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THE EFFECTS OF HUMIC ACID AND PHOSPHORIC ACID ON GRAFTED HASS AVOCADO ON MEXICAN SEEDLING ROOTSTOCKS

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SUMMARY

An investigation was conducted to determine the effects of 12 % humic acid (HA) and 29 % phosphorous acids + 26% potassium (PAK) on the plant growth of grafted Hass avocado on Mexican seedling rootstocks over a 7 months period (May 2002-November 2002). The addition of a combination of HA+PAK indicated the highest increase in shoot height by 36.2 % and shoot diameter by 21.2% over the untreated trees. Humic acid treated trees increased by 28% in shoot height and 19.2% in shoot diameter. PAK treated trees increased by 21.7% in shoot height and 15.5% in shoot diameter over untreated trees at $p<0.01$ levels. The combination of HA+PAK and HA alone significantly increased tree biomass and relative growth rate (RGR) in comparing to untreated trees. There was no significant difference between the PAK treated trees and the untreated trees.

Iron uptake by the plants was also effected by the addition of HA+PAK and HA. Leaf analysis showed a high level of nitrogen and a slight increase in potassium in the tree treated with HA and HA+PAK. However, untreated trees and PAK treated trees did not have any effect in N and K uptake. The application of HA also increased Ca and Fe. This study showed that the application of humic acid has a positive influence in promoting overall tree vigor. Treated trees were larger and the root system was better developed than the untreated trees.

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INTRODUCTION

The establishment of a successful avocado orchard requires careful planting and caring of the trees during the first 2-3 years after planting. One of the most important factors is the selection of healthy and vigorous nursery trees. No combination of favorable climate, good soil, water, and management can overcome the handicap of inferior trees. Many young trees fail to become established in the ground, especially clonal rootstocks, which tend to have weaker root systems due to less developed taproot compared with seedling rootstocks. Another problem in establishing the trees is wind damage. During strong Santa Ana winds, young trees without a strong root system tend to be more damaged than those with a good strong root system. Healthy, strong and vigorous trees are able to withstand pest and disease infections and recover much faster from adverse effects.

In California, avocado seedlings of the Mexican race are commonly used for rootstock as they are more adapted to the cooler subtropical areas. Grafted avocado trees generally take at least 6 months to reach saleable tree size. Reducing time and labor by stimulating tree growth may help to decrease production cost of nurseries.

Currently, at Cal Poly Pomona avocado orchards, phosphoric acid and 12% humic acid are used to promote tree growth. Phosphoric acid is a soluble fertilizer, which has shown to help fruit trees growing in *Phytophthora cininamoni* root rot infected soils. Injecting phosphoric acid into infected avocado trees resulted in improved root growth in *P. cininamoni* root infected areas. During the past several years, humic acid has been promoted by many commercial companies as a plant growth amendment. However, most of the research has been done in annual crops such as, vegetables growing in the hydroponics systems. Data on the influence of humic acid on avocado is currently very limited or non-existent. More information is needed on increasing plant nutrient content and improving avocado growth by using humic acid and phosphoric acid as a cultural practice.

The purpose of this study was to monitor the influence of 12% humic acid (HA), 29% phosphoric acid + 26% potassium (PAK) and a combination of HA+PAK on avocado growth (dry shoot and root weight) and relative growth rate of Hass scions grafted onto Mexican seedling rootstocks. The objectives of this study were to: 1) observe and monitor monthly the influence of HA, PAK and HA+PAK on tree height and tree diameter of Hass scions grafted onto Zutano seedling rootstocks. 2) Measure any differences in the dry weight of shoots and roots of the Hass avocado trees treated with HA, PAK and HA+PAK. Leaf tissue analysis was used to check the relative nutrient status of the treated avocado trees.

LITERATURE REVIEW

Humic acid (HA) is a heterogeneous mixture of many compounds with generally similar chemical properties; it performs various functions in the soil and on plant growth. One of the functions of HA is the positive effect on the promotion of root development. Tattini et al. (1990 and 1991) reported that HA increased the root/shoot ratio as well as the production of thin lateral roots of olive plants. In addition, HA, prepared from leonardite coal, stimulated both shoot and root growth (Adani et al., 1998).

Humic acid is also known to improve nutrient absorption and plant growth. In many soils, phosphate readily forms in almost insoluble mineral compounds, such as apatite. Experimental data conducted by Lobartini et al. (1994) reported that increasing the amount of HA increased the rate of dissolution of apatite. Olk and Cassman (1995) reported that the addition of HA to vermiculitic soils reduced K fixation and resulted in greater total extractable K and highly labile K, as well as plant K uptake.

Organic phosphates are the compounds that provide the energy for most of the chemical reactions that occur in living cells and help stimulate root growth. Pegg et al. (1987) reported that avocado trees affected by root rot caused by *Phytophthora cininamoni* recovered rapidly when phosphoric acid was applied.

