Identifying Fruit Mineral Removal Differences in Four Avocado Cultivars

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The goal of this research was identification of proper fertilization management strategies for sustained production of high quality fruit for dominant commercial avocado in Mexico by assessing nutrient removal by four major avocado cultivars.

Mexico is an important avocado producer, with close to half of the world's production. Commercial avocado producers are concentrated in the states of Michoacan and Nayarit (Téliz-Ortíz et al., 2000). With an area of more than 95,000 ha and a production of over 800,000 t of fruit per year, the Mexican avocado industry provides a direct source of income to more than 61,000 families. It is estimated that new plantations and technology will increase Mexico's production to over 1 M t/yr by 2005. With an internal market value estimated at over US$1 billion, the avocado industry will play an important role in the regional economy.

For many years, profitability of avocado production was measured in terms of total fruit yield per tree or hectare. However, this parameter has lost importance due to market globalization. Currently, harvest time, size, and fruit quality (external and internal) are considered the main factors for successful avocado marketing. To determine the proper fertilization management that sustains fruit production of the size and quality required, it is necessary to have information on nutrient removal for each commercial avocado variety grown in the region.

Traditionally, little fertilizer has been used, based on the belief that the avocado tree is adapted to medium and low fertility soils. Given the fruit's high oil content (up to 20 percent), high yield avocado production requires an adequate supply of nutrients, especially potassium (K). Owners of old orchards argue that it was common, 30 to 40 years ago, to get 20 t/ha yields without fertilization, but today it is almost impossible because native soil fertility levels have declined significantly.

Average yields for avocado orchards in Mexico now range from 4 to 10 t/ha/yr. In most orchards, fertilization rates range from 0 to 100 kg/ha of nitrogen (N) and from 0 to 115 kg/ha for P_2O_5 and K_2O. Growing evidence indicates scientifically managed orchards may

easily produce yields greater than 25 t/ha/yr, minimizing the alternate bearing problem (when trees or orchards bear a high yield...“on” crop year...followed by a low yield...“off” crop year). Despite improvements in orchard management, no local information is available on crop nutrient export in commercial avocado orchards. This study, which assessed mineral nutrient removal by fruit of four major avocado cultivars, will give growers important information regarding improved fertilization and will help create rational nutrition management plans for avocado orchards under rain-fed conditions.

Materials and Methods

Four avocado cultivars, Booth-8, Choquette, Hall, and Hass, were grown in commercial orchards. Booth-8, Choquette and Hall avocado orchards were located at 700 meters above sea level (masl). The Hass avocado orchard was at 950 masl. Soils in all four sites were typical of most avocado orchards and were well suited to each cultivar. Sites were located at Tepic, Nayarit, on sandy loam soils with cation exchange capacity (CEC) values between 5.2 and 9.2 $cmol_c$/kg, pH values from 5.0 to 5.8, 4 to 15 parts per million (ppm) Bray P-1, 222 to 1,000 ppm exchangeable K, 2.9 to 4.0 percent organic matter, and low to mid levels of micronutrients at all sites. All avocado tree management followed traditional fertilization practices used by cooperators without irrigation. Each tree received 6 kg 17-17-17 (N-P_2O_5-K_2O) in two applications, one at the beginning of the rainy season (June to July) and another at mid-growth. No foliar applications of micronutrients were provided despite apparent zinc (Zn) deficiency symptoms, mostly in the Hass orchard. Five physiologically ripe, average size avocado fruit were harvested from each of 20 trees. These were analyzed for mineral nutrient content, various quality traits, and yield components, including epidermis, pulp, seed coat, and cotyledons plus embryo. Each fruit part was weighed fresh and dried. Chemical analyses were performed using standard methods approved by the Mexican Soil Science Society. Nutrient removal was calculated as the amount of each nutrient in dry matter. Calculations based on dry and fresh fruit weight are reported.

Results and Discussion

Fresh fruit weight is a common parameter to estimate yield and profitability of an avocado orchard. However, this does not mean that bigger fruit or an abundant harvest of big fruit will extract more nutrients from the soil. Information on the difference in fruit fresh weight among avocado cultivars is provided in **Figure 1**. Hass avocado (239 g/fruit) could be considered a small fruit compared to Booth-8, Hall and Choquette.

Dry matter content showed a different pattern than fresh fruit weight

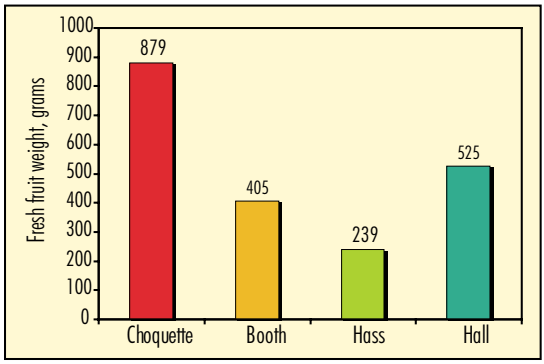


Figure 1. Average fruit fresh weight of four avocado cultivars.

(**Figure 2**). Hass fruit had the highest dry matter content (23.2 percent) compared to other cultivars. This study showed that fruit size was not directly related to total nutrient removal. There were significant nutrient removal differences among cultivars. Nutrient removal was much higher for smaller, higher dry matter content fruit, such as Hass.

Dry matter is composed of carbon and other nutrients accumulated during fruit growth and development. Nutrients are also used in protein and oil synthesis, both found in high amounts in the Hass cultivar fruit. Therefore, it is expected that fruit with high dry matter and oil content will require more nutrients.

