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Status of Macro and Micro Nutrients of Olive Orchard in Northern Iran

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Abstract: Gilan Province, located in the north of Iran, is from among the main centres and critical poles of olive production in Iran. The average yield of Gilan Province olive orchards are about 2200 kg per hectare which is slightly higher than the average of global yield, but it is considerably lower than the European countries or the desired status. One reason is the nutritional disorders. The index of deviation from optimum percentage is a simple way to diagnose the orchards' nutritional disorders. This index indicates the nutritional status of plant or shortage and/or surplus of nutritional elements and can be used for prioritizing the plant's need to nutrients. This study was conducted aiming at investigating the nutritional balance of olive orchard using the deviation from optimum percentage (DOP). To conduct this research, more than 80 olive orchards with strong, moderate and weak yields in Gilan Province were selected. The mean concentration of nutrients (reference numbers) in the leaves of orchards with relative strong yield for N, P and K were obtained 1.54, 0.12 and 1.36, respectively and for Fe, Mn, Zn, Cu and Br obtained 128.31, 44.79, 22.31, 4.95 and 27.05 mg/kg. The reference numbers obtained in this study can be evaluated in each olive orchard of the province. On the basis of index of deviation from optimum percentage, the need to nutrients were in this order: N > Zn > B > K > Fe > Mn > P > Cu.

Key words: Olive, deviation from optimum percentage, nutritional balance, plant analysis.

Introduction

Olive is one of the most important horticultural crops of Gilan Province, but there are problems such as low qualitative and quantitative yield and biennial bearing in orchards and even non-bearing rush among the trees has been reported. One reason can be the nutritional problems and disorders. Although the olive is a plant which adapts itself to the various types of soil, especially the calcareous soils and is compatible with a wide range of fertility degrees of soil, existence of soils with appropriate depth, texture and quality and optimal nutrition using the proper nutrients is necessary to produce a good and economic product. Like other agriculture crops, the increased yield of olive in area is possible when the factors of crop production are in desired level. Therefore, collecting a huge amount of information about the factors affecting the crop production and calibrating them to offer appropriate and more accurate recommendations for enhancing

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the growth status and increasing the qualitative and quantitative yield of crops is highly crucial. Generally speaking, the optimal use of fertilizer with the optimum ratio among the nutrients in soil and plant is of high importance in enhancing the agriculture crops qualitatively and quantitatively. In balanced fertilization, informing of the usable nutrients of plant in soil is necessary, i.e. the soil fertility evaluation. Soil fertility evaluation can be expressed as the estimation of soil power in offering the plant nutrients sufficiently for growth in appropriate form and optimum ratio.

Measurement of the nutrients concentration in the plant textures is the most accurate way to investigate the nutritional status of fruit trees (Bold, 1966). In plant nutrition, not only each element should be accessible sufficiently by the plant, but also a balanced ratio of nutrients should also be taken into account. In case of inattention, the nutrients growth will be disrupted. If severe deficiency is felt, more concentration of nutrients in leaves will be observed than the healthy plant (Sumner, 1997). Sumner believes that nutrients imbalance in fruit trees affects their yield and quality. Relations between the nutrients and qualitative and quantitative yield of fruit trees in balanced nutrition, is a crucial factor in fruit yield and quality. Habib (2000) believes that in addition to the accurate meeting of sampling time, plant decomposition efficiency, sampled element and standardized decomposition methods depend on the interpretation of results obtained from decomposition (Montans et al., 1993).

The main interpretation methods of results obtained from the plant decomposition are Critical Nutrient Concentration (CNC), Sufficiency range and Diagnosis and Recommendation Integrated System (DRIS) (Tisdal et al., 1990). Critical nutrient concentration (CNC) is an extent of nutrient concentration lower than which, the crop yield is decreasing compared to the plants with higher concentrations. In other words, concentration of 90%-95% is achieved in this level. In DRIS, many indices and calculated numbers are required which were invented in contrary to the simple and easy method of Deviation from Optimum Percentage (DOP). Like DRIS, the latter calculates an index for each nutrient and specifies them in terms of positive or negative numbers or zero indicating the surplus, deficiency or appropriate concentration of nutrient in the plant. The most negative index in this method is the limiting factor in plant nutrition and the need order would be from negative to positive index. Also, by calculating the sum of absolute values of DOP index, the intensity of exiting the balance status can be found out (Montans et al., 1993).

