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# The Nutrition Status of *Punica Granatum L. Gardens* On Soils with Limited Conditions In Semi-Arid Southeastern Anatolia, Turkey

**Gökhan BÜYÜK[1*], Ceren Ayşe BAYRAM[1], Muzaffer KIRPIK[1], Ahmet ÇELİK[1], Armağan KAYA[2], Erhan AKÇA[3] Halil İbrahim OĞUZ[4]**

[1]Adiyaman University, Kahta Vocational School, 02040, Adiyaman, Turkey
[2] Alanya Alaaddin Keykubat University, Education Faculty Antalya, Turkey
[3]Adiyaman University, Technical Scinces Vocational School, 02040, Adiyaman,Turkey
[4]Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey
* Corresponding author: gbuyuk@adiyaman.edu.tr

**Abstract**
As the soils without limiting condition for plant growth is about 10% of the country's all arable lands, cultivation generally undertaken at soils with shallow, stony, sloping and deficient nutrient contents which is also valid for Adıyaman region. The pomegranate orchard establishment manifested a very rapid growth recently due various reasons alike subsidies however soil properties in the region is not well known. Soil and plant sampling were taken from 40 points for determination of plant nutrient and soil relations of pomegranate grown in soils with limiting properties in this study. Orchards were generally set 5 to 6 years ago with Hicaz variety. Soil samples were collected from 0-30 and 30-60cm depth, plant leaves were sampled during 20 August – 20 September period of the year 2015. Pomegranate soils have shallow-moderate depth (30-60cm) with alkaline pH, calcareous and clayey texture. While all orchards soils have high phosphorous and potassium content, the iron, zinc and organic matter were determined as insufficient. In case of leaf analysis nitrogen, phosphorous, potassium, magnesium, iron, copper and manganese were determined as sufficient while zinc was deficient. For example, excess bottom fertilizing particularly resulted phosphorous accumulation and it is determined that lack of decent knowledge on soil plant nutrient in the region induced zinc and iron deficiency. Soil organic matter was a disregarded property by farmers and its importance is not well-known by them. Finally, along with limiting soil conditions the inadequate nursing knowledge determined as constraining factor of Adıyaman pomegranate production.

**Keywords:** Pomegranate, plant nutrient elements, horticulture, limiting soil conditions

## INTRODUCTION

While the Mediterranean Region of Turkey is in the first place with 61% production in fruit growing, it is followed by the Aegean Region with 28%, and the South-Eastern Anatolia Region with 10% production. In Adıyaman province, the share of the fruit production area in the agricultural production areas is 15.59%. According to the data of 2011, a total of 10.000 da area in Adıyaman has 164.185 pomegranate trees and the total production amount is 3.230 tons (Anonymous 2012).

In the study conducted by Çıtak and Sönmez (2013) for determining the nutritional status of the pomegranate gardens in Antalya and surrounding areas, soil samples taken from pomegranate gardens revealed areas lacking in Zn and deficiency, and plants were found to be deficient in terms of Fe, Cu, Zn and Mn.

Antioxidant activity for fruit quality is definitely associated with the amount of phenolic material. Phenolic substances in the peel that pass from the peel to the juice during the pressing of the fruit cause the bitter taste of pomegranate juice (Bravo 1998).

To date, no studies have been carried out to determine nutritional problems and proper fertilization program of pomegranate gardens in Adiyaman province and its vicinity. In order to determine the nutritional problems of pomegranate cultivation and to improve the economic situation of the farmers of the region, a field observation study was needed to determine the fertilization program, which is the most important of the cultural processes.
In this study, it was aimed to reveal the nutritional status and soil-plant relationships of the pomegranate gardens spreading rapidly in and around Adiyaman province and the priority problems were put forward.

This study was carried out with the aim of revealing the nutritional status and soil-plant relationships of pomegranate gardens that are is spreading rapidly in and around Adiyaman province.

## MATERIAL and METHOD

Leaf and soil samples were taken from the plants found in 40 different pomegranate orchards which were established with the grown-up Hicaz variety in the areas with limited soil characteristics in Adiyaman area.

