Nutrient Management: A New Option for Olive Orchards in North Africa

By Hakim Boulal, Lhassane Sikaoui and Mohamed El Gharous

North Africa's goal of expanding its olive sector has led to large orchard area expansion under both rainfed and irrigated systems. This summary of best management practices (BMPs) for nutrient application in olive describes the foundation that research must build upon to sustain olive production.

Olive (*Olea europea* L.) is one of the most important crops for North African region. Tunisia, Morocco and Algeria are North Africa's largest olive producers. More than 95% of the world's olive production comes from the Mediterranean basin (IOC, 2012).

Olive trees are adapted to a large variety of soils, however soils with high clay or salt content are not suitable for olive groves. Olive trees grow across a wide range of precipitation regimes, i.e., from less than 200 mm to more than 800 mm. Olive trees cannot tolerate low temperatures and can be severely damaged by winter or early spring frost. Planting densities vary widely, varying from 17 trees/ha (Sfax region, Tunisia) to more than 1,000 trees/ha (irrigated intensive system). In the last few years, the introduction of high-density olive orchards with over 1,800 trees/ha, called the "super-intensive" orchards, has occurred.

Mature olive trees naturally produce a large number of flowers. Depending on the variety, the first production begins in the 3rd or 4th year after plantation establishment. The annual production of olives depends on climatic conditions and the alternate bearing of trees characterized by one year with high and the successive year with low production. Olive yield per hectare can range from less than 1 t/ha to more than 20 t/ha (Vossen, 2009).

Recently in North Africa, there has been a renewed attention to the improvement of the olive sector. In Algeria, a development plan was launched with the objective to reach a total area of 1 million (M) ha by 2014. More than 240,000 ha area was planted with olive trees between 2000 and 2012, making it the most important tree crop in Algeria. In Tunisia, olive trees cover over 33% of the agricultural area with 1,700,000 ha of planted area, making it 2nd in the world in terms of olive cultivated area next to Spain. The plan for olive development in Tunisia is to reach a production of 210,000 t by 2016. In Morocco, the Green Morocco Plan expects the extension of olive groves to more than 1.2 M ha by the year 2020.

Importance of Nutrients for Olive Groves

Most of olive trees are under rainfed conditions. In some regions with a scarcity of water, supplemental irrigation is practiced to improve olive yield. In the last several years, the emergence of intensive systems under irrigation, with very high plant densities, has increased the need for fertigation.

Plant growth, fruit production, oil production and quality are all expected to be influenced by the availability of nutrients.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; Mg = magnesium; Na = sodium; B = boron; Cl^- = chloride; Cu = copper; Fe = iron; Mn = manganese; Zn = zinc; ppm = parts per million.

Super-intensive irrigated olive orchards in Marrakech region of Morocco.

Most nutrients are removed during fruit harvest, pruning, and natural leaf drop. Studies on olive orchards have shown that fertilizers had an important effect on olive production (Elloumi et al., 2009) and oil quality (Fernandez-Escobar et al., 2006). Each nutrient plays a fundamental role in the productivity of olive trees. After planting, olive groves need fertilizers until the tree begins its productive stage, i.e., for a period of 3 to 4 years. Nitrogen, P, K, and B have been reported to be the essential nutrients for olive orchards (Delgado et al., 1994).

Macronutrients

Nitrogen

Olives respond to N in low fertile soils and the lack of N is the most common nutrient deficiency in olive tree groves (Gregoriou and El-Kholy, 2010). The critical period for N availability is floral induction, and more specifically, before flower bud differentiation. The remainder is applied during the flowering period. In olive-bearing trees, N is applied before this critical period. Excessive N fertilization decreases olive oil quality due a decreased polyphenol content (Fernandez-Escobar et al., 2006). Excess N supply can also negatively affect olive fruit production and delay fruit ripening. The best time for N application depends on the availability of water. In rainfed system, N is applied in the middle to end of winter (February to mid March). Under irrigated system, N can be applied periodically from February to September.

Potassium

Potassium is one of the important nutrients for olive trees. Potassium fertilization is essential for olive growth because a high concentration of K is found in the fruit, which is removed at harvest. Potassium has a significant effect on fruit growth, oil quality (Ben Mimoun et al., 2005) and olive yield (Elloumi et al., 2009). Potassium is required at later stages of crop growth for ripening of fruits. The amount of applied K is normally adjusted to equal N application.

Phosphorus

Phosphorus deficiency is not common in olive trees across North Africa. However, P application at the first stage of the crop has an important role in supporting root growth.

Olive orchards under rainfed system in Essaouira region, Morocco.

Phosphorus is usually applied once every 2 or 3 years. Phosphorus sources should be incorporated into the soil due to immobility after application. Phosphorus fertilizer use has become more common with the increase in intensive olive grove systems. Some recent studies have shown improved flowering and fruit set levels with increased P uptake (Erel et al., 2008). It is generally recommended that P application should not exceed 30% of N application.

Micronutrients

Among the micronutrients that have been shown to have a key role in olive productivity, B requires the most attention. Boron plays an important role in olive fruit set, oil content and oil quality (Desouky et al., 2009). In the case of B deficiency, it is commonly first observed in the growing tips of trees.