Many scholars have determined the DOP index for various agronomic and horticultural crops. Samadi and Majidi (2011) specified the DOP index in white seedless grapes. Based on their results, DOP index in all vineyards with low yield was much larger than zero indicating the lack of balance in nutrients absorbed in vineyards. For vineyards with low yield (Goudarzi, 2005), DOP index was calculated. Results showed that all orchards with relative low yield experience imbalanced status of nutrients and deficiency of Fe, Mn, Cu, K, Zn and B in such orchards are predictable as 91%, 82%, 82%, 67%, 59%, and 54.5%, respectively. In investigating the status of nutrition of lemon orchard by using DOP index, Hosseini et al. (2016) determined the order of nutrients need as Mn > Fe > Zn > N > K > Cu > Cl > B and stated that the low consumption elements of Mn, Fe and Zn are on the top priority of nutrition.

In the studies on nutritional status and nutrients absorption in various cultivars of apricot in Serbia for two years, Milosevic and Milosevic (2011) used DOP method for analysing them of nutrients existing in leaf. For this purpose, they chose the reference numbers from the table of apricot nutrients optimum percentage and reported that the amount of potassium and phosphorous, nutrients are higher than the optimal limit and there is a weak nutritional balance between some cultivars. Tausz et al. (2004) studied the concentration of macro- and micro-nutrients in Pinus canariensis. Results showed that nitrogen within the presented range for pine species was desirable. Micronutrients were also within this range, except for Cu. In their studies on cherry, Jiménez et al. (2004) used the leaf and flower analysis for diagnosing the nutritional need and also applied the DOP. These researchers used the global optimum reference numbers to be incorporated in the formula and expressed that DOP offers similar information to DRIS method. They also reported that there is a significant correlation between the crops on the next year and nutrients concentrations in leaves. The nutritional status of peach trees was evaluated by using the DOP and DRIS methods, Monge et al. (1995) obtained the same results for grouping the elements by both methods. Soyergin et al. (2002) investigated the nutritional status in olive orchards by DOP methods in Turkey and then reported the nutrients imbalance in olive orchard as well as the potassium and zinc deficiencies.

To investigate the nutritional status of zink-fed pear orchards, Mirabdoulbaghi (2014) used the DOP to determine the nutritional status of orchards and stated that the orchards fed with a combination of such elements had more stable nutritional status. Milosevic et al. (2013) examined the agronomic characteristics and nutritional status of plum orchards in Serbia under different cultivars and observed a significant difference in cultivars of main macronutrients within 120 days after flowering (N, P, K, Ca, Mg). Sum of ΣDOP index was imbalanced in all cultivars indicating the improper and sufficient nutrition in orchards. This also shows that mineral fertilizer was not used in this field. Shaban et al. (2016) used the soil test in investigating the nutritional status of olive orchards in north-eastern Egypt and expressed that soils with high pH and organic material were low and K, Mg and Fe and amount of N, P, $CaCO_3$, Na and EC ranged low to high. Cu, Zn, Mg and Ca elements ranged low to high in olive leaf and a strong relationship was found between the Mg levels and yield.

Results of leaf decomposition with the need order of K > Ca > Mg showed that the olive tree are capable to absorb more Ca and Mg. Results of study by El-Fouly et al. (2005) on leaf analysis of olive orchards revealed that the levels of nutrients in sample leaves in the first season were 61, 44, 94, 33 and 22% for N, P, K, Mg and Ca, respectively and 100, 22, 89, 61 and 18% for Fe, Mn, Zn, Cu and B, respectively, while during the second season, they were 94, 18, 88, 18 and 18% for N, P, K, Mg and Ca and also 88, 6, 52, 45 and 21% for Fe, Mn, Zn, Cu and B, respectively. Therefore, the present study was conducted aiming at evaluating the nutritional status of olive orchards in the north of Iran and its connection to yield and also determining the nutritional priority of macro and micronutrients for each orchard.

Materials and Methods

In this study, over 80 orchards with various yield and aging about ten years were selected. Leaf samples were collected from the middle of current season branches from 2015 to 2016 in July. Thirty leaves from different sunlight exposure over the canopy were randomly collected within each garden. The sampling points were located in geographic coordinates and were transferred to a Global Positioning System (GPS) instrument with an accuracy of ±5 m. After labelling leaf samples were transferred to the laboratory washed with tap water, rinsed with distilled water and put on the oven for 48 hours in 65°C. Dried leaves samples were powdered by electrical grinder and 2 M hydrochloric acid was used for dissolving the nutrients in the ash obtained by congestion with dry oxidation method (Benton Jones and Kiss, 1990). Concentration of Fe, Zn, Cu and Mg were read by DTPA method with the help of Thermoelmental atomic absorption device and the K concentration of samples was read by JENWAY flame photometer device. Sample phosphorous was measured with chlorometric method by spectrophotometer. Amount of nitrogen in leaf samples was measured by wet oxidation and Kjeldahl method via kejeltec auto-analyser (Benton Jones and Kiss, 1990). Orchards were divided into two groups with high and low yield. Concentration of nutrients in leaves of orchards with high yield was calculated, then used as the optimum contents. By using such optimum range, for orchards with low yield, DOP index for nutrients was calculated by the following formula. By making use of it, nutritional balance, DOP index, deficiency and surplus of elements and order of gardens' nutritional need to various nutrients were observed (Montaz, 1993; Jiménez, 2004).

