DETERMINATION OF SPATIAL VARIABILITY IN OLIVE PRODUCTION. PART I - SOIL

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Abstract


The aim of this research is to determine soil spatial variability and strategies of fertilization. This research was carried out in an olive orchard which has 84 trees in Turkey. Soil analyses were realized by using samples which were taken from grids. Soil of the olive orchard was suitable for olive growing due to physical and chemical analysis except organic matter, (partially P), Mn, and Zn. Due to the results of analyses; N, P, Mn and Zn will be required for the next year olive production. The fertilization strategies must be included these applications. It should not be forgotten that the soils which are adequate in potassium and partially phosphorus, may become poor in P and K as like organic material in the length of time.

Key words: Olive, spatial variability, nutrition, soil analysis

Introduction

Olive is generally being grown in sandy loam, sandy, lime and stony soils which are ventilated well. High level of underground water causes root rot. Olive growing is poor under the condition of heavy clay soils (Kacar and Katkat, 2007).

Olive whose homeland is Turkey is one of the culture plants coming from the old times. It is often encountered nutrition problems because the olive trees grown are generally placed on slope and the lack in the application of care precautions.

Olive is mostly damaged from cold whether conditions (Kutevin, 1990). Olive are produced over 8.5 Million Ha and 15 Million Tones in the World. Total number of olive trees which 97% of these trees are growing in Mediterranean Countries is 810 Million (Anonymous, 2004). Olive is usually produced in poor soil which is not suitable for field crops in Turkey. Big percentage (75%) of olive orchard is located in sloppy hills. Olive orchard are usually established by grafting of wild olive trees Mean density of olive trees is 100-110 trees per hectare in Turkey (Goksu, 2003).

One of the factors which effect yield quality, resistance to dry and cold climatic conditions of olive is fertilization.

There is an important place of chemical fertili-
tion between cultural applications for improving yield. Unnecessary and unconscious applications of fertilizers cause also economical losses and environmental pollution. Especially, nitrogen which causes pollution must be applied with required technical precautions for preventing leaching and accumulation in soils. Mineral fertilizer must be applied with right rate because no use or restriction of mineral fertilizer has negative effect on agricultural production. Excessive fertilization may be prevented by taking into account of soil and plant analysis (Belliturk and Saglam, 2005).

Soils are generally poor in organic matter in Turkey. According to the research Belliturk and Saglam, 2005), levels of organic matters of soils (90%) in Tekirdag were found insufficient. Losses in amount of nitrogen cause decreasing yield and quality. Fertilizers which contain nitrogen can not be stored in soils for the next year. Nitrogen should be applied to the soils every year (Belliturk et al., 2007).

Approximately 50% of nitrogen which is applied with fertilizer is taken in the first year by plants, 30% of N is fixed via microorganisms, %15 of N is lost via de-nitrification and 5% of N is lost by leaching (Aydemir, 1979). These losses depend on soil type and climatic conditions. Consequently, fertilizers should be applied according to these factors.

Lack of microelements such as Fe, Mn, Zn, Cu, B, Mo ve Cl in soils and plants affect agricultural production in stead of few amount of these elements. If there is lack of micro elements, fertilization does not improve the yield (Sendemirci and Korkmaz, 2008).

Zinc shortages are seen widely in limy, arid and semi-arid soils exists in approximately 30 % of world soils according to Sillanpaa (1982) and approximately 50 % according to Eyupoglu et al (1998).

High amount of lime, high clay content, P and K application in high ratios and low soil temperature as well as high pH are some of the factors that increase the shortage of Zn. Especially, increasing pH by means of liming effects the benefit of Zn and Mn more than the benefit of other nutrition materials involving phosphorus (Gunes et al., 2007).

Olive is known as rich plants of poor soils and it is not given any importance to its nutrition. Plant nutrition elements are exposed to a loss via eluviations with water and wind erosion because olive orchards are generally placed on slope and stony terrain. Thus, the levels of plant nutrition elements in olive orchards give variation with subject to coordinates. In application, the growers fertilize the soils without considering this variation.

This research is carried out in order to determine the local variation of plant nutrition elements in soil in the olive orchards and to set fertilization program considering this local variation. This research is carried out in an olive orchard placed in Sarkoy borough in Tekirdag province. Plant nutrition elements in soil samples are determined in the research. Local variation maps are charted from the data obtained by the help of coordinate information and fertilizers are applied for every tree in the ratio of its need.

Yield mapping and soil sampling tend to be the first stage in implementing PF. Yields are produced by processing data from an adapted combine that has a vehicle positioning system integrated with a yield recording system. The combine has a fitted to it that can be identified by the GPS receiver on the roof of the cab and the differential aerial above the engine. The output from the combine is a data file that recorded every 1.2 seconds the position of the combine in Longitude and Latitude with the yield at that point. This data set can then be processed by various geo statistical techniques (usually involving Kriging) into a yield map (Blackmore, 2003).

Materials and Methods

Trimble AgGps132 and Ag170 Field Computer were used in this research for the determination of the position of spreader. Longitudinal slope was measured with Nivelman and evaluated. Accuracy of the Nivelman was $\pm 0.2 \%$ (Yuksel and Albut, 1998). The amount of the fertilizers was applied according to results of the soil and leaves analyses used to determine the requirement of olive trees.

