farming practices can provide food for a world population expected to exceed 7.4 billion by 2020 (Pendey and Chandra, 2013). For this reason, it has become a necessity to increase agricultural production. The agricultural production consists of animal and plant production, while plant production is made up of fruits, vegetables, grains and industrial plants. Vegetables, particularly tomatoes, have a great significance in human nutrition and health. Tomato (*Solanum lycopersicum*) is an annual plant, which grows 1-3 m tall, among the Solanaceae family, native to central, south, and north America ranging from Mexico to Peru (Guntekin et al., 2009). Considering the global plant production, tomato is the third most consumed and popular vegetable following potato and sweet potato (FAOSTAT, 2018).

A total of 12750 tons of tomatoes, about 8750 tons of table tomatoes and 4000 tons of paste tomatoes, were produced in 2017 in Çanakkale, which covered 2.56% of the vegetable fields of Turkey (TSI, 2017). In addition,

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Figure 1. Geographical location and map of the research area.

among the vegetables, tomatoes have taken the first place with 12,750,000 tons of production in 2017 year (TSI, 2017). Therefore, tomato is the most important vegetable of the research area (TSI, 2017). Popularity of tomato depends on its chemical content as 93-95% of a tomato is composed of water, and 5-7% composed of inorganic compounds, organic acids (citric and malic acid), alcohol-insoluble proteins, cellulose, pectin, polysaccharides, carotenoids and lipids (Petro-Turza, 1987). It is an important source for human nutrition since it contains potassium, organic acids, and vitamins A and C at high levels (Moreno et al., 2008).

Efficiency is required for a qualified agriculture and quality products. This is only possible with proper fertilization together with other applications. In the ideal soils for tomatoes; pH: 6.0 - 6.5; texture: composed of combination of sand-loam or sand-loam-clay; lime: <5%; CEC: 15-20 meq.100 g^{-1}; P: > 90 $kg.ha^{-1}$; exchangeable Zn: 1-2 ppm; Fe: 2.5-4.5 ppm; Mn: < 10 ppm; Cu: > 0.2 ppm and the clay should be <35% (Kacar, 2012). On the other hand, soil fertility varies in different places (Mandal et al., 2015). Therefore, nutrients and microorganisms in the soil play an important role in improving soil quality (Sun et al., 2011). Farmers may excessively use inorganic and organic fertilizers and pesticides in order to harvest good yield. Particularly, the continuous use of chemical fertilizers increases the concentration of heavy metal in the soil (Arya and Roy, 2011).

The aim was to ensure controlled chemicals needed to protect the environment and to grow quality products. Determining the character of the soil is the first step in this process. Therefore, this research study was carried out to determine the soil character of the study area, and to suggest a solution if there was a problem.

METHODOLOGY

The research was conducted in Lâpseki, Ezine, Bayramiç and central districts of Çanakkale province. Çanakkale is a neighbor to Edirne and Tekirdağ provinces on the European side of Turkey, while it only neighbors Balıkesir on the Anatolian side. The city is located between longitudes 25°40'- 27°30' East and latitudes 39°27'- 40° 45' North (Figure 1). The large part of its territory is on the Anatolian side and its coastal length is 671 km (TSI, 2017). Mediterranean climate largely prevails in Çanakkale. However, because it is located in the north-west, it is colder in the winter compared to the Mediterranean climate. The lowest temperature falls to 6.4°C in February, while the highest temperature is about 41.7°C in August. Çanakkale has an average annual temperature of 15.2°C and an average humidity of 72.6%. There are more winds in Çanakkale than its neighboring provinces. In the winter season, there are very little snow falls and even if it snows, it stands on the ground up to one week. Rainfalls mostly occur during December, November, January and February (TSI, 2017). Climate is also very suitable for vegetable farming. Çanakkale province has a total area of 9933 km^2, 55% of which is comprised of forests. The remaining land consists of arable lands, meadows, and pastures. Just like in the climate, the vegetation is Mediterranean vegetation (TSI, 2017).

In this research, the coordinates of 114 locations to be studied were initially identified on the maps (1/100000) of the region. Locations of the identified points were found by GPS and marked. Mixed soil samples were taken from the 114 points at a depth of 0 to 30 cm (Kacar, 2012).