$$DOP = \left[\frac{(C \times 100)}{C_{ref}}\right] - 100$$

where C is the concentration of macronutrient in the plant sample for which its need to fertilizer should be determined.

C_{ref} is the concentration of macronutrient in the plant which is in favourable status in terms of yield and quality, but from other similar conditions point of view, the sample is unknown. There are two simple rules for interpreting the results: (A) Absolute value of DOP shows the importance or intensity of imbalance, because zero indicates the balance status and high absolute values of DOP index refer to much deviation from balance status. (B) For each element, the negative value of DOP index indicates the deficiency and the positive value shows its surplus. Sum of DOP index refer to the imbalance. Sum of DOP index (ΣDOP) has a very positive correlation with the sum of absolute values of DRIS index. This correlation can be useful, because, as per the results of previous studies, there is a significantly inverse relationship between the sum of DRIS absolute values and yield.

Results and Discussion

The optimum range was obtained by calculating the average concentration of high yield of orchards in the region, as shown in Table 1 of which the numbers are much similar to the results by other researcher (Tombsi et al., 1996) who have reported the optimum range of 1.5-2 for N, between 0.1-0.2 for P, more than 1.2 for K, more than 30 for Mn, more than 25 for Zn, and for B is 30 mg per dry material in the olive leaf.

Mean, standard deviation, coefficient of changes, maximum and minimum of nutrients' concentrations on olive leaves with relative high yield are given in Table 2. The average nutrients' concentrations given in this table are used as the standard reference numbers which were applied to determine DOP index.

As the mean of DOP index is seen in diagram (Figure 1) and concerning the results related to the DOP index calculations, nutritional imbalance in olive orchards. Based in this, the sum of absolute values of orchards (ΣDOP) is more than zero and generally values range 90 to 376 units.

It is necessary to mention that the more distance there is to the ΣDOP from zero, the severe the nutritional imbalance is.

Generally, the order of nutritional need for nutritional elements was obtained as N > Zn > B > K > Fe > Mn > P > Cu. Concerning the macronutrients, order was N > K > P. 82.56% of nitrogen in studied orchards lacks such element which is the first priority in orchards nutrition. The reasons for the lack of this element can be a little organic matter in the region in terms of providing part of the required nitrogen from soil organic matter, as well as the lightness of soil texture and irrigation systems will be leached nitrogen of soil profile. K is the second element in terms of deficiency of microelements, but fourth in the nutrition point of view where 79.07% of orchards suffer such deficiency. Since the olive has used a great deal of this element

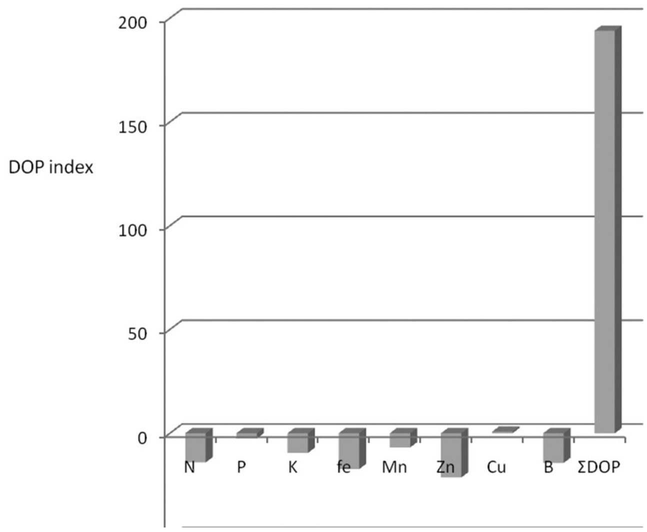

Figure 1: Average DOP index of elements in olive orchards of the area.