### Soil Sampling and Analyses

A total of 80 soil samples were collected from 40 different points, which represent the Adiyaman Region, from 0-30 cm and 30-60 cm depth (Carter 1993).

Soil samples collected from pomegranate orchards are passed through a 2 mm sieve, and stored in plastic containers for physical and chemical analysis. Soils analyses were undertaken as follows: texture by Bouyoucos hydrometer method (Bouyocous 1952), calcimetric carbonates according to Allison and Moody (1965) pH and EC in saturation paste [15, 28], organic matter according to the modified Walkley Black method, 1947, cation exchange capacity (CEC) with saturated ammonium method (Chapman and Pratt 1961).

Total nitrogen according to Kjeldahl method (Bremner 1965), available phosphorus, sodium bicarbonate (pH 8.5) by the method of Olsen and Sommers, 1982, available potassium with 1.0 N neutral (pH 7.0) ammonium acetate ($CH_3COONH_4$) and extracted with the flame photometer (Pratt, 1965), and available Fe, Cu, Zn and Mn were determined with DTPA (Karaman et. al. 2007).

### Leaf Sampling and Analyses

Leaf specimens were taken from August 20 to September 20, 2015, from 40 pomegranate gardens representing the region. The leaves with stems located in the middle of the shoot of the year which were completed the development, were taken from four sides of the trees (Arslan 2002). Collected leaf samples were prepared according to the Kaçar ve İnal, 2008 for analyses.

After the plants are ground, nitrogen was determined according to the Kjeldahl method. The P, K, We, Mg, Fe, Mn, Zn and Cu determinations of leaves were made in extracts obtained by the dry combustion of samples at 500°C (Kaçar, 1984). The obtained soil and leaf values were compared with limit ranges for evaluating the nutrient status of pomegranate orchards.

### Total Phenolic Material Determination

The total phenolic compounds of extracts prepared by six different solvents (acetone, ethanol, ethyl acetate, chloroform, methanol and water) were determined according to the Folin Ciocalteu's phenol reaction. Total phenolic compounds were colorimetrically determined by UV spectrophotometer (Singleton et. al. 1999). Gallic acid was used as phenolic compound standard.

First, in order to create standard chart five different concentrations prepared with Gallic acid solution (0.1-0.5 mg/ml) is taken to the tubes, and the volume was completed to 1 ml with distilled water.

Folin-Ciocaltaeu reactant (2.5 ml) and sodium carbonate solution (7.5 ml, w/v, water) were mixed in the test tube and allowed to stand at room temperature for 2 hours. The sample solutions prepared using methanol, ethanol, ethyl acetate, chloroform, acetone and distilled water were taken into 0.5 ml tubes and treated with the above-mentioned Folin-Ciocaltaeu reagent.

At the end of the reaction, the absorbance values of the samples were read against the witness at a wavelength of 760 nm in the spectrophotometer. The total amount of phenolic compound in the samples is given in µg/g FW.

## RESULTS AND DISCUSSIONS

### Soil Analyses

The results of physical and chemical analyzes of soil samples taken from 0-30 cm and 30-60 cm depths in October 2015 in 40 different pomegranate orchards in Adiyaman province were compared with the limit values (Table 1). The minimum, maximum and average values are given in Table 2. Pomegranate gardens show slightly alkaline and alkaline reactions according to pH analysis results (Evliya 1964), (Table 1).