After gathering, soil samples were sent to the laboratory for then air-drying. Stones, plants and animal remains were picked out. These samples were then milled and sieved with a 10-mesh sieve (Kacar, 2012). Subsequently, they were analyzed. In the soil samples, texture and clay percentage were detected by the hydrometer method (Bouyoucos, 1962); soil pH was determined by using 1:2.5 soil-water suspension method (Jackson, 1973); % $CaCO_3$ was obtained by the Scheibler Calcimeter (Kacar, 2012); available phosphorous by Olsen et al. (1954) method and DTPA extractable Zn, Fe, Mn and Cu were determined with the standard method given by Lindsay and Norvell (1978). The results of the analysis of soil samples belonging to the research area were given collectively in Table 1. In addition, the productivity maps and graphs of the research area were separately drawn according to the results (Figures 2 and 3). Correlations between the obtained parameter values (Table 2) and descriptive statistics (Table 3) were investigated with MSTAT statistic program (Akdemir et al., 1994).

RESULTS AND DISCUSSION

Four different soil textures were identified in the research area (Table 1 and Figure 2). Of the soil, 42.9% was identified as sandy, 29.8% as loamy-sand, 11.6% as sandy-loam and 11.6% as sandy-clay-loam (Bouyoucos, 1962). According to the analyses, 84.3% of the area is composed of sand and sand-loam mixture (Table 1 and Figure 2). Texture, which does not easily change, is an important physical property that affects the land character the most. This property is directly related to water, air and heat, and it significantly affects the nutrient reserve (Brady and Weil, 2008). A texture consisting of sand-loam or sand-loam-clay combinations is suitable for vegetable agriculture; thus, there is no problem for tomato in this respect (Güneş et al., 2013).

In the research, the pH value was determined to be varying between 4.6 and 8.1, and the average was found to be 6.7 (Table 2). The pH value was determined lower than 5.5 for 12.2%, higher than 6.5 for 58.7% and between 5.5 and 6.5 for 29.1% (Table 1, Figures 2 and 3). In this range, there would be no problem in retrieving macro and micro elements. Soil pH is one of the most important factors in the relationship between soil chemistry and nutrients, and in the intake of elements (Güneş et al., 2013).

The ideal soil pH should be between 6.0-6.5. If pH is higher than 6.5, the plant's intake of metallic micro nutrients (Fe, Zn, Mn, Cu) and boron (B) becomes more difficult and it decreases. However, if the pH is lower than 5.5, the phosphorus (P) and molybdenum (Mo) cannot be taken by the plant (Kacar and Katkat, 2010). When Table 3 was examined, a statistically insignificant negative correlation was observed between pH and Fe, Mn, and P. In the areas with the pH above 6.5, 1000-2000 kg ha^{-1} elemental sülfür should be used, and the fertilizers should be chosen in physiological acidic character. On the other hand, in areas with the pH value below 6.5, 1000-2000 kg ha^{-1} $CaCO_3$ or $Ca(OH)_2$ and fertilizers in physiological alkaline character should be used (Kacar and Katkat, 2010). When Table 3 was examined, a statistically insignificant negative correlation was observed between pH with Fe, Mn, and P. In the areas with the pH value above 6.5, 1000-2000 kg ha^{-1} elemental sülfür and the fertilizers in physiological acidic character should be used. On the other hand, in areas with the pH value below 6.5, 1000-2000 kg ha^{-1} $CaCO_3$ or $Ca(OH)_2$ and fertilizers in physiological alkaline character should be used (Kacar and Katkat, 2010).

The lime [Calcium Carbonate ($CaCO_3$%)] in the study, ranged from 0.1 to 41.8%, while its average was detected as 10.95% (Table 2). In an ideal soil, the lime content should not exceed 5% (Brady and Weil, 2008; Kacar and Katkat, 2010). However, there is no problem at the level of lime up to 15%. In 33.33% of the study area, lime has exceeded 15% (Table 1, Figures 2 and 3). Except for the 33.33%, the research area does not have a problem concerning the lime under the conditions that correct feeding and pH control is conducted. Phosphorus is bound at 33.33% of the research area. In addition, Zn, Fe and Mn are taken at low levels (Güneş et al., 2013). The negative relationship between lime and P, Fe, Mn, and Cu (Table 2) can be explained by the high lime content of the soils in the region (Güneş et al., 2013).

Moreover, a proportional formation was observed between lime and pH. It was suggested to use sulfur and organic acid for problematic soils (for 33.33%) in the research area (Güneş et al., 2013).