Nutrient Management of Olive Trees

Research with olive trees has shown that soil analysis is not enough to diagnose nutrient status (Fernández-Escobar, 2004). Foliar analysis is considered the best tool for detecting the nutritional status of an olive orchard (Fernández-Escobar et al., 2009). Sampling olive leaves for nutrient analysis should be done when the concentration of the nutrient elements is most stable, which in North Africa is the period between the end of June and the end of July. Sampled leaves should be picked from the current year's new growth shoots, which are not bearing fruit. Comparing actual leaf nutrient concentration to reference (critical) values (**Table 1**) allows the diagnosis of nutrient deficiency, sufficiency or excess. Fertilizer application to correct any deficiency can be made directly to the soil, by foliar application or through a drip irrigation system.

Table 1. Critical nutrient levels in olive leaves.

	Concentration of elements in plants		
Nutrient	Deficiency	Optimum levels	Toxicity
N, %	<1.4	1.50-2.00	>2.55
P, %	<0.05	0.10-0.30	>0.34
K, %	<0.40	0.80-1.00	>1.65
Mg, %	<0.08	0.10-0.16	>0.69
Ca, %	<0.60	1.00-1.43	>3.15
Na, %			>0.20
S, %	<0.02	0.08-0.16	>0.32
Cl-, %			>0.50
Cu, ppm	<1.5	4-9	>78
Zn, ppm	<8	10-24	>84
Mn, ppm	<5	20-36	>164
Fe, ppm	<40	90-124	>460
B, ppm	<14	19-150	>185

Adapted from Freeman et al (1994); Fernández-Escobar (2004) and Connel and Vossen (2007) as cited by Haifa-group (available online at www.haifa-group.com/files/Guides/Olive_Booklet.pdf; verified Aug. 30, 2013.).

Table 2. Uptake of nutrients (kg/ha) based on olive production in Tunisia.

Yield, t/ha	N	P_2O_5	K_2O	References
0.7	7	1.7	11.5	Braham (1999)
2.3	15.6	4.2	30	Braham (1999)
10	120	40	160	Malek and Mustapha (2009)

Since the first year of plantation establishment, nutrient requirement of olive trees should be met using a combination of both organic and inorganic nutrient sources. The rate and type of fertilizers used are based on the type of management used in the olive orchard and the yield potential. Nutrients removed as a result of fruit harvest, annual pruning and natural leaf drop must be replaced and returned to the soil to maintain its fertility and crop productivity. Most of the data from North Africa has shown that N and K are taken up in significantly larger amounts compared to P. The quantities of nutrient removed by olive trees (**Table 2**) should be taken into account in any fertilizer recommendation program.

Summary

Management of fertilization in olive groves is a complex issue, dependent on factors including tree variety, age, planting density and whether the groves are irrigated or rainfed. Future success of olive expansion in North Africa, where governments are encouraging the development of the sector, requires further and more detailed research to identify the best management practices (BMPs) needed for improved fruit and oil production under both rainfed and irrigated systems. BC

Dr. Boulal is Deputy Director IPNI North Africa Program; e-mail: hboulal@ipni.net. Mr. Sikaoui is Olive Specialist, INRA Marrakech, Morocco; e-mail: sikaovilhassane@yahoo.fr. Dr. El Gharous is Consulting Director IPNI North Africa; e-mail: melgharous@ipni.net.

References

Ben Mimoun, M., O. Loumi, M. Gharab, K. Latiri, and R. Hellali. 2005. Revue H.T.E. N° 131 - Mars/Juin pp 61-64.

Braham, M. 1999. Revue ezzaitouna, 5(1&2): 22-29.

Delgado, A., M. Benlloch, and R. Fernández-Escobar. 1994. HortScience 29(6): 616–618.

Desouky, I.M., L.F. Haggag, M.M.M. Abd El-Migeed, Y.F.M. Kishk, and E.S. El Hady. 2009. World J. Agri. Sci. 5(2): 180-185.

Elloumi, O., M. Ghrab, and M. Ben Mimoun. 2009. Proc. Intl. Plant Nutrition Colloquium XVI, Department of Plant Sciences, UC Davis. Aug 26-29, 2009.

Erel, R., R. Dag, A. Ben-Gal, A. Schwartz, and U. Yermiyahu. 2008. J. Amer. Soc. Hort. Sci. 133(5): 639-647.

Fernández-Escobar, R., G. Beltran, M.A. Sanchez-Zamora, G. Garcia-Novelo, M.P. Aguilera, and M. Uceda, 2006. Hort. Sci. 41(1): 215-219.

Fernández-Escobar, R., M.A. Parra, C. Navarro, and O. Arquero. 2009. Spanish J. Agri. Res. 7(1): 212-223.

Fernández-Escobar, R. 2004. *In* D. Barranco, R. Fernández-Escobar, L. Rallo (eds.). El cultivo del olivo. Mundi-Prensa, Madrid, pp. 286–319.

Freeman, M., K. Uriu, and H.T. Hartmann. 1994. *In*, L. Ferguson, G.S. Silbert, G.C. Martin (eds.). Olive Production Manual. Univ. CA. Division of Agri. and Resources. Publ. 3353, pp. 77-86. Oakland, California.

Gregoriou, C. and M. El-Kholy. 2010. *In*, AARINENA & FAO Ed., pp: 182-196, ISBN 978-92-5-106348-4.

IOC, 2012. International Olive Council. www.internationaloliveoil.org

Malek, B., and S. Mustapha. 2009. Olivebioteq S6-C3: 169-176.

Vossen, P. 2009. Olivebioteq S4-C2: 8-37.