The pH values of the regional soils are very high. For this reason, it is suggested that the pH of pomegranate gardens soil should be reduced by using acid-based fertilizers or sulfur. Similar results were reported by Albayrak and Katkat 2007. Soils' lime ($CaCO_3$) when the results of the analysis were classified according to Çıtak and Sönmez (2013), it is seen that they are high and very high calcareous soils (Table 1). Minimum, maximum and average values are given in Table 2. When EC analysis results of soil samples were classified according to Singleton et. al.(1999). It was determined that the soil of pomegranate garden where the research was made was salt-free (Table 1). When the organic matter content of soil samples is classified according to SSS, 1951. It is seen that the pomegranate horticultural soil is poor in organic matter and have low humus content (Table 1). Thus, organic matter should be increased by applying animal manure or other organic sources such as compost and green manuring. The soil samples of the study were found to have significant differences between texture classes, but they were mostly clayey and clayey soils (Table 1).When soil is classifiable according to Lindsay and Norvell (1978) for their available Fe analysis, Fe deficiency is observed in 90% of all soil samples (Table 3). However, it can be argued that the vast majority of pomegranate gardens have a slight alkaline and alkaline pH, as well as high lime content (Table 3) along with high P and Cu in the soil. Thus, that Fe is more likely to be converted into unavailable form that plants cannot uptake. As a matter of fact, this situation has been reported by many researchers (Kaçar and Katkat 2007, Karaman et. al. 2007 and Karaçal, 2008). There is visible iron deficiency in plants. This situation can also be caused by not applying fertilizers containing micro elements in the region. Available Mn and Cu analysis, results show that the soil samples are in sufficient level according to Lindsay and Norvell (1978) and there is no nutritional problem in pomegranate horticulture in terms of Mn and Cu (Table 3).

**Table 1.** Classification of soil samples some chemical and physical analysis results according to their limit values

| | | | Depth (cm) | | | |
|---|---|---|---|---|---|---|
| | | | 0-30 | 30-60 | 0-30 | 30-60 |
| Soil Porperties | Limit Values | Assesment | Sample numbers | | % | |
| pH | 6.6-7.3 | Nötr | 3 | 1 | 8 | 2.5 |
| | 7.4-7.8 | Slightly alkaline | 27 | 36 | 67 | 90 |
| | 7.9-8.4 | Alkaline | 10 | 3 | 25 | 7.5 |
| $CaCO_3$ (%) | 0-2.5 | Low | - | - | -- | - |
| | 2.6-5 | Adequate | - | - | - | - |
| | 5.1-10 | High | 40 | 40 | 100 | 100 |
| | 10.1-20 | Very high | 18 | 22 | 45 | 55 |
| | 20+ | Extreme | 18 | 18 | 45 | 45 |
| EC (mmhos $cm^{-1}$) | 0-4 | Unsalted | 40 | 40 | 100 | 100 |
| Organik madde (%) | 0-2 | Inadequate | 2 | 22 | 5 | 55 |
| | 2-5 | Adequate | 38 | 18 | 95 | 45 |
| | 5-10 | High | - | - | - | - |
| Texture | Loamy | | 7 | 1 | 17.5 | 2.5 |
| | Clay-loam | | 25 | 12 | 62.5 | 30 |
| | Clay | | 8 | 27 | 20 | 67.5 |
| $P_2O_5$ (kg $ha^{-1}$) | 0-30 | Low | - | - | - | - |
| | 60-90 | Medium | - | 2 | - | 5 |
| | 90-120 | High | 40 | 38 | 100 | 95 |
| $K_2O$ (kg $ha^{-1}$) | 0-200 | Low | - | - | - | - |
| | 300-600 | Adequate | - | - | - | - |
| | 600-1000 | High | - | - | - | - |
| | 1000≥ | Very high | 40 | 40 | 100 | 100 |
| Fe (mg $kg^{-1}$) | 2.5-4.5 | Inadequate | 36 | 40 | 90 | 100 |
| | 4.5≥ | Adequate | 4 | - | 10 | - |
| Zn (mg $kg^{-1}$) | 0-0.5 | Low | 23 | 29 | 57.5 | 72.5 |
| | 0.5-1.0 | Adequate | 9 | 11 | 22.5 | 27.5 |
| | 1.0≥ | Good | 8 | - | 20 | |
| Mn (mg $kg^{-1}$) | 1≤ | Inadequate | - | - | - | - |
| | 1≥ | Adequate | 40 | 40 | 100 | 100 |
| Cu (mg $kg^{-1}$) | 0.2≤ | Inadequate | - | - | - | - |
| | 0.2≥ | Adequate | 40 | 40 | 100 | 100 |

When the Zn analysis results are classified according to 21, the Zn contents of the soil samples are found to vary from deficient to good (Table 3). Considering the high soil pH and high lime content (Table 2) of pomegranate gardens and the adverse effects on Zn availability (Kaçar and Katkat 2007, Karaman et. al. 2007 and Karaçal 2008), it seems that pomegranate gardens may have problems in Zn nutrition.

