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Assessment of leaf secondary macronutrient variability in olive cultivars grown on shale and sand stone derived soils

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Abstract

The awareness of Calcium (Ca) and Magnesium (Mg) variation in olive is pertinent for healthy plant growth. The aim of this research was to examine the seasonal variation of Ca and Mg contents in olive leaves. A field study was conducted for one year at University Research Farm, Chakwal, Pakistan. Leaf nutrients were measured on monthly basis during 2017 growing season. Six olive varieties BARI Zaitoon-1, PS-1, VP-1, Balkasar, Moraiolo and Chitina were selected. Preliminary soil sampling was done for evaluation of fertility status, soil texture, soil pH, EC, total organic matter, $CaCO_3$, NO_3^-, available P, extractable K^+, soluble Ca, Mg and Ca were analyzed initially. Soil was categorized as alkaline having no salinity issue and it was found weak to moderate calcareous, soil texture was sandy loam to loam. Organic Matter was less. The study revealed that there was deficient N, P whereas K, Ca and Mg were adequate in olive orchard. In olive, highest Ca peaks were noticed in summer season during the initiation of leaf development. The varietal comparison revealed that Ca concentration in each olive variety was above the sufficient level. In winter highest Mg peaks were noticed from fruit growth to the end of dormancy. There was no Mg deficiency among olive cultivars. The results recommend that there is further need to sample flower or fruits to understand the nutrient status of orchards.

Keywords: Soil texture, Calcium Magnesium, Organic matter, Deficiencies

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Introduction

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Olive (*Olea europaea*) belongs to Oleaceae family. It is ever green tree cultivated for its edible fruits which is used in pickles or crushed to obtain vegetable oil. Virgin olive oil obtained from fresh fruits is one of the healthiest and major ingredient of daily diet in many nations of the world. Olive cultivars are characterized on the basis of their final use as oil production, table olives or dual purpose. It has been noticed that 1200 olive cultivars were available for olive production around the globe, and 800 cultivars were cultivated for oil production, 100 cultivars bear table olives fruits while others were dual purpose (Bartolini et al., 1998).

Olive orchards have not yielded as per their potential yield which may be affected by physical factors. Poor management practices were also among the key yield deteriorating factors (Gargouri et al., 2006). Proper nutrition management was very crucial aspect for improving the growth and yield potential of plant (Ilyas et al., 2015). Different factors may cause the changes in chemical composition of tissues which include genetic, physiological or environment (Tekaya et al., 2016). Fruit yield and quality depend on the precise availability of various mineral nutrient which are subsequently obtained by the plant from soil. Among various minerals, Ca being an important part of cell membrane and has significant role in olive fruits shelf life while, Mg being the co-factor of various enzymatic pathways help to improve triglyceride and fatty acid metabolism. Olive trees are very susceptible to deficiency of calcium as in plants, mobility of calcium is low.

The composition of minerals in plants fluctuated with the season in olive orchards around the globe (Stateras & Moustakas, 2018; Zouari et al. 2020), however sufficient information regarding status of macronutrient in olive orchard of Pakistan was not available. Different olive varieties grown in same environment have different leaf chemical composition, nutrients uptake and usage abilities (Jordao et al., 1997). The knowledge about seasonal variation in leaf nutrient composition is important which may help to understand uptake of various macro or micronutrient during different parts of the year and may also depict status of various minerals within soil (Chatzissavvidis et al., 2005). Ca^{+2} deficiency causes soft nose restricting the fruit suitability for processing of table olives. Deficiency of Mg^{+2} caused yellow spots on leaves (Camp *et al*., 1949). Optimum level of nutrients may be required to maximize crop production and to exploit the highest benefits through management practices (Kucukyumuk & Erdal, 2011).