Table 1: Nutrient concentration references of calculated

Element	*%N*	*%P*	*%K*	*B (ppm)*	*Fe (ppm)*	*Mn (ppm)*	*Zn (ppm)*	*Cu (ppm)*
Optimum	1.54	0.12	1.36	27.05	128.31	44.79	22.31	4.95

Table 2: Summary of statistical results of nutrient of olive leaf

	N	*P*	*K*	*fe*	*Mn*	*Zn*	*Cu*	*B*
Min	0.98	0.06	0.730	37.2	15.8	8.20	1.8	14.20
Max	2.50	0.20	2.100	246.8	83.2	40.00	10.3	76.80
Mean	1.54697	0.11709	1.2677	106.093	41.65348	19.680	5.03372	25.7116
Median	1.5500	0.11000	1.255	92.5000	41.1000	18.750	4.7	23.450
Stdev	0.284096	0.03187	0.23478	45.827692	11.5213	6.4692	1.80949	9.2165
Variance	0.080710	0.00101	0.05512	2100.1773	132.74111	41.85148	3.274261	84.944
Skew	0.573636	0.432218	0.76537	1.2209014	0.5338453	0.801544	1.047422	2.68171
Kurt	0.969498	-0.49325	1.62483	1.0214477	1.067481	0.453585	1.156128	10.8576
Coefficient of variation	18.36461	27.22382	18.5191	43.195764	27.659946	32.87193	35.94740	35.8457

that accumulated in the fruit and then taken out of the farm, potassium supply is the main nutritional problem in olive orchards. Fernandez-Escobar (2004) stated that olive is a plant which needs high level of potassium, because more potassium is absorbed by fruits compared to nitrogen and phosphorus. A great deal of this element gets out due to pruning of plant organs. Light texture of soil also indicates its deficiency. On the other hand, the region's gardeners do not pay attention to this nutrient in terms of fertilizing feeding.

Phosphorus deficiency in macronutrients is on the third setting, but on the seventh status with 55.8% of which the results can be lack of attention to nutrition of this element and high pH of region's soil and their stabilization in soils. Because of calcareous soil in the region, phosphorus with calcium precipitated in fluor apatite and hydroxyl apatite forms and consequently, phosphorus usable for plant is low and the need to the element is prioritized for the plant. As far as the microelements are concerned, the arrangement is obtained Zn > B > Fe > Mn > Cu. About 81.4% of the olive gardens have zinc deficiency, which is nutritionally placed in the second place, giving priority to total plant nutrition after nitrogen, but only in micronutrient deficiency have first place.

The third priority is boron, 80.23% of the gardens are deficient in this element of all elements but in microelements priority is second place. Iron is placed in the fifth priority nutrition of gardens, with 74.4% of the gardens being deficient in this element. Manganese with 64.44% deficiency in the sixth priority nutrition of gardens. Finally, the copper element is in the eighth place of nutrition deficiency with 56.98% lack of gardens. The elements of boron and zinc, in the first priority, have a deficiency among microelements and even the highest priority among all elements. As this is not expected due to the lack of consumption of these elements among farmers and high soil pH in olive orchards.

This is consistent with results of study by Noori et al. (2015), where among Tarom olive orchards, all orchards with relative low yield are in imbalanced status in terms of nutrients and N, K, Mn, Zn and Br deficiencies are 36%, 84%, 93%, 35% and 95%, respectively. But considering their displacement, priority varies due to different characteristics of souls and type of fertilizer used by the gardeners. This finding is also consistent with the studies by Soyrgin et al. (2002) who observed lack of Br and Zn in most orchards with low yield. Therefore, with regards to the role these elements play in flowering (Salih and Andderson, 1999) and fruit formation and survival, measures should be taken to use them in olive orchards with low yield.

Conclusion

Results obtained by DOP method showed that the status of nutrients is imbalanced in most orchards in the region indicating the lack of proper management in their nutrition. Another significant point is that sum of DOP absolute values for orchards with low yield is higher than zero and in most cases, too much higher than zero indicating lack of balance among the nutrients absorbed by the olive tree in these orchards. The more nutritional balance is disrupted, the more yield deteriorates. The order of need determined to nutrients in olive orchards as N > Zn > B > K > Fe > Mn > P > Cu with the help of DOP index. Most of such orchards suffer lack of high consumption elements such as N and K; they also lack greatly the low consumption elements like Zn, B and Fe. In view of the reference numbers obtained in this study, nutritional balance be evaluated in each olive orchard in the Province by DOP method and the proper decision can be made. Based on the results of present study, it is recommended to provide the nutrition of olive orchards in the region based on the prioritization already made.

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