Cation Exchange Capacity [CEC (meq.100 g^{-1})] varied from 4.2 to 31.6 in the research, and the average was determined as 13.65 meq.100 g^{-1} (Table 2). In 33.33% (sand) of the research area, CEC was found to be lower than 10 meq.100 g^{-1}; in 29.84% (loamy-sand), it was detected as 10-15 meq.100 g^{-1}; in 19.29% (sandy-loam), it was determined as 15-20 meq.100 g^{-1}; whereas in 17.54% (sandy-loamy-clay), it was higher than 20 meq.100 g^{-1}. CEC increased as the clay rate increased in the soils (Table 1). Rathore et al. (2017) have found similar results. According to the results of the analysis, it was found that 33.33% of the research area was inadequate (< 10 meq.100 g^{-1}), 49.13% was adequate (10-20 meq.100 g^{-1}) and 17.54% was high (>20 meq.100 g^{-1}) (Table 1, Figures 2 and 3). In the soil, where CEC is low, applying compost (20 ton ha^{-1}) or leonardite (20-30 ton ha^{-1}), which are the sources of organic matter will be very useful. Additionally, though not statistically significant, a negative relationship between CEC and Fe, Mn, P, a positive low relationship between CEC and Zn, Cu, and a positive high relationship between CEC and clay were determined, respectively (Table 3) (Kacar and Katkat, 2010).

Phosphorus (P) content of soil samples ranges from 105.0 to 2147.0 kg.ha^{-1}, with an average of 416.8 kg ha^{-1} (Table 2, Figures 2 and 3). According to Kacar (2012), phosphorus level determined in the research area was found to be sufficient (P ≥ 90 kg ha^{-1}) (Güneş et al., 2013). This is because of the suppression of the lime and pH factor, which inhibits phosphorus intake (Güneş et al., 2013). It can be explained by the accumulation of dicalcium phosphate or tricalcium phosphate with the repetitive application of phosphorus in each production year (Kacar and Katkat, 2010; Güneş et al., 2013). In addition, although not statistically significant, a negative correlation was detected between CEC and Fe, Mn, P, a positive low correlation between CEC and Zn, Cu, and a high correlation between CEC and clay (Table 3). It is necessary to increase the solubility of the Phosphorus. For this purpose, sülfür, leonardite, organic acids or

Table 1. Analysis results of research area samples according to coordinates.

Samples no	Coordinate X	Coordinate Y	Soil reaction pH	$CaCO_3$ (%)	CEC (meq.100 g^{-1})	P kg.ha^{-1}	Zn ppm	Cu ppm	Fe ppm	Mn ppm	Clay %	Texture
1	472700	4465800	7.8	40.5	17.6	10.5	0.8	1.1	2.0	1.9	15	SL
2	472500	4465400	7.6	41.3	18.3	14.8	0.6	0.5	1.8	2.1	19	SL
3	472050	4465000	7.3	17.4	13.4	13.8	0.9	0.5	2.0	2.4	13	LS
4	473775	4466700	7.6	16.7	14.1	40.1	1.2	0.6	2.0	1.8	13	LS
5	473800	4466700	7.5	39.7	16.6	29.2	0.8	2.3	1.5	1.7	16	LS
6	468300	4455200	7.7	36.2	16.2	30.9	0.7	0.4	1.1	1.7	15	LS
7	465500	4455200	7.6	2.2	12.3	44.7	0.7	2.0	1.2	2.0	11	LS
8	469500	4455500	6.7	3.2	24.9	36.8	0.8	0.5	3.5	2.9	26	SCL
9	466700	4453700	5.8	0.1	16.1	39.5	0.6	1.0	4.5	7.2	13	LS
10	466700	4454700	6.2	0.1	15.7	43.3	0.5	0.5	4.8	5.4	16	SL
11	467500	4454600	6.3	0.2	15.8	30.0	1.5	2.6	3.5	5.3	13	LS
12	461500	4450500	6.3	0.1	16.3	40.0	1.3	2.6	4.0	5.0	13	LS
13	460600	4450480	7.1	23.6	13.7	35.2	0.8	1.1	4.4	3.2	11	LS
14	458400	4450800	7.7	32.6	11.9	33.8	0.6	0.5	2.0	2.6	12	LS
15	459500	4451600	7.6	1.2	13.3	57.4	0.6	0.8	2.6	2.2	15	LS
16	460300	4451700	7.7	1.0	18.1	19.4	0.5	0.7	1.5	1.9	20	SL
17	461650	4451850	7.8	36.6	31.3	28.9	2.6	0.7	1.6	1.4	32	SCL
18	462600	4451700	7.6	29.1	31.6	35.0	1.7	0.9	2.6	1.6	34	SCL
19	460700	4449300	7.7	30.5	14.9	36.3	0.8	0.5	2.1	1.6	14	LS
20	458600	4449500	7.4	21.5	13.8	35.6	0.5	0.4	2.6	1.3	15	LS
21	458500	4450600	7.6	27.2	13.0	36.4	0.9	1.5	1.0	1.5	12	LS
22	442400	4429300	7.5	28.6	14.8	47.2	0.7	0.8	2.0	1.7	15	LS
23	441500	4428600	7.7	1.6	12.9	30.9	0.6	1.1	2.5	1.2	14	LS
24	440800	4428100	7.8	1.9	13.7	35.0	0.7	1.3	2.4	1.8	15	LS
25	429500	4422500	6.6	0.2	13.1	29.4	1.3	2.4	4.1	4.3	12	LS
26	429500	4420500	6.0	0.2	11.4	32.5	0.9	1.7	2.4	5.9	10	LS
27	438500	4417300	6.9	1.3	13.7	24.6	0.7	1.9	5.1	3.8	13	LS
28	438450	4416500	7.6	0.7	21.8	40.7	0.9	1.8	4.3	2.7	21	SCL
29	437300	4416450	7.6	38.2	13.2	37.4	0.6	1.1	1.7	2.3	13	LS
30	438700	4415750	7.5	23.9	18.3	45.6	0.7	0.6	1.6	2.9	20	SL
31	438500	4415350	7.6	2.9	14.5	32.5	0.9	1.2	2.0	1.8	13	LS
32	434700	4415300	7.4	3.5	21.2	22.7	0.5	0.8	1.4	3.1	22	SCL
33	434600	4413800	7.8	9.2	11.4	28.4	0.7	0.8	2.1	1.7	9	S
34	435400	4413450	7.2	8.8	12.1	46.6	0.7	0.5	2.6	2.4	10	S
35	435500	4412500	7.3	1.5	10.9	40.7	1.4	1.5	2.9	2.4	8	S