Olive production in Pakistan has recently started in pockets of potohar to reduce the dependence over the import of edible oil and to finally gain self-sufficiency (Shahid et al., 2010). Seasonal fluctuation of macronutrients may help to determine the nutrient availability during various parts of year. Availability of nutrients may affect the yield due to insufficient supply of photosynthates, which affects blooming, gametophyte fertility and insufficient fruit size, hardness, poor formation of fatty acids, oil bodies and their deposition in skin. In order to determine the nutrient status of olive tree, leaf analysis was considered a reliable marker to determine the mineral status of tree and their availability for tree.

Materials and Methods

Olive orchard of University Research Farm, Koont in Chakwal was selected for research purpose. Six olive varieties BARI Zaitoon-1, PS-1, VP-1, Balkasar, Moraiolo, Chitina and four replicates were selected. Trees of each variety were properly tagged for soil and leaves sampling.

Soil Sampling, Processing and Analysis

Soil samples were collected at 0-15 cm and 15-30 cm depth using auger. The samples were air dried ground and sieved (2 mm sieve size). Plastic bags were used for storage of prepared soil samples for further soil analysis. Soil samples were analyzed for Soil texture (Gee and Bauder, 1982), soil pH (Gupta, 2006), EC (Mclean, 1982), Total Organic Matter (Nelson and Sommers, 1982), Calcium Carbonate (Loeppert *et al*., 1984), Nitrate, Nitrogen (Vendrell and Zupancic, 1990), Available Phosphorus (Kuo, 1996), Extractable Potassium (Helmke and Sparks, 1996), Soluble Calcium plus Magnesium and Soluble Calcium (Richard, 1954). All analytical work was done at Department of Soil Science and SWC laboratories of PMAS-Arid Agriculture University Rawalpindi.

Plant Sampling, Processing and Analysis

Trees having same stature and canopy were selected for samples collection. Samples were collected at leaf and Inflorescence development, flowering, fruit development and at ripening stage. Sampling was done on monthly basis from August 2016 to June 2017. Samples were collected from five positions i.e. sun face, shaded face, basal, central and apical position and then mixed to form composite sample. Samples were washed, air dried, oven dried for 24 hours at 65 °C and then stored in paper bags for further analysis. Secondary nutrients (Ca and Mg) in plant leaves were estimated through dry ash (Chapman and Pratt, 1961).

The data was subjected to descriptive statistics; obtained data was analyzed for mean, minimum, maximum values and standard deviation. (Steel *et al.,* 1986).

Table 1. Guideline criteria for soil macronutrients

Nutrients	**Deficient (mg kg^{-1})**	**Optimum (mg kg^{-1})**	**Excess (mg kg^{-1})**
NO_3-N	<11	11-20	>20
P	<8	8-15	>15
K	<100	100-150	>150
Ca	<152.4	152.4 - 281.3	> 281.3
Mg	<28.3	28.3 - 79.4	>79.4

(Khalid *et al.,* 2012; Sarangthem *et al*., 2014)

Table 2. Guideline criteria for foliage secondary macronutrients in olive

Nutrients	Deficient (%)	Optimum (%)	Excess (%)
Calcium	<0.6	1-1.43	>3.15
Magnesium	<0.08	0.1-0.16	>0.69

(Connel & Vossen, 2007)

