Importance of Potassium in Avocado Cultivation

Related Crops

A. Potassium (K) functions in all higher plants

The potassium cation K^+ is the most abundant cation in plant cell's chloroplasts and cytosol (the liquid matrix around the cell's functioning organelles), but it is not fixed to any specific organ. High K concentrations balance the negative charge of all kinds of organic and inorganic anions, and thus, stabilize and buffer the cytosol's pH at 7–8, which is the optimum for most enzymatic reactions. Furthermore, K^+ and its accompanying anions are a major factor determining the osmotic potential of the cells and tissues of the plant. It is highly mobile in plants at all levels: within the cells, within tissues, and in long-distance transport, via the xylem and phloem. This high mobility enables it to become a multi-task factor in plant metabolism. Apart from its roles in maintaining pH, EC and osmotic potential, K has a prominent effect on enzymes and coenzymes, by stabilizing their structure and activity. These enzymes and coenzymes participate in nearly one hundred physiological plant processes, like cell division, transpirationphotosynthesis, sugars and lipids metabolism, proteins synthesis, biotic- and abiotic stress reduction, winter hardiness, disease- and pest- resistance, fruit growth, and pre-, and post-harvest fruit quality.

Potassium has an outstanding role in the plant–water relations. It is central in the regulation of water balance and turgor pressure, by controlling the opening and closure of leaves' stomata, via controlling the concentration of sugars in the stomata's guard cells, see adjacent photomicrograph. It is the potassium, therefore, that massively affects the entire photosynthetic, and respiration activity of the plant, affecting, in turn, all other plant apparatus performance.

Additionally, K^+ is the main cation that accompanies anionic amino-acids, fatty acids and sugars within the plant, from their source, in the leaves, to their sinks in the developing buds, inflorescence, fruitlets, developing fruits, and all parts of the root system, feeding them with carbohydrates and amino-acids.

A. The specific importance of adequate K level for the avocado crop

In light of the abovementioned facts, potassium performs central roles, which determine the performance of the avocado tree, mainly by the following manners:

1. Resistance towards heat and drought stresses, especially- during flowering, fruit-set and first stages of fruit development. This function is very important for avocado final yield, because the tree is very sensitive to such stresses. If the tree's stomata don't close immediately under suboptimal K nutrition, the tree may dehydrate rapidly. This will provoke rapid shedding of its flowers, decimate fruit-set rate, and drop its recently formed fruitlets. This may end up with almost complete loss of an entire season's yield. Water stress can also negatively affect, internal fruit quality (Moreno-Ortega et al. 2019).

2. Avocado fruit volume is initially composed of about 80% of water, and it normally keeps reducing throughout the season, being replaced by oil, see figure 1. Insufficient hydration status of the tree, seriously reduces fruit growth, especially if it takes place at the critical stages, at which final fruit size is determined. This will have a harmful effect on cultivars that normally produce a significant share of small and less commercial fruits, like the very popular cultivar *'Hass'*.

Figure 1: Water content in the pulp of the fruits of three avocado cultivars, throughout their growth development. Ref. Haas, 1938.

Moreover, inadequate hydration status of the tree reduces cells elongation and volume, of the growth tips of the trees' shoots and roots. It also harms cells' aqueous environment, regarding its EC and pH, thereby reducing physical stability, and biochemical activity of the avocado tree.

3. As mentioned above, the avocado tree is very sensitive to heat. Fortunately, when the tree is at a good hydration status, it can cool itself by positively opening up its stomatal system. The massive, though controllable, water transpiration via the stomata, can markedly reduce the tree's temperature bringing it to a tolerable range. Therefore, adequate K status of the tree can minimize the injury that heat waves, (contemporary ones, and those predicted for the upcoming decades) may provoke to subtropical avocado plantations (Moreno-Ortega et al. 2019).

4. As mentioned in paragraphs #1 & 2, avocado fruit growth is characterized by continuous reduction of water content, and parallel increase in its oil content. The central role of potassium in synthesis and translocation of fatty acids, has, therefore, a direct, major effect on avocado fruit growth process, its size, and its high human nutritional value, as an excellent source of healthy monounsaturated, and polyunsaturated oils.

An additional aspect regarding the importance of potassium to avocado crop, is that it serves as a super-food, thanks to its very high K contents (485mg /100g), which is 40% greater (w/w basis) than a banana fruit. Therefore, it's in the consumer's and grower's interest to make the fruit as rich in potassium as possible.