Table 1. Contd.

36	435300	4415100	7.8	3.1	10.1	92.4	1.0	1.1	1.9	1.8	8	S
37	430500	4412500	6.8	1.1	16.6	214.7	1.0	1.1	3.9	4.1	16	SL
38	428500	4413500	6.6	0.2	27.1	148.6	2.4	0.6	3.8	5.2	30	SCL
39	428600	4412450	6.8	0.5	29.3	145.5	2.8	2.1	8.1	7.7	30	SCL
40	431000	4406700	7.1	0.7	11.1	152.7	1.2	2.4	5.1	4.2	10	S
41	429600	4406600	5.2	0.2	6.6	74.7	0.8	1.9	27.0	25.2	4	S
42	429500	4407650	5.7	0.1	9.0	61.9	0.8	1.0	13.5	16.4	7	S
43	430700	4407575	5.3	0.1	6.7	68.8	0.6	0.9	21.4	19.3	6	S
44	428600	4410500	5.7	0.1	8.1	60.9	0.6	0.9	10.1	20.1	7	LS
45	429450	4409625	5.3	0.2	7.4	62.0	1.2	1.2	25.4	24.2	3	S
46	430525	4409700	5.5	0.5	8.2	52.3	0.8	0.7	17.1	19.3	6	S
47	430725	4410450	5.2	0.2	9.1	71.1	0.9	1.1	26.9	27.8	5	S
48	429425	4410675	5.9	0.2	11.8	48.9	0.6	0.6	13.4	18.5	11	LS
49	427200	4400850	6.1	0.1	11.4	61.0	1.3	1.1	18.5	13.7	11	LS
50	428400	4401750	5.7	0.2	11.6	31.8	0.8	0.9	18.1	21.2	11	LS
51	429550	4402700	4.6	0.1	8.3	53.4	1.0	0.8	5.5	7.8	6	S
52	428400	4403525	5.5	0.1	5.9	49.8	0.8	0.4	15.5	14.6	4	S
53	428050	4400250	5.9	0.1	6.1	69.1	0.6	0.5	14.0	15.2	5	S
54	434400	4402350	6.0	0.3	5.8	47.8	0.5	0.2	8.1	7.5	4	S
55	434850	4401325	6.3	1.3	5.3	43.6	0.7	0.6	17.8	16.3	2	S
56	435475	4400500	6.2	2.9	7.2	61.8	0.9	0.5	12.3	13.2	5	S
57	443300	4406650	5.6	0.2	6.1	56.8	1.0	0.8	22.4	23.5	4	S
58	443450	4405500	6.5	0.3	6.5	76.6	0.5	1.8	11.1	12.1	6	S
59	444500	4404575	4.8	0.2	5.9	62.9	0.7	1.5	21.6	19.4	4	S
60	445600	4404400	5.9	0.2	12.2	51.9	0.6	1.4	24.9	25.7	11	LS
61	445690	4403450	5.4	1.0	7.1	48.4	0.6	1.0	16.4	14.2	5	S
62	433000	4399000	6.8	0.3	6.7	65.6	0.5	1.8	17.1	16.5	5	S
63	432300	4397800	4.8	0.3	5.5	52.0	0.8	1.6	23.0	20.9	4	S
64	431600	4394500	6.1	1.6	5.4	74.8	0.5	1.5	12.5	12.3	5	S
65	432000	4393000	5.4	1.3	5.1	62.2	0.9	0.8	26.4	19.7	2	S
66	431500	4391900	5.9	0.1	5.3	74.6	0.5	0.8	23.6	22.8	3	S
67	432750	4392800	5.2	0.1	4.9	84.2	1.5	1.3	25.0	25.7	2	S
68	429200	4384750	5.4	0.1	5.1	79.9	1.0	1.3	22.2	20.4	3	S
69	428600	4384200	5.5	1.5	4.8	89.5	0.6	0.7	19.9	17.2	2	S
70	427650	4382800	6.2	0.2	5.4	80.7	0.7	0.6	14.6	13.1	5	S
71	428300	4385500	5.4	0.2	6.0	102.5	0.4	0.6	13.0	14.2	5	S
72	457500	4401600	6.0	0.1	6.2	100.2	2.6	0.5	10.3	9.8	6	S