Results and Discussion

Physiochemical Properties of Olive Orchard Soil

Data showed that in olive orchard the clay, silt and sand % ranged from 9.13 to 15.50, 25.60 to 34.30 and 53.36 to 59.92 respectively having mean value 12.31 ± 2.11, 30.40 ± 2.58 and 57.27 ± 1.59 (Table 3). Texture varied from sandy loam to loam. Khalid *et al*. (2012) declared sandy loam to loam texture of Chakwal soils. The pH ranged from 7.20-8.13 and 7.21-7.99 with an average value 7.73 ± 0.29 and 7.48 ± 0.30 at 0-15 cm and 15-30 cm soil depth respectively (Table 4). The pH of soil was alkaline due to calcareous soil nature. Rizwan *et al*. (2016) reported that Chakwal soils are alkaline. At 0-15 cm and 15-30 cm soil depth EC ranged between 0.10-0.34 dS m^{-1} and 0.10-0.30 dS m^{-1} having mean values 0.30 ± 0.04 and 0.19 ± 0.03 respectively. Zeeshan *et al*. (2017) documented that in Chakwal area EC was ranging from 0.06-0.47 dS m^{-1} having mean value 0.246 dS m^{-1}. OM was found 0.32-0.90 % and 0.24- 0.79 % at 0-15 cm and 15-30 cm soil depth having mean value 0.69 ± 0.20 and 0.61 ± 0.16 respectively. Less OM was due to high summer temperature resulted high decomposition of OM therefore less OM was noticed in olive orchard. Zeeshan *et al*. (2017) reported that in Chakwal mean value of OM was 0.63%. $CaCO_3$ in olive orchard ranged between 4.00-12.90 % and 4.17-18.85 % at 0-15 cm and 15-30 cm soil depth having mean value 9.22 ± 2.68 and 10.19 ± 3.85 respectively (Table 4). Similar results were declared by Zeeshan *et al*. (2017) that Chakwal soils are moderately calcareous.

Table 3. Descriptive statistics of particle size distribution in olive orchard

Soil Separate (%)	Mean	Minimum	Maximum	Standard Deviation (±)
Clay	12.31	9.13	15.50	2.11
Silt	30.40	25.60	34.30	2.58
Sand	57.27	53.36	59.96	1.59

Table 4. Descriptive statistics of soil chemical properties in olive orchard (n=48)

Soil Characteristics	Depth (cm)	Mean	Minimum	Maximum	Standard Deviation (±)
pH	0-15	7.73	7.20	8.13	0.29
	15-30	7.48	7.21	7.99	0.30
EC (dS m^{-1})	0-15	0.30	0.14	0.34	0.04
	15-30	0.19	0.10	0.30	0.03
OM (%)	0-15	0.69	0.32	0.90	0.20
	15-30	0.61	0.24	0.79	0.16
$CaCO_3$ (%)	0-15	9.22	4.00	12.90	2.68
	15-30	10.19	4.17	18.85	3.85

Macronutrients Status in Olive Orchard Soils

Nitrogen content was 2.24-15.6 mg kg^{-1} and 1.68-16.20 mg kg^{-1} at 0-15 cm and 15-30 cm soil depth having mean value 7.69 ± 4.54 and 6.89 ± 3.75 respectively (Table 5). According to the given criteria (Table 1), N was deficient in olive orchard. Less availability of N might be due to climatic conditions. P ranged between 2.28-15.54 mg kg^{-1} and 1.31-13.30 mg kg^{-1} with mean value 7.13 ± 3.01 and 6.24 ± 2.95 at 0-15 cm and 15-30 cm soil depth. According to the given criteria (Table 1), P was deficient. This is due to P fixation, at high soil pH. K was ranged between 80.20-125.24 mg kg^{-1} and 75.60-113.60 mg kg^{-1} with the mean of 103.73 ± 13.53 and 96.85±13.01 at 0-15cm and 15-30 cm soil depth respectively. Adequate K is due to presence of mica mineral. Similar results are given by Rashid *et al*. (2008). Ca concentration was 118-322.80 mg kg^{-1} and 90.9 to 298.3 mg kg^{-1} with the mean value 212.5 ± 73.16 and 192.51 ± 73.3 at 0-15 cm and 15-30 cm soil depth. According to the given criteria (Table 1), there is no deficiency of Ca because of the presence of $CaCO_3$ and $CaSO_4$ in calcareous soils. Mg value ranged between 13.55-22.56 mg/kg and 24.64-72.32 mg/kg at 0-15 cm and 15-30 cm soil depths with mean were 58.22 ± 13.55 and 55.35 ± 14.89 respectively. According to criteria of Srivastava *et al*. (2014) (Table 1) Mg was sufficient in olive orchard because of the presence of Vermiculite, chlorite and montmorillonite.