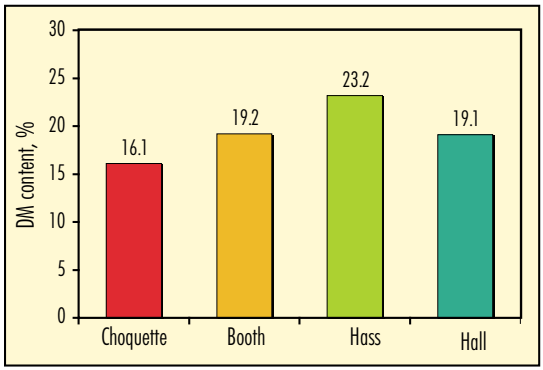
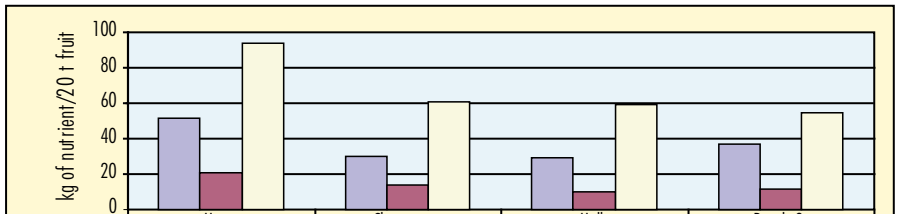


Figure 2. Average percent dry matter content per fruit.

Despite many cases of higher yields in Mexico, energy costs have established the yield potential for Hass avocado at 32.5 t/ha (Wolstenholme, 1986). In this study, calculations of nutrient removal were based on a fresh fruit yield of 20 t/ha. It is important to mention that for Choquette orchards (with 100 trees/ha) yields may go over 60 t/ha. Thus, nutrient removal might be greater when these yield potentials are included. However, no research has been done to determine fruit nutrient content for record yields in this cultivar.

In this study, the amount of N, phosphorus (P) and potassium (K) removed by a crop of Hass avocado was highest (**Figure 3**). A crop of 20 t/ha removed 52, 21 and 94 kg of N, P_2O_5 and K_2O, respectively. Potassium removal by Hass avocado fruit was 70, 77 and 39 percent higher than Choquette, Hall and Booth-8, respectively.

Figure 3. Nitrogen, phosphorus (P_2O_5) and potassium (K_2O) removal in 20 t of avocado fruit.



	Hass	Choquette	Hall	Booth-8
Nitrogen	51.5	30.2	29.1	36.9
Phosphorus	20.6	13.8	10.0	11.6
Potassium	93.8	60.5	59.2	54.3

Table 1. Nutrient removal according to fresh fruit production of several avocado cultivars grown without irrigation in Nayarit, Mexico.

	Nutrient removal							
	Grams per 100 kg of fresh fruit				kg per 20 t of fresh fruit			
Nutrient	Hass	Choquette	Hall	Booth-8	Hass	Choquette	Hall	Booth-8
N	257.0	151.0	145.0	185.0	51.5	30.1	29.1	36.9
P_2O_5	103.0	69.2	49.9	58.2	20.6	13.0	10.0	11.6
K_2O	469.0	302.0	296.0	271.0	93.8	60.5	59.2	54.3
Ca[1]	8.4	8.7	6.5	10.4	1.7	1.7	1.3	2.1
Mg	29.5	16.3	16.5	22.3	5.9	3.3	3.3	4.5
S	34.5	19.2	18.4	22.6	6.9	3.8	3.7	4.5
Cl[1]	12.0	7.3	0.2	7.4	2.4	1.5	0.04	1.5
Fe[1]	0.6	1.0	0.4	0.7	0.12	0.2	0.08	0.14
Cu[1]	0.2	0.1	0.2	0.2	0.04	0.02	0.04	0.04
Mn[1]	0.1	0.1	0.01	0.07	0.02	0.02	0.002	0.014
Zn	0.4	0.3	0.3	0.2	0.08	0.06	0.06	0.04
B	0.4	0.2	0.2	0.3	0.08	0.04	0.04	0.06
Mo	0.02	0.01	0.01	0.01	0.004	0.002	0.002	0.002
Na[1]	1.0	0.6	0.8	1.0	0.2	0.12	0.16	0.2
Al[1]	0.3	0.3	0.2	0.4	0.06	0.06	0.04	0.08

[1]Ca=calcium; Cl=chloride; Fe=iron; Cu=copper; Mn=manganese; Na=sodium; Al=aluminum.

Export of magnesium (Mg), sulfur (S), Zn, boron (B), and molybdenum (Mo) by fruit was highest with Hass avocado (**Table 1**). Nutrient removal by Choquette, Booth-8 and Hall avocados were similar; however, Hall showed a lower removal for several nutrients when compared to either Choquette or Booth-8 (**Table 1**).

Conclusions

These results show that it is reasonable to expect significant differences in nutrient removal among avocado cultivars. Growers should pay attention to each cultivar's yield potential and its fruit's total nutrient removal, by insuring sufficient N and K to achieve optimal growth and quality. Soil P, Mg and S should be in the sufficient range prior to planting, micronutrient status should be monitored, and foliar applications made if necessary.

Balanced fertilization programs that are cultivar-specific are essential for improving fruit yield and quality. A rational avocado fertilization program must include analyses of fruit nutrient content along with soil and leaf nutrient content to better estimate fertilizer application requirements. **BCI**

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