Table 1. Contd.

73	457600	4402400	6.1	1.0	23.1	35.2	2.1	0.5	9.4	10.1	25	SCL
74	456450	4401500	5.9	0.2	5.8	11.9	0.8	1.5	11.9	12.4	5	S
75	456525	4402575	5.5	0.3	10.9	22.3	0.8	0.7	13.8	12.7	11	LS
76	431150	4368600	5.5	0.8	8.3	12.2	0.6	0.9	13.4	14.3	7	S
77	434250	4369925	5.6	1.1	4.2	13.8	0.8	0.6	19.9	21.2	4	S
78	428100	4369400	6.8	1.2	5.3	12.2	0.4	0.1	13.1	14.7	6	S
79	428000	4372000	6.3	1.0	5.5	18.0	0.9	0.6	10.3	8.9	6	S
80	445200	4371800	6.8	0.2	6.1	18.0	0.5	0.8	10.8	9.5	7	S
81	444100	4372200	5.0	0.2	5.2	19.1	1.0	0.6	26.0	24.3	5	S
82	442900	4372400	5.8	1.5	4.9	18.9	0.3	1.8	18.4	17.1	5	S
83	440250	4372150	7.6	11.0	20.9	15.8	1.1	0.9	3.5	2.9	20	SL
84	439200	4372450	7.6	11.4	20.4	15.7	1.6	1.1	3.4	3.1	18	SL
85	438300	4371850	7.4	35.6	23.8	14.6	1.3	1.4	3.6	3.4	23	SCL
86	439400	4373000	7.8	36.6	19.9	12.6	1.2	1.4	3.1	2.8	19	SL
87	447650	4372700	7.7	28.0	20.8	15.8	1.8	1.0	3.2	3.3	21	SCL
88	449100	4373000	7.5	29.4	17.4	32.5	0.9	1.6	3.9	3.7	16	LS
89	450200	4373550	7.6	41.8	18.7	19.1	1.6	1.4	3.6	3.1	19	LS
90	449650	4374450	7.7	33.9	21.3	14.2	1.2	1.2	3.9	3.8	23	SCL
91	450550	4374825	7.4	30.5	15.1	14.3	0.9	1.3	3.6	2.9	14	LS
92	451400	4376300	7.3	28.8	19.6	13.1	0.5	1.4	3.4	3.2	18	LS
93	452950	4374950	7.2	18.0	11.4	13.6	0.6	1.4	3.5	3.8	10	S
94	454450	4375200	7.6	22.1	11.5	15.0	0.5	1.6	3.1	3.4	10	S
95	454600	4376050	7.6	23.4	23.1	15.6	0.8	1.4	3.4	2.8	21	SCL
96	455350	4376100	7.8	37.1	14.4	14.5	0.5	1.2	2.4	2.3	13	LS
97	456400	4375850	7.7	19.9	11.8	14.8	0.4	1.7	2.9	2.7	10	S
98	456650	4377500	7.6	19.6	22.1	13.6	0.3	0.6	3.1	3.2	24	SCL
99	456850	4376100	7.8	21.9	11.1	14.7	0.2	0.5	2.0	2.1	9	S
100	454800	4376200	7.4	31.1	15.2	17.4	0.3	1.4	2.5	2.7	17	SL
101	453750	4376300	7.5	34.1	11.7	15.9	0.5	1.2	2.5	2.3	11	LS
102	458900	4376250	7.9	31.3	26.4	19.9	0.6	0.8	2.9	2.4	28	SCL
103	460875	4376400	7.4	8.9	17.6	15.8	0.7	0.8	2.8	3.1	18	SL
104	460925	4376775	7.3	14.9	15.9	20.8	0.7	0.2	2.1	1.9	15	LS
105	461150	4376400	7.5	8.9	30.6	28.9	1.0	0.2	2.4	1.9	33	SCL
106	461950	4376650	7.7	15.9	31.1	18.4	0.8	1.4	2.9	3.1	33	SCL
107	462250	4376700	7.4	8.1	22.6	16.3	1.9	1.1	2.5	2.4	34	SCL
108	463200	4377100	8.1	14.4	15.3	15.0	0.8	0.8	2.6	2.8	19	SL
109	463900	4377600	7.7	8.3	22.5	13.6	1.2	0.7	2.1	1.7	26	SCL