Table 5. Descriptive statistics of soil macronutrients in olive orchard (n=48)

Nutrients (mg kg^{-1})	Depth (cm)	Mean	Minimum	Maximum	Standard Deviation (±)
NO_3-N	0-15	7.69	2.24	15.60	4.54
	15-30	6.89	1.68	16.20	3.75
Available P	0-15	7.13	2.28	15.54	3.01
	15-30	6.24	1.31	13.30	2.95
Extractable K	0-15	103.73	80.2	125.24	13.53
	15-30	96.85	75.6	113.60	13.01
Soluble Calcium	0-15	212.5	118.0	322.80	73.16
	15-30	192.51	90.9	298.30	73.3
Soluble Magnesium	0-15	58.22	13.55	22.56	13.55
	15-30	55.35	24.64	72.32	14.89

Variation of Foliage Calcium Concentration in Olive with Time

The results showed that Ca content in olive leaves was changed with time (Figure 1). Increasing trend of Ca concentration was noticed in summer time during initiation of leaf development stage (Apr-July). Ca availability is increased due to high transpiration rate. Results are similar to the findings of El-Fouly *et al*. (2008) who had grown olive on calcareous soils and found high Ca peaks during summer. Mainly during the fruit development stage, the nutrient concentration tends to decrease in leaves i.e., N, P, K but calcium donot follow this trend. Dris and Niskanen, (2004) found that relatively to N, P, K, calcium content showed differential trend because of its special uptake in plant. In plant tissue calcium is immobile therefore it is not redistributed in plant. Lowest Ca concentration in olive was observed at resting stage in January (Figure 1) because high K and Mg reduce the Ca absorption.

Variation of Calcium Concentration in Six Olive Varieties

Data showed that high leaf calcium content was observed in BARI Zaitoon-1 value ranged between 0.52 to 3.5% having mean value 2.02 ± 0.87 (Figure 2). In Chitina and VP-1 the maximum value of Ca was 2.89 % with average value 2.07 ± 0.79 and 1.86 ± 0.81 respectively. In Balkasar variety Ca ranged between 0.6 to 2.6% with average value 1.52 ± 0.73. In PS-1 Ca range was 0.67-2.80 % having mean value 1.81 ± 0.79. In Moraiolo Ca range was 2.88-0.65 % having mean value 1.64 ± 0.78. The data showed that there was no deficiency of Ca in six olive varieties. Among the varieties differential behavior for

calcium accumulation is evident because each variety has different phenological characteristics and physiology.