A fertilization program was set up according to N and P content of all trees and the soils around them with a calculation of 1 kg of pure N to the tree with
minimum N and 0.5 kg of P$_2$O$_5$ to the tree with mini-
mum P and fertilization has been applied according to
trolled calculations. In the fertilization, ammonium
nitrate (%33) and triple super phosphate (% 42 P$_2$O$_5$)
are used. Moreover, Mn and Zn fertilizers are given
by leaf fertilization.

Only 20 soil samples used in the research are taken
from 0-30 cm depth of the olive orchard with 84 trees
which represents Sarkoy borough (Jackson, 1965).
Leaf samples are taken properly from these 20 olive
trees and analyzed.

It is declared that it is adequate to take the soil
samples from 0-30 cm depth in order to set a fertili-
ization program (Doran and Aydin, 1999).

According to meteorological data of Tekirdag re-
region covering long years (57 years) included year 2006,
the average annual temperature is 13.9°C, the aver-
age annual total rainfall is 578.6 kg m$^{-2}$, the average
annual vapour pressure is 12.7 hPa, the average an-
nual atmosphere pressure is 998.3 mb, the average
annual rainy days is 99.3 days and the average annual
relative moisture ratio is 76.0 % (Anonymous, 2007).

Textures of the soil samples were determined by
Bouyoucos Hydrometer method (Tuzuner, 1990), pH
(1:2.5 soil: distilled water) was measured by pH meter
with glass electrodes (Bayrakli, 1986). Organic ma-
terial of the soil samples were analyzed by Walkley-
Black method (Greweling and Pech, 1960), the sa-
linity was measured (1:2.5 soil: distilled water) by elec-
trical conductivity instrument, exchangeable cations
(Ca$^{2+}$, Mg$^{2+}$, K$^+$) by flame photometer and lime with
Scheibler calcimeter method and Vapor distillation
(Kjeldahl) method is used to determine the amounts
of total N as stated and available Fe, Mn, Zn and Cu
content of the soil samples are determined with ICP-
OES instrument by Saglam (2008).

Field divided into grids with dimensions of 7 m x 7
m.

Measured results were used to produce maps tex-
ture (claysilt-sand) maps, plant nutrition elements maps
etc.) The maps were produced by using a methodology
that developed and published by Denmark Royal
Veterinary and Agricultural University, Centre for Pre-
cision Farming (Blackmore and Marshall, 1996; Blackmore, 2003; Akdemir and Blackmore, 2004). Positioning of data points on the maps were deter-
dined due to field size.

**Results and Discussions**

The results of the soil texture analyses are given in
Table 1. Spatial variability of field slope is given in
Figure 1.

Some physical and chemical properties of soil
samples are given in Table 2 and Figure 2 to Figure
10. The average pH value of soil samples used in the
experiment is 7.65. The soils are in “light alkaline”
class according to pH values (Ulgen and Yurtsever,

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<th>Sand</th>
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**Table 1**

Texture analyses
Fig. 1. Spatial variability of slope of the field

Fig. 2. Spatial variability of pH

Table 2
Physical and chemical properties of soil samples

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<tr>
<th>Soil No</th>
<th>pH (1/2.5 H₂O)</th>
<th>Salt, dS/m</th>
<th>CaCO₃ %</th>
<th>Organic material, %</th>
<th>Total nitrogen, %</th>
<th>Beneficial macro nutrition elements, ppm</th>
<th>Beneficial micro nutrition elements, ppm</th>
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Min. 7.42 0.132 5.37 0.92 0.08 11 365 3011 426 4.3 2.5 0.45 2.9
Max. 7.86 0.423 15 1.4 0.12 22 726 6718 675 6.2 6.4 0.91 5.8
Avg. 7.65 0.245 8.87 1.18 0.099 14 473 5987 512 5.3 4.26 0.61 4.2

Determination of Spatial Variability in Olive Production. Part I - Soil
The pH values of the soils are in the quality of the needs for olive (Kacar and Katkat, 2007). All the soils are in “unsalted” class when the % salt values of the soil samples are examined (Saglam, 2008). The average salt content of the soils are determined as 0.245 dS/m and it is accepted that it is not a salt problem for olive. 

CaCO<sub>3</sub> values of the soil samples vary between
5.37% and 15.00%. The soils with 8.87% lime content are in the “medium limy” class and this is in the quality for olive (Ulgen and Yurtsever, 1995; Kacar and Katkat, 2007).

The organic material content of the soil samples vary between 0.92 % and 1.40 %. It is determined that the total amount of nitrogen varies between 0.080 % and 1.120 % and the average is 0.099 %. It is appeared that the soil samples are in “poor” class when organic material and total nitrogen amounts are examined (Ulgen and Yurtsever, 1995). Organic material and nitrogen results resemble the previous studies carried out in the soils of the region (Belliturk and Saglam, 2005; Belliturk et al., 2007).