Table 1. Contd.

110	464750	4377725	7.5	19.9	18.7	19.1	0.9	0.4	2.4	3.2	21	SCL
111	465100	4378200	7.2	26.5	9.0	20.8	1.6	0.5	1.9	1.6	7	S
112	465900	4378400	7.2	25.7	8.9	18.4	1.4	0.9	1.1	1.3	8	S
113	465000	4379000	6.2	0.2	19.0	18.9	1.5	1.9	15.0	14.2	19	SL
114	466150	4378700	6.8	0.2	26.4	19.8	1.0	1.2	10.1	8.9	30	SCL

chemical acids should be applied (Kacar and Katkat, 2010). Iron (Fe) varied from 1-27 ppm in the research area, with an average of 8.239 ppm(Table 2, Figures 2 and 3). It was determined to be at low levels (Fe ≤ 2.5) in 28.9% of the samples, at adequate levels (2.5-4.5) in 28.9%, and at high levels (Fe >4.5) in 42.2% (Table 1) (Eyupoglu et al., 1996). The usefulness of iron in calcareous soils is reduced by the concentration of HCO_3^{-1} (Bloom and Inskeep, 1988). In addition, the effect of high pH is more conspicuous. Due to high pH (pH>6.5), Fe cannot be received at 58% of the soils (Table 1) (Kalbasi et al., 1988; Kacar and Katkat, 2010). In 33.33% of the soils, in which lime ($CaCO_3$ > 15%) is high, it will not be possible to intake the iron. In return, the tomato highly reacts to iron deficiency. Therefore, iron deficiency should be observed in those areas, and fertilization should be done through the leaf. On the other hand, although statistically not significant, there exists a negative relationship between Fe and Zn, as well as % clay content (Table 3). The solution is to lower the pH level (Kacar, 2012; Güneş et al., 2013).

Manganese (Mn) varied from 1.2 to 27.8 ppm, with an average of 8.2 ppm (Table 2; Figures 2 and 3). In addition, a statistically non-significant negative relationship between Mn and Zn, along with clay % was determined (Table 3). While useful manganese increased at a lower pH level, it decreased at higher pH levels (Table 1; Figure 3). Mn level was found to be sufficient (< 10 ppm) in 66.67% of the samples, high (10-20 ppm) in 21.93% and very high (> 20 ppm) in 11.40% in research (Table 1) (Kacar, 2012; Güneş et al., 2013). In 65% of the soils in Turkey, Mn varies between 15-50 ppm (Eyupoğlu et al., 1996).

According to the results, Mn level is considered sufficient (Martens and Westermann, 1991). 31.57% of the research soil is calcareous alkaline, and 30.70% is sandy-acidic. However, in the lime-alkaline soil (pH>7; $CaCO_3$ > 15%) Mn is difficult to absorb, because the formed manganese oxide (MnO) and manganese hydroxides [$Mn(OH)_2$] prevent absorption (McKenzie, 1989). In sandy acidic soil, Mn undergoes a washing process due to the lack of bonding surface despite high solubility, and it cannot be taken at sufficient levels. Therefore, there may be Mn deficiency in plants grown in sandy-acidic soils and in calcareous-alkaline soils (Kacar and Katkat, 2010). Furthermore, high phosphorus has a negative effect on Mn intake and its transport in plants (Taban et al., 1995; Kacar and Katkat, 2010). As a result, in 62.70% of the soils of the research area, high phosphorus (P), pH and lime conditions should be taken into account and the pH must be adjusted (Karaman et al., 2012).