MATERIALS AND METHODS

Uniform grafted Hass avocado trees on Mexican seedling rootstocks were obtained from LaVerne nursery. The experiment was conducted in the nursery at Cal Poly Pomona University. The trees were maintained conventionally except no lateral shoots were removed in order to prevent any effect on shoot growth. Plants were watered every two days or as needed. Soluble fertilizer, 150 ppm of N, 100 ppm of P, and 100 ppm of K, was applied every week to all of the trees.. The final fertilizer application was done 3 week before the leaves were taken for leaf analysis in order to prevent excess accumulation of the nutrients.

The experiment consisted of four treatments (control), commercial humic acid (HA) derived from leonardite coat, commercial phosphoric acid + potassium (PAK), and combination of HA and PAK. The treatments were arranged in a complete randomized block design with 4 replications. Each treatment consisted of 6 trees for a total of 96 plants. The experiment started on May 15, 2002 and ended on 25 November 2002. Humic acid was applied monthly to the pots at the rate of 1 ounce of 12% humic acid per gallon of water. One ounce of 29% phosphoric acid + 26 % potassium per one gallon of water was applied as a foliar application with a low volume sprayer till run off. The last application was applied in October 2002. Pesticides were not needed for any pests or diseases during the experiment.

Shoot growths from ground to apical meristem were monitored every 30 days for stem height measurements. At the end of the experiment, stem diameter at 1" above bud union was measured. Leaf tissue analysis was done at the end of experiment to check the effects of humic acid and phosphoric acid treatments on the nutrient uptake. Ten of the expanded and fully mature leaves were randomly selected from each block of each treatment for a total of 40 leaves per treatment. A plant tissue analysis was done at Fruit Growers Laboratory, Inc. in Santa Paula in Ventura County, California.

Before harvesting the trees, final shoot diameter and length were measured. After the measurements two trees of each treatment, for a total of 32 trees, were randomly picked. Plant roots were carefully removed from the pot and washed with water to remove the soil. Roots and shoots were separated and oven-dried at 90°C for 72 hours and weighed for dry shoot and root mass measurements (Whiley et al., 1995). The hypothesis was tested with complete randomized block ANOVAs. Tukey's Honest Significant Difference Test (HSD) was used for the mean separation.

RESULTS AND DISCUSSION

In this study, the application of humic acid indicated an improved nutrient uptake on grafted avocados due to it is high cation exchange capacity (CEC). The addition of humic acid to grafted avocado resulted in the increase of plant nutrient uptake. Leaf analysis indicated an increase in nitrogen and potassium due to the addition of HA and HA+PAK (Table1). However, the application of PAK and untreated did not have any effect in N and K uptake. The study provided evidence that N content with application of HA was higher than the optimum range of N requirement, while N content with the application of PAK was lower than the optimum rage (Fig 1). The increase of N uptake with addition of humic acid had been previously reported (David, 1994, Tan, 1967 and Tattini, 1990). The effect of HA and HA+PAK supplementation showed better K uptake than the PAK treat-

ment (Fig 2). K fixation is one of the fertilizer application problems due to the fact that K is trapped and tied up between soil layers, especially in clay soils. The mechanism of HA that affects K^+ availability is not clear. Olk and Cassman (1995) proposed that the increase in K availability and decrease in K fixation results from an expansion of K-bearing interlayer and rapid exchange reaction at the interlayer of clay platelets rather than the dissolution of minerals. Humic acid is abundant in functional groups, which leads to the active interaction with a diverse range of mineral components. Among them are carboxylic acid (COOH) and hydroxyl (OH) groups with ability to chelate positively charged ions.

Table 1. Leaf tissue analysis of 7-month-old avocado leaves. The avocado plants were treated with humic acid (HA), phosphoric acid + potassium (PAK), HA+PAK, and an untreated control.

Treatments	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Mn (ppm)	Fe (ppm)
Control	2.2	0.15	0.83	0.38	1.38	135	41
HA	2.6	0.14	0.98	0.45	1.73	169	50
PA	2.2	0.14	0.84	0.44	1.65	178	44
HA+PA	2.5	0.16	0.95	0.41	1.58	153	44
Optimum Range	**2.2 - 2.4**	**0.08 - 0.44**	**1.0 - 3.0**	**0.25 - 1.0**	**1.0 - 4.5**	**30 - 750**	**50 - 300**

The addition of humic acid by itself showed better results in nutrient uptake when compared to the combination of humic acid and phosphoric acid. The lower nutrient availability in the combination of humic acid and phosphoric acid may be associated with decrease in pH. As pH decreases, CEC can decrease due to the protonation of carboxylic groups as the concentration of hydrogen in solution increase. In this study, the decrease in nutrient uptake may be due to the decrease in pH in application solution rather than decrease in soil pH. The pH of humic acid application was dropped from 11.5 to 5.1 when mixed with phosphoric acid, which has a pH of 4.2. On the other hand soil, pH from humic acid and combination of HA+PAK treated soils remained at a pH of 6.1.