5. Adequate K content in the avocado fruit is a prerequisite for its postharvest life, in terms of its internal quality. The balance between the concentrations of potassium, calcium and magnesium is an important factor, determining its mesocarp's (pulp) color. K deficiency, expressed as high (Ca+Mg)/K ratio, greatly

increases mesocarp browning of *'Hass'* fruits, due to excessive activity of polyphenol oxidase. K deficient fruits easily reduce their aesthetic value by discoloration of their vascular system (Mhlophe & Kruger, 2013).

6. On the other hand, excessive plant's potassium may increase phloem transport, and decrease calcium level in the fruit, due to depressed xylem flow into it. So, potassium application rate must be calculated very carefully.

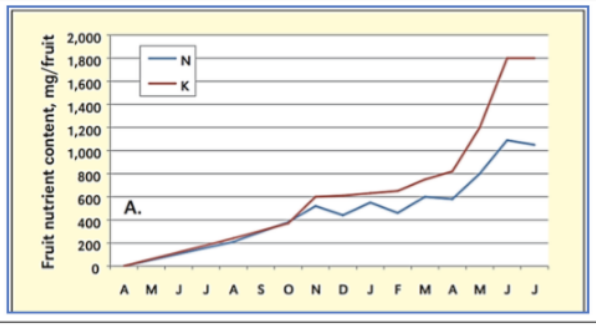
7. The said interplay between K^+, NH_4^+, Mg^{2+} and Ca^{2+} also takes place in the root-soil level, whereby all these cationic nutrients compete with each other on being taken up by the tree roots. It should be mentioned in this context, that K uptake by the roots is highly selective, and closely coupled to the avocado tree's metabolic activity.

To sum it up, it can be stated that avocado trees must be supplied with copious potassium rates, to produce more fruit units and larger and higher external and internal fruit quality. And since a high proportion of the nutrients taken up from the soil, end up in the fruit, which will be eventually exported from the plot, it is essential to continuously replenish potassium levels in the soil, for next seasons' crops.

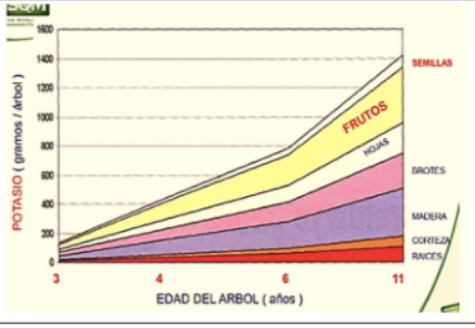
A. Potassium uptake by avocado trees

Avocado fruit is unique, as it may remain on the tree for up to 18 months after spring bloom, during which, the developing fruit features a strong sink for nutrients. It is very important to supply the avocado tree with its necessary nutrients, right when they are physiologically required. Timely application maximizes yields, improves fruit quality, increases nutrient uptake, and use efficiency.

N & K accumulation curves in '*Hass*' avocado fruit from bloom to harvest. California. (Rosecrance, 2012)



Distribucion del potasio en los diferentes organos del arbol de aguacate (Snidjer & Stassen, 2000)



The above left figure shows that fruit uptake rates of nitrogen and potassium are very similar, during its initial growth stages, but as of November (Northern hemisphere), potassium uptake rate keeps increasing markedly, above that of nitrogen. The above right figure shows that at every moment of an avocado

tree's life, the highest potassium concentrations are found in the tree's trunk, somewhat less- in the fruits, and considerably less- in the buds.

Literature cited

Abercrombie, R.A. 2009. Fertilization. In: The Cultivation of Avocado (eds. De Villiers, E.A. & Joubert, P.H.), pp. 142-150.

Stones, W. 2009. Management in Brief. AvoInfo 166: 8-9

Lovatt, C. 2015. Optimizing 'Hass' avocado tree nutrient status to increase grower profit - an overview. VIII Congreso Mundial de la Palta, Lima, Peru. 2015.

Rosecrance, R., Faber, B., Lovatt, C. 2012. California, Patterns of Nutrient Accumulation in 'Hass' Avocado Fruit.. Better Crops, 2012, No. 1. Vol. 96. Pp. 12-13.

Guerrero-Polanco, F., Alejo-Santiago, G., Sánchez Hernández, Bugarín Montoya, R.R., Aburto-González, C.A., Isiordia-Aquino, N. 2018. Respuesta del cultivo de aguacate, variedad Hass a la aplicación de nitrato de potasio. Acta Agron. (2018) 67 (3) p. 425-430.

Mhlophe, S.D. & Kruger, F.J. 2013. Addressing the Postharvest Vascular Staining Disorder of 'Maluma' Avocado (Persea americana Mill.) Fruit. Proc. 2nd All Africa Horticulture Congress, Eds.: K. Hannweg and M. Penter. Acta Hort. 1007, ISHS. 2013