Zinc (Zn) varied from 0.2 to 2.8 ppm in the research area, with an average value of 0.9 ppm (Table 2, Figures 2 and 3). There was no statistically significant relationship between Zn and other parameters (Table 3). According to these values, it was determined to be at sufficient and high levels in 23.68% of research area soils, and at low and very low levels in 76.32% of the soils (Table 1; Figures 2 and 3) (Kaplan et al., 1997; Kacar and Katkat, 2010; Karaman et al., 2012). Marschner (1991) stated that the amount of exchangeable zinc varied between 0.1 and 2.0 ppm depending on soil properties (Hacısalihooğlu et al., 2004).

This information confirms the results of the research. There is a difference between plants in terms of zinc intake. For example, tomatoes receive only 30% of the given zinc. Due to its being at low soil temperature, high pH and high phosphorus contents also reduce Zn intake (Hacısalihooğlu et al., 2004). As soil pH increases, variable Zn decreases (Kacar and Katkat, 2010). The information provided confirms the research findings. Therefore, while applying Zn in the research area, phosphorus and pH must be taken into consideration, and the pH must be absolutely calibrated (Güneş et al., 2013).

Zinc should be given as needed. In fact, it should be applied through the leaf, especially in areas where pH is high. Because of the high pH and high calcareous conditions; its solubility decreases and it cannot be taken by forming compounds such as zinc carbonate ($ZnCO_3$) and zinc hydroxide [$Zn(OH)_2$] with carbonates (Karaman et al., 2012).

Copper (Cu) was varied between 0.1 and 2.6 ppm in the samples, and the mean value was determined to be 1.06 ppm (Table 2, Figures 2

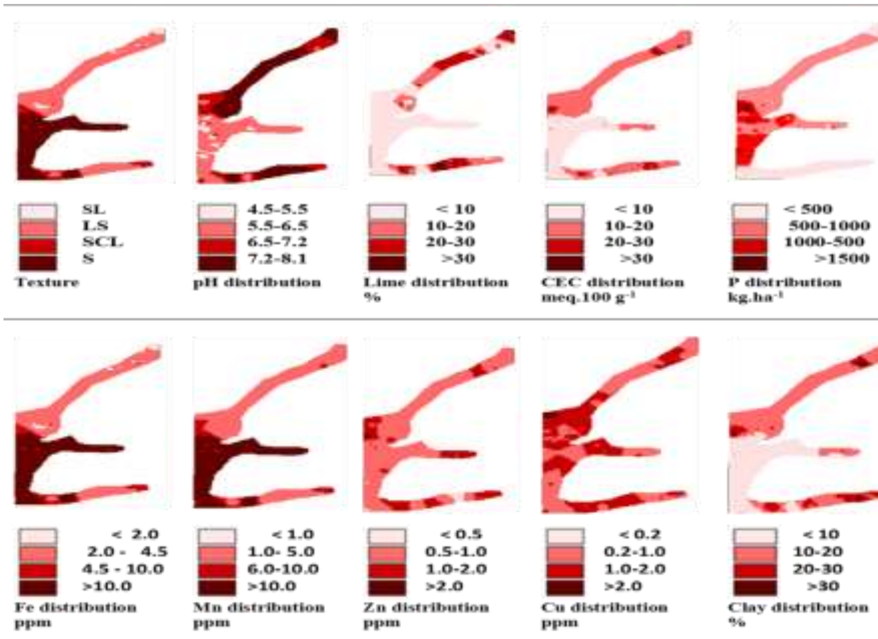

Figure 2. Mappings according to levels of research findings.

Figure 3. Analysis results of the soils samples according to coordinates.

Table 2. Descriptive statistics.