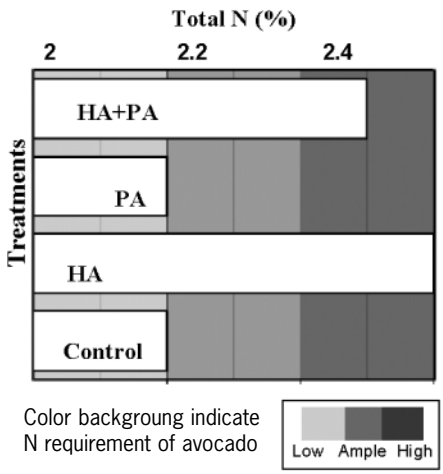

Figure 1. Total N in 7 month old avocado trees. The trees were treated with humic acid (HA), phosphoric acid (PA), HA+PA and untreated control.

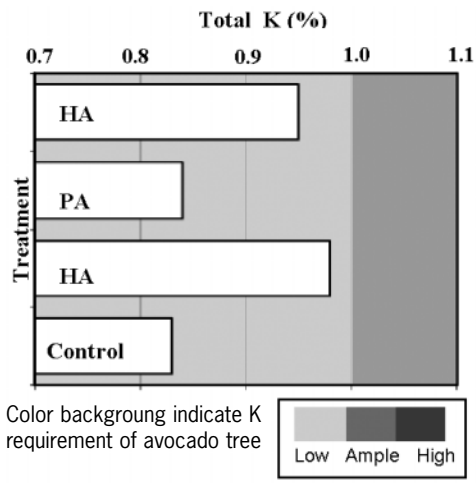

Figure 2. Total K in 7 month old avocado trees. The trees were treated with humic acid (HA), phosphoric acid (PA), HA+PA and untreated control.

This study indicated that the growth of grafted avocado was significantly increased with the additions of HA, PAK, and HA+PAK over the untreated trees (Fig 3). Shoot dry weight significantly increased with HA and HA+PAK treatments over the control at $p < 0.05$ and dry root weight at $p < 0.07$ (Fig 4). The increase of plant growth, plant biomass, and relative growth rate were likely an influence of humic acid since it was able to improve nutrient uptake, especially of nitrogen that leads to better growth in avocados. The effects of humic acid on plant growth have been reported in corn (Tan and Nopamornbodi, 1979), teak seedling (Fagbenro and Agboola, 1993), tomato seeding (David et al., 1994), (Ayuso et al., 1996), creeping bentgrass (Liu et al., 1998) and tomato (Adani et al., 1998).

Phosphoric acid and potassium seemed to be less effective in plant growth when compared with humic acid although there was no significant difference between humic acid, phosphoric acid and potassium, and the combination of both acids. Phosphoric acid by itself caused significant increase in tree height and diameter but not on shoot and root dry weight. However, Teng and Timmer (1994) reported that addition of phosphoric acid stimulated growth (107%), dry weight (362%) and N and P uptake.

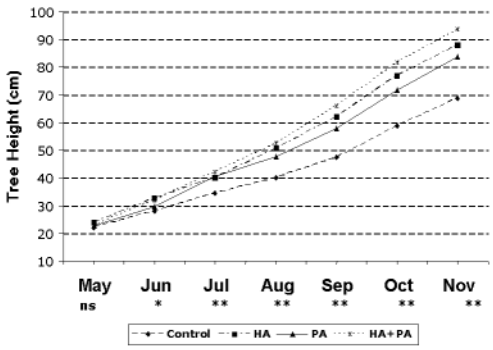

Figure 3. The effects of humic acid (HA) and phosphoric acid (PA) on tree height (cm) of grafted Hass avocado trees. ns = no significant, * significant at 5% level and ** significant at 1% level

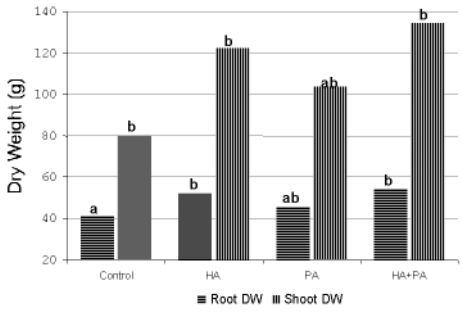

Figure 4. The effects of humic acid (HA) and phosphoric acid (PA) on shoot and root dry weight (g) of grafted Hass avocado trees. Bars with the same letters are not significantly different at $p < 0.05$ with HSD Test.

CONCLUSIONS

In this study, the combination of humic acid and phosphoric acid and potassium led to the highest results on plant growth, biomass, and relative growth rate. However, humic acid by itself seemed to be the best option on improving avocado plant growth since humic acid and the combination of humic acid and phosphoric acid + potassium did not show any significant difference between plant growth and biomass. In addition, application of only humic acid was less expensive when compared to the combination of humic acid and phosphoric acid + potassium.

The effects of humic acid on plant growth and nutrient uptake have been studied in many crops. However, no data are available on its effects on fruit production. The reduction of nitrogen fertilizer applications can help reduce the amount of N in the ground water. High levels of nitrogen in the ground water is becoming a serious problem. Long-term effects of humic acid on avocado growth and fruit production, including reducing nitrogen fertilizer, need to be further investigated.

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