On the other hand, when the P contents of pomegranate orchards are taken into consideration due to the antagonistic interaction between P and Zn (Table 3), it seems that the plants may have problems for Zn uptake (Kaçar and Katkat 2007). In addition, the Zn uptake of plants is decreased as the P content increases due to the excess fertilization.

**Table 2.** Soil samples of some chemical and physical analysis results according to their maximum and average values

| Soil Properties | 0-30 cm | | | 30-60 cm | | |
|---|---|---|---|---|---|---|
| | **Min.** | **Max.** | **Ort.** | **Min.** | **Max.** | **Avearge** |
| Texture | Tın | Killi-Tın | Killi-Tın | Killi | Killi-Tın | Killi-Tın |
| pH | 6.49 | 7.97 | 7.60 | 7.26 | 7.90 | 7.45 |
| EC (mmhos $cm^{-1}$) | 528 | 1773 | 791.3 | 486 | 1548 | 784 |
| $CaCO_3$ (%) | 8.4 | 33.2 | 17.4 | 11.6 | 26.4 | 11.3 |
| Organik matter (%) | 1.48 | 3.76 | 2.79 | 0.89 | 2.65 | 1.10 |
| $P_2O_5$ (kg $ha^{-1}$) | 88.8 | 622.8 | 339.9 | 76.5 | 492.3 | 238 |
| $K_2O$ (kg $ha^{-1}$) | 1150 | 10300 | 4154 | 1275 | 6950 | 3144 |
| Fe (mg $kg^{-1}$) | 1.2 | 5.2 | 2.57 | 0.9 | 3.9 | 2.05 |
| Cu (mg $kg^{-1}$) | 1.3 | 4.4 | 2.54 | 0.89 | 3.4 | 1.94 |
| Zn (mg $kg^{-1}$) | 0.04 | 2.20 | 0.65 | 0.02 | 0.64 | 0.38 |
| Mn (mg $kg^{-1}$) | 6.80 | 46.8 | 30.84 | 5.6 | 38.4 | 22.9 |

Table 3. Plant samples of some chemical analysis results according to their maximum, minimum and average values

| | **N** | **P** | **K** | **Mg** | **Fe** | **Cu** | **Zn** | **Mn** |
|---|---|---|---|---|---|---|---|---|
| | % | | | | mg $kg^{-1}$ | | | |
| **Min.** | 0.80 | 0.50 | 0.65 | 0.66 | 18.7 | 0.80 | 5.5 | 9.8 |
| **Max.** | 2.43 | 0.91 | 1.68 | 1.49 | 257 | 40.2 | 48.4 | 80.4 |
| **Average** | 1.60 | 0.74 | 1.10 | 1.00 | 152.2 | 9.33 | 13.35 | 40.3 |

## Plant Analyses

The minimum, maximum and average values of leaf samples selected from 40 different pomegranate orchards in Adiyaman Region are given in Table 3 and the average of two year findings are provided in Table 4. The N contents of leaf samples taken from the pomegranate gardens around Adiyaman Region area vary between 0.80-2.43% (Table 4).

When the analysis results of leaf samples are compared with the qualification limit values given by Sheil, 2006; 5% of the gardens had a deficiency, 10% has adequate and 85% has excess N content. Since the chemical fertilization is usually done without soil analysis in the region, excess N is found in the majority of the orchards. This situation causes great loss in terms of human health and farmer's economy. In addition, during the pomegranate period, the difference between the day and night temperatures in the region is large and the N concentration in the plant is high, which both increase the cracking rate of fruits. High nitrogen availability can adversely affect plant yields as plants prolong the vegetative growth period and degrade the nitrogen potassium balance. Due to the high content of N, the fruit storage life is shortened and it is more susceptible to some storage diseases (Aktaş and Ateş 1998). The content of leaf samples phosphorus ranged between from 0.50 to 0.91% (Table 4). Phosphorus in all leaf samples was above the sufficient level (Sheik 2006).