*Paramet.	N. Stat.	Range Stat.	Min. Stat.	Maxi. Stat.	Mean Stat.	Std. Stat.	Variance Stat.	Skewness Statist	Skewness Std.	Kurtosıs Statist	Kurtosıs Std.
pH	114	3.5	4.6	8.1	6.756	0.9373	8.7859	-0.506	0.226	-1.14	0.449
$CaCO_3$	114	41.7	0.1	41.8	10.95	13.69101	1874.44	0.903	0.226	0.733	0.449
CEC	114	27.4	4.2	31.6	13.65	6.93345	480.73	0.697	0.226	0.119	0.449
Fe	114	26	1	27	8.239	7.78484	606.04	1.05	0.226	0.237	0.499
Mn	114	26.6	1.2	27.8	8.217	7.61804	580.34	0.973	0.226	0.414	0.449
Zn	114	2.6	0.2	2.8	0.911	0.48477	2.35	1.792	0.226	3.779	0.499
Cu	114	2.4	0.2	2.6	1.066	0.53511	2.8634	0.807	0.226	0.291	0.499
P	114	204.2	10.5	214.7	41.68	33.09612	109535	2.304	0.226	7.564	0.449
Clay	114	3.2	0.2	3.4	1.31	0.81646	6.6661	0.807	0.226	0.02	0.499

*pH (1:2.5); $CaCO_3$ (%); CEC (meq.100 g^{-1}); Fe (ppm); Mn (ppm); Zn (ppm); Cu (ppm); P (kg.ha^{-1}); Clay (%).

Table 3. Correlations between parameters.

Parameters	pH (1:2.5)	$CaCO_3$ (%)	CEC (meq.100 g^{-1})	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	P (kg.ha^{-1})
$CaCO_3$ (%)	0.672							
CEC (meq.100 g^{-1})	0.613	0.429						
Fe (ppm)	-0.847	-0.566	-0.605					
Mn (ppm)	-0.872	-0.585	-0.608	0.975				
Zn (ppm)	0.028	0.012	0.402	-0.080	-0.095			
Cu (ppm)	0.001	-0.061	0.023	0.013	0.005	0.106		
P (kg.ha^{-1})	-0.369	-0.431	-0.203	0.312	0.315	0.237	0.079	
Clay(%)	0.613	0.396	0.977	-0.599	-0.603	0.389	-0.028	-0.217

and 3). Cu was found to be at inadequate levels (≤0.2) in 3.5%, and adequate levels in 96.5% of the research area (Table 1) (Eyupoğlu et al., 1996; Karaman et al., 2012). This depends on the copper-based pesticides used. Kochian (1991) reported that 98% of Cu in the soil solution forms a complex with organic compounds and therefore it is immobilized (Kacar and Katkat, 2010). In addition, Haldar and Mandal (1981) reported that Zn^{++} and Cu^{++}, which are present in excessive amounts in the soil, adversely affect their intake by plants (Kacar and Katkat, 2010). No application proposal was needed because it was found to be sufficient in almost all soil samples (Hacısalihooğlu et al., 2004).

In the survey, clay was detected only in 20 samples (clay: 20-35%) (Figures 2 and 3). These fields are defined as SCL (Güneş et al., 2013). No clay-textures (clay >35%) were detected in any of the other units. In this respect, the research area was determined to be suitable for tomato production (Brady and Weil, 2008).

Conclusion

The main problem in the research area is that there may be problems related to the intake of P, Zn, Mn and Fe depending on the level of pH and lime. According to the research results, texture containing sand, loam and clay combinations except for 100% clay are suitable for tomatoes. Whereas at pH 6.5 and above 10% of lime; 1-2 ton.ha^{-1} of elemental powder sulfur or organic acids should be used and where pH is below 6.0, $CaCO_3$ or $Ca(OH)_2$ should be used depending on the pH level. Thus, the pH will be calibrated and antagonistic relationship between P, Zn, Mn and Fe will be prevented. Especially where the lime is above 10%, application of P is given locally without mixing to the soil, while Zn, Mn and Fe should be fed to the plants from the leaves.

CEC was under 15 meq.100 g^{-1} in 63.17% of the research areas. For these areas, 20-30 tons.ha^{-1} leonardite should be used to increase the CEC values.

Cu, Mn and Fe was enough with higher percentages (96.5, 88.6 and 71.1%) of the soil samples, respectively. Zn was found to be low and very low in 76.3% of the samples. Because there is a more important antagonistic relationship between the Zn with pH, % $CaCO_3$ and P, Zn is found to be low; so the application must be made from the leaves.

Higher Mn is related to rich mangan soils of Turkey, while higher Cu is related to the copper element in the compositions of pesticides. The state of Fe also depends on high iron application.

Therefore, when Cu and Mn are not given, Fe should be applied to the leaf.

If the recommendations are followed, the pH and CEC in the research area will be adjusted and P and Zn intake will be easier. In addition, the nutrition problem of tomatoes will be eliminated and the yield will be increased.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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