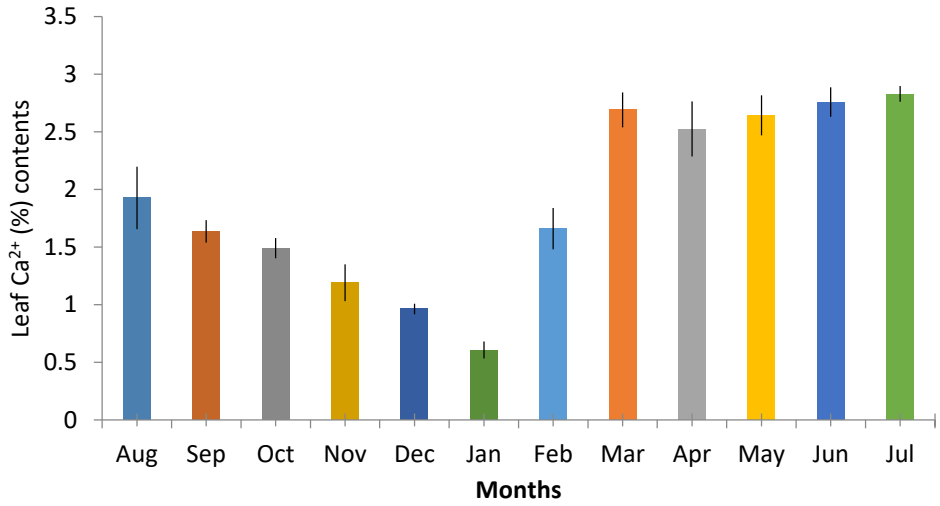

Figure 1. Mean seasonal changes in calcium content in olive orchard

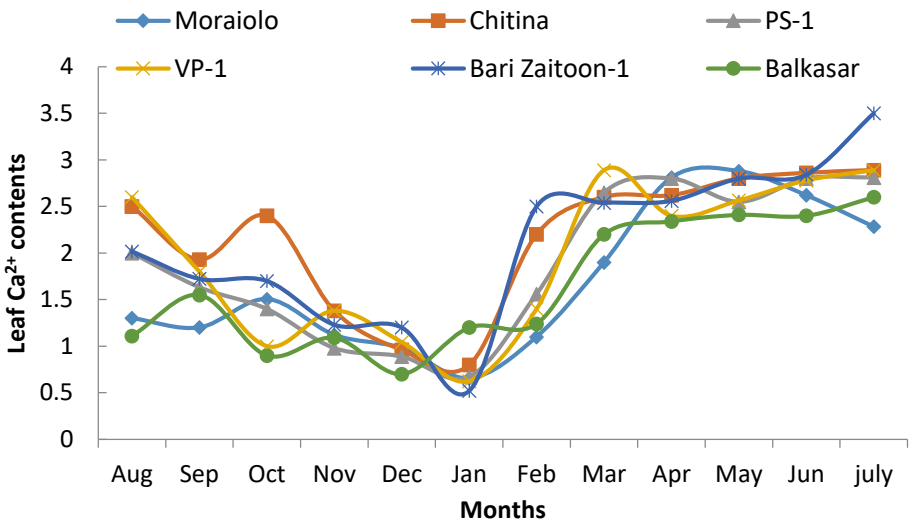

Figure 2. Seasonal changes in Leaf Ca^{2+} in different olive varieties

Variation of Foliage Magnesium Concentration in Olive with Time

In winter highest Mg peaks were seen from fruit growth to the end of dormancy (Aug-Jan). This was due to the less competition among the nutrient's absorption by plant

root. Marschner (1995) reported that NH_4, K^+ and Ca^{2+} ion can depress uptake of magnesium. Decreasing trend of Mg content was observed during initiation of leaf development stage (Feb-July) (Figure 3). Data showed that Mg content vary in olive varieties during the whole growing period. The values of foliage Mg concentration were above the adequate level. Similar results were observed by El-Fouly *et al*. (2008) during winter (November-January) magnesium concentration peaks were rise up. Similarly, Escobar et al. (2009) evaluated Mg concentration in the olive orchards and found that Mg concentration in leaf was always higher than the optimum level of 0.1%.

Variation of Magnesium Concentration in Different Olive Varieties

Data showed that highest magnesium value was observed in Moraiolo variety. Value ranged between 0.12-0.64% with mean value 0.338 ± 0.19 In Chitina variety Mg ranged between 0.16-0.61 % having an average value 0.40 ± 0.14. Maximum range of Mg in VP-1 and PS-1 was 0.54% and minimum range was 0.16 and 0.31 % having mean value 0.37 ± 0.14 and 0.32 ± 0.14 respectively. In Balkasar variety Mg was 0.14-0.57 % having average value 0.31 ± 0.14 was observed. In BARI Zaitoon-1 variety ranged between 0.24-0.60 having an average value 0.44 ± 0.13 (Figure 4). According to Connel and Vossen, (2007) Mg concentration below 0.08% is deficient. In current investigation Mg content in olive cultivars was not less than 0.08 %.