The reason for this is the unconscious use of base fertilizer (18-46 or compound) application by farmers. The vast majority of the orchards P level was found high. The high P especially in marl, clay and alkaline soils hinders Fe, Zn and Cu uptake of plants which causes low production. The K content of the pomegranate leaves ranged from 0.65% to 1.68%

(Table 4). Leaf specimens obtained from the study were found to be at a sufficient level as high as the K content of the gardens when compared with the qualification limit values given by Richards, 1954. In the remaining 7.5%, potassium was found to be more than the sufficiency limit.

Comparing the results of the leaf samples obtained from the survey with the qualification limit values given by (Richards, 1954), the K contents in the gardens were found to be satisfactory at 92.5%. In the remaining 7.5%, it was determined that the K level exceeded the sufficient limit. The adequate level of potassium in pomegranate orchards, or even excess, actually does not stem from applied K fertilizer to the gardens. The high potassium in the gardens is primarily due to clay content and irregularly applied animal manure fertilizer. As a result, no K deficiency problems are observed in orchards. However, by paying attention to the desired N/K ratio (1/4), fertilization will increase fertility and quality, and may reduce fruit cracking, which is seen intensely in the region. In some pomegranate varieties, there was a correlation between fruit cracking and nutrition level. The leaf N and K/Ca ratio were found to have a high correlation with fruit cracking (Hepaksoy et. al. 1998). The Mg concentration of the plants ranged from 0.66 to 1.49% (Table 4).

**Table 4.** Classification of plant samples chemical analysis results according to their limit values

| Plant Nutrient | Limit Values | Assesment | Sample Numbers | % |
|---|---|---|---|---|
| N | Inadequate | ≤0.90 | 2 | 5 |
| | Adequate | 0.91-1.66 | 4 | 10 |
| | High | ≥ 1.66 | 34 | 85 |
| P | Inadequate | ≤0.11 | - | - |
| | Adequate | 0.12-0.18 | - | - |
| | High | ≥0.18 | 40 | 100 |
| K | Inadequate | ≤0.60 | - | - |
| | Adequate | 0.61-1.59 | 37 | 92.5 |
| | High | ≥1.59 | 3 | 7.5 |
| Mg | Inadequate | ≤0.15 | - | - |
| | Adequate | 0.16-0.42 | - | - |
| | High | ≥0.42 | 40 | 100 |
| Fe | Inadequate | ≤70 | 2 | 5 |
| | Adequate | 71-214 | 35 | 87.5 |
| | High | ≥214 | 3 | 7.5 |
| Cu | Inadequate | ≤28 | 39 | 97.5 |
| | Adequate | 29-72 | 1 | 2.5 |
| | High | ≥72 | - | - |
| Zn | Inadequate | ≤13 | 22 | 55 |
| | Adequate | 14-72 | 18 | 45 |
| | High | ≥72 | - | - |
| Mn | Inadequate | ≤28 | 11 | 27.5 |
| | Adequate | 29-89 | 29 | 72.5 |
| | High | ≥89 | - | - |

When the analysis results of plant samples are compared with the limit values given by Sheik, 2006; The Mg concentration was measured over the sufficient limit in all of the gardens. Though Mg is not given by fertilization in Adiyaman Region. Thus, the source of Mg source is most probably high clay content and the type of clay. The clay suite of the region is dominated by Mg rich smectite and palygorskite. Also, because of high lime in the soil, the Mg concentration of plants has been measured as elevated amounts (Yılmaz 1999). The Zn contents of the samples varied between 5.5-48.4 ppm (Table 4). When the Zn leaf analysis results obtained from the study are compared with the limit values; 55% of the gardens have deficient in their Zn content, and 45% of the gardens contain less than 13 ppm of Zn, which is the adequate limit for plants (Table 4).

The pomegranate gardens of the study show that the majority of the soil is deficient in Zn nutrition (Table 6), and leaf analysis also revealed low Zn contents. Both findings indicate a problem in Zn nutrition of plants in the region. It should not also ignored that the high P contents has negative effect on Zn uptake of plants. In addition to these drawbacks, there is almost no micro-element fertilization to the soil or plant leaves in Adiyaman region.