The average available phosphorus content of the soil samples is determined as 14 ppm. Eighteen of the soil samples are in “middle” class because of phosphorus content which is between 7 and 20 ppm, two of them is in “high” class because of phosphorus content which is more than 20 ppm (Olsen and Dean, 1965).

After the determination of the necessary amount of phosphorus according to their phosphorus contents, triple super phosphate (42% P₃O₅) is given for each tree. It is important to fertilize in the ratio of need for each tree. The application of P in excess to the soils with low Zn content as in the research soils, causes shortage of Zn affecting both soil and plant factors (Robson and Pitman, 1983). Different from the previous years, the fertilization with nitrogen and phosphorus fertilizers is carried out in control in order to be effective on amount and quality of the product of the next year considering the inadequacy of Zn in research soils.

The average K⁺ content of the soils is found to be 473 ppm when the average changeable cation amounts are examined, while Ca++ is 5987 ppm and Mg++] is 512 ppm. It is observed that the soil samples are in “high” class since the average K⁺ content of the soil samples are 370-1000 ppm, Ca++ is 3500-10000 ppm, Mg++] is 480-1500 ppm (Gunes et al, 2007). The average changeable cation distribution sequence is Ca++>Mg++]>K⁺. These findings are corroborated by Usta (1995). According to Usta (1995), exchangeable cation distribution sequence in fertile soils are generally Ca++>Mg++]>K⁺>NH₄⁺>Na⁺.

It is determined that the soil samples are in “silt loam (SiL)” class when the texture classes of the soil samples are examined. (Table 1 and Table 2) The texture classes of the soil samples are in the quality of olive (Kacar and Katkat, 2007).

The average Fe, Cu, Zn and Mn content of the soil samples are determined to be 5.30, 4.20, 0.61 and 4.26 ppm respectively when beneficial micro element contents are examined. Beneficial Fe content of one of the soil samples is “middle” since it is between 0.2 and 4.5 ppm and it is in “high” class in the other 19 soil samples since they are more than 4.5 ppm. Mn content of the soil samples are in “low” class since it is in the level of lower than 14 ppm. When the soils are examined in terms of Zn, 17 of the soils are in “low” class with 0.2 to 0.7 ppm Zn content; the
other 3 soils are “adequate” class with 0.7 to 2.4 ppm Zn content. All of the research soils are in “adequate” class because of Cu content with more than 0.2 ppm (Gunes et al., 2007).

Gunes et al. (2007) assesses the average Zn content of the soils according to pH, lime content and organic material content as if pH is 7.0-8.0, Zn is 0.71 ppm; if lime content is 5-15 %, Zn is 0.69 ppm and if organic material content is 1-2% Zn is 0.66 ppm. It is parallel to this assessment since the average pH of the soils is 7.65, lime content is 8.87 %, organic material content is 1.18 % and beneficial Zn content is 0.61 ppm.

The average lime content of the soils is 8.87 % and it is middle degree limy soils class. The probability of seeing shortage of Zn and Mn is higher in limy soils (Graham et al., 1992). Rather seed and grain efficiency is affected from the shortage of zinc (Gunes et al., 2007).

High pH limits the efficiency of not only iron but also Zn and Mn. Thus, the shortages of zinc and manganese are mostly come upon occasion in the plants grown in these soils. Also, in many situations, the shortages of two or three of these substances are seen together (Gunes et al., 2007). pH to be alkaline and lime to be in the middle levels may be shown as a cause for the shortage of manganese and zinc in the research soils. It is possible to say that liming the olive trees for protection is not correct because of the probability of seeing Mn and Zn shortage in limy soils.

Excess of potassium may cause shortages of Mg, Ca, B, Zn and Mn. Excess of potassium negatively affects fruit quality (Gunes et al., 2007). Excess of K in our research soils may be given as a cause of Mn and Zn to be in low ratios in these soils. Because of the excess of potassium, fertilization with potassium is not applied to these soils this year (Figure 1).

The interest to the toxicity of Cu increase for many reasons day by day. Agricultural medicines with Cu (Fungisides) are increasingly being used especially in viticulture, industrial and urbanization activities (air pollution, wastes, and canalization wastes). The increase in the use of organic wastes with high Cu content (purification clay, chicken compost etc.) can be counted in these reasons (Gunes et al., 2007). Thus, careful fertilization and medicine application with excess Cu should be carried out in the soils. Attention should be paid to the situation because of the existence of excess amount of the element Cu in both soil and leaves and because of the existence of dense viticulture activities in the research area. The situation of dense viticulture in the region may be shown as a reason of the excess amount of the element Cu in soil and leaves (Figures 2 - 10).

Conclusions

Olives mostly consume N and K from soils. Amount of the required P is less then N and K. Fertilizers mostly used in olive production are the ones with N, K, and P. There is not requirement for the fertilizer with K in the research field because of the existence of excessive K. There are some problems from production to consumption in olive breeding like other agricultural products in Turkey. Not fertilizing the olives according to soil and leaf analyses and also never fertilizing of some growers are at the head of these problems. Especially the cost increase in fertilizer input can be partially decreased by balanced fertilization. There is only one way for this which is to know the soil.

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