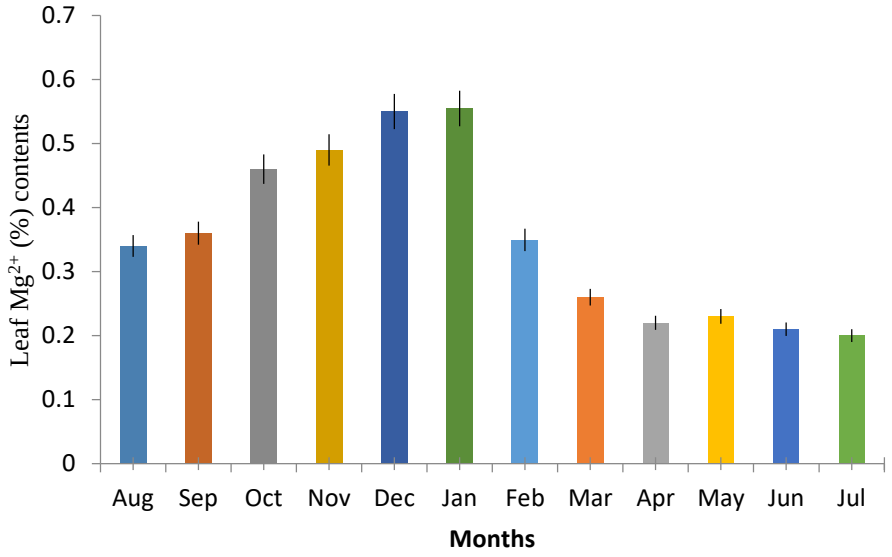

Figure 3. Mean seasonal changes in Magnesium content in olive varieties

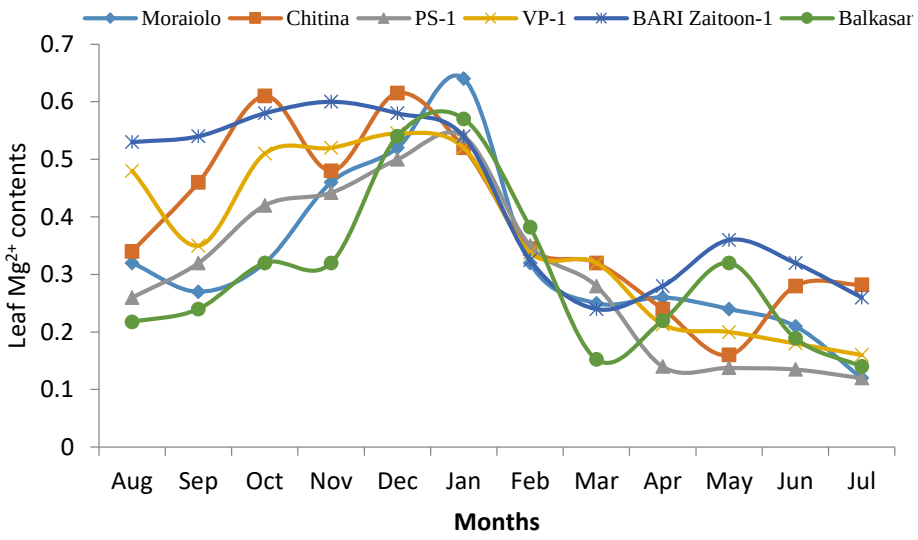

Figure 4. Seasonal changes in magnesium content in different olive varieties

Conclusion

Soil fertility is generally asses to evaluate the nutrient status in olive orchard. Results of study indicated that Soil texture was sandy loam to loam,pH was alkaline and OM was less in olive orchard and there was weak to moderate calcareous soil texture.No salinity problem was reported, although less availability of N and P in olive orchard was noticed. The adequate K and sufficient soluble Ca and soluble Mg were recorded. Highest Ca contents were observed from the beginning of leaf development and lowest concentration was recorded after fruit ripening stage and the varietal comparison revealed that there was no deficiency of Ca. Duringwinters highest Mg peaks were noticed from fruit growth to the end of dormancy. Seasonal changes of magnesium content in different olive varieties showed different trends in each variety as compared to other. The outcome of the study provides information for the development of nutrition management guidelines of olive orchards for potential quality yield.

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