The Fe contents of leaf samples taken from pomegranate gardens ranged from 18.7 to 257 ppm (Table 4). When the leaf analysis results were compared with the limit values (Sheik 2006), it was determined that while 87.5% of the gardens' had sufficient Fe, the 5% had deficient and 7.5% had excess Fe contents (Table 4). Although Fe concentration is inadequate in the majority of the garden soil, sufficient Fe level in the plant may be due to the Fe intake mechanism that the pomegranate plant developed, or it is thought to be originated from Fe-containing pesticides such as iron sulfate that farmers applied.

The leaf coverage of pomegranate gardens showed varying Cu contents ranging from 0.8 to 40.2 ppm (Table 4). When the analysis results of leaf samples are compared with the limit values given by Richards, 1954; 2.5% of pomegranate gardens were found to be have adequate Cu and 97.5% of them contained low Cu (Table 3). This fact is thought to be caused by high pH and lime origin. The Cu, is more strongly bound to the organic substance than other cationic micronutrients such as $Zn^{+2}$ and $Mn^{+2}$. Therefore, Cu is regulated by organic Cu complexes in the soil and, when compared to other cations, Cu is also strongly bound to the inorganic exchange surfaces in the soil (Mengel and Kirkby 1982). Therefore, it is thought that adsorbed Cu ions can not be easily taken up by plants although it is exchangeable. The Mn contents of leaf samples taken from pomegranate gardens ranged from 9.8-80.4 ppm (Table 4). When the leaf analysis results were compared with the sufficiency limit, it was determined that the 72.5 %of the gardens have sufficient Mn contents whereas 27.5% has deficient Mn content (Table 4). This also revealed the need of micronutrient fertilization in Adiyaman region.

**Total Phenolic Compounds of Leaves**

The amount of total phenolic compounds ranged from 0,436462 to 2,005794 µg/g FW of pomegranate leaves (Table 5). Phenolic compounds contribute to the aroma and taste of many foods. Bitterness and resentment are the source of phenolic compounds in foods (Nizamlıoğlu and Sebahattin 2010).

Although the sampled pomegranate varieties are the same, the amounts of phenolic substances are measured differently. Nutrition and climatic conditions may change the amount of phenolic substances in plants. In a study of some foods with regard to their total phenolic content, the total phenolic content of the pomegranate plant was determined to be 2046 mg/kg. In the pomegranate plants in the Adiyaman Region, the total phenolic substance amounts were all lower than the average value indicated above. This situation arises from conditions such as the cultivation of pomegranate in arid conditions and areas with limited growing characteristics, such as insufficient irrigation and soils with low micronutrients. For this reason, when considering the effects of phenolic substances on fruit and human health, detailed planning of plant feeding and irrigation programs is required to correct this situation.

**Table 5.** Amounts of total phenolic compounds in plant samples (µg/g FW)

| No | Total phenolic compounds µg/g FW | No | Total phenolic compounds µg/g FW | No | Total phenolic compounds µg/g FW | No | Total phenolic compounds µg/g FW |
|---|---|---|---|---|---|---|---|
| 1 | 0.863212 | 11 | 0,882194 | 21 | 1.034567 | 31 | 1,081499 |
| 2 | 0,436462 | 12 | 1.268424 | 22 | 1.268790 | 32 | 1,509463 |
| 3 | 0.652314 | 13 | 0.856426 | 23 | 0.987532 | 33 | 1,087292 |
| 4 | 1.235611 | 14 | 0.705468 | 24 | 1.054783 | 34 | 0.458761 |
| 5 | 1.547852 | 15 | 0.445761 | 25 | 1.678123 | 35 | 2,005794 |
| 6 | 0.865478 | 16 | 0.664755 | 26 | 0.785124 | 36 | 1,076091 |
| 7 | 1.254785 | 17 | 0.799584 | 27 | 0.564781 | 37 | 1,406721 |
| 8 | 1.654782 | 18 | 1.180245 | 28 | 1,156431 | 38 | 0,382773 |
| 9 | 0.468791 | 19 | 1.125486 | 29 | 1.457825 | 39 | 0.864217 |
| 10 | 1.456723 | 20 | 0.874652 | 30 | 1,137891 | 40 | 0.756326 |

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