California Avocado Society 2007 Yearbook 90: 131-148

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The Use of Naphthaleneacetic Acid (NAA) to Control Vegetative Vigor in Avocado Trees

Introduction

The California avocado industry exists on the interface of the urban agriculture complex of southern California where water availability, labor issues, exotic pests, and land prices threaten the continued sustainability of the state's avocado production. This is especially true when trees are planted on steep hillsides. Additionally, the California grower must compete with imported 'Hass' fruit from Mexico, Chile, Dominican Republic and New Zealand. Growers in many of these countries have access to plant growth regulators that help them manage tree vigor following pruning and overall growth.

In order to sustain the viability of the avocado industry in such a challenging environment, California growers must develop the necessary tools to maximize productivity while minimizing inputs into the agricultural system. Naphthaleneacetic acid (NAA), a plant growth regulator, has the potential to be such a tool. It is a synthetic auxin that is used for rooting, fruit thinning, reducing preharvest fruit drop and controlling the growth of watershoots and root suckers following pruning or topworking. NAA is registered for use in California on several commodities including citrus (both as a fruit thinning agent and for sucker regrowth), olives (as a fruit thinning agent), as well as sucker regrowth for apples, pears and nectarines. NAA has been previously evaluated for use in avocados. Boswell et al. (1976), reported promising results using NAA to control rootstock suckers in avocados. They found that a trunk application applied to topworked trees effectively controlled rootstock suckers for up to 7 months.

Prompted by the work of Boswell et al. (1976) we initiated a study in 2002 to re-evaluate the potential use of NAA on avocados. Our hope was to ultimately gain registration of this material to control vegetative growth and vigor of stumped and pruned avocado trees and thus provide the California avocado grower with a management tool that will assist in canopy management of this perennial subtropical tree grown primarily on steep hillsides. Our results, described below, suggest that the use of NAA as a vegetative management tool could help sustain the continued viability of the California avocado industry.

We hope that NAA will have several uses in the typical California avocado grove. First, it will be extremely helpful to the grower who wishes to rejuvenate their grove through "stumping", which is cutting a mature tree back down to a height of 3 to 5 feet. The natural disasters experienced by many growers during 2007 (freeze and fire), as well as water shortages, have prompted many to consider tree stumping. Experience has shown that when the avocado tree is cut back in this manner, vigorous growth results all over the tree stump including unwanted growth from the rootstock and lower portions of the stump.

A second use of NAA will be to control tree height when a grower chooses to maintain trees at a specific height. Tree height control and the subsequent reduction of ladder work are crucial for continued viability of hillside plantings from the perspective of harvesting and pest monitoring and management. We foresee in the next 3 to 5 years, as more growers move toward high density plantings and tree height control, that the use of NAA will have a place in this type of management strategy.

The final use of NAA would be for shoot tipping when a grower is doing maintenance pruning either in a high density or hedgerow setting. Successfully controlling vegetative vigor of the side branches will reduce subsequent labor inputs and will also increase sunlight penetration into the tree interior, thus reducing the dieback of interior branches due to the lack of sunlight.

We conducted 3 trials to evaluate the use of NAA for these purposes using a material manufactured by Amvac Chemical Corporation, Tre-Hold A-112. The results of these trials are summarized below.

The use of NAA as a trunk sprout inhibitor

For this portion of the project we asked the following questions: Does application of NAA to stumped trees inhibit the number and vigor of rootstock suckers and regrowth near the soil area? Does NAA application to the rootstock and lower portion of the tree inhibit growth and vigor above the bud union?

Mature 'Hass' trees on seedling Mexican rootstock (approximately 18 years old) were stumped to approximately 1.5 meters (5 feet) in mid-May 2003. Forty-two trees were selected and divided into 21 blocks of 2 trees each. The stump of one tree was whitewashed to the ground level and served as the control. The second tree was painted with an application concentration of 1.15% NAA (Tre-Hold A-112 diluted in water and latex paint; Amvac Chemical Corporation) to a height of approximately 90 cm (35.4 inches) above the soil line. The remainder of the stumped tree was whitewashed similar to the control tree. A band of brown paint was applied at the interface of the treated area to assist in subsequent evaluation (Figure 1). Treatments were applied on June 2, 2003. The number of suckers in the treated area, the number of shoots above the treated area and the vigor of the regrowth was evaluated on September 24, 2003.

At the time of evaluation, the number and relative vigor of shoots arising below and above the treated area were assessed. Shoot vigor was rated using the following scale: 0 = no growth or sprouting; -1 = sprouted but died back; 1 = some growth, not vigorous (growth < 25 cm; 10 inches); 2 = moderate growth (growth 25 - 50 cm; 10 – 20 inches); and 3 = vigorous growth (growth > 50 cm; >20 inches). All data was analyzed using CoStat version 6.204 (CoHort Software, Monterey, CA).

Figure 1. View of stumped tree just after application of 1.15% NAA (TreHold A-112 diluted in water and latex paint; Amvac Chemical Corporation). Note a control tree in background.

Table 1 reports the results of this part of the study. The results corroborate those reported by Boswell et al (1976). We observed fewer and less vigorous regrowth shoots in treated trees as compared to the controls. Shoot regrowth and vigor above the treated area was not impaired. This portion of the study demonstrates that an application of NAA to the lower portion of the stump successfully reduced both the number and vigor of shoot regrowth without negatively impacting regrowth of the upper portion of the tree.

The use of NAA to control regrowth on topped trees

For this portion of the project we were interested in answering the following questions. Does treating cut branches with NAA inhibit the number of shoots and vigor or the subsequent regrowth? Does the treated surface area of wood influence this response?

Table 1. The number of shoots and shoot vigor within the NAA treated area or above for stumped 'Hass' avocado trees (N = 21). NAA applied to trunk from soil line to 90 cm height. Trees treated 06/02/03 and evaluated 09/24/03.

	Treated Area		Above Treated Area	
	Shoot number	Shoot vigor (0 – 3)[z]	Shoot number	Shoot Vigor (0 – 3)
Control	3.95 a	1.30 a	10.55	2.35
Treated	0.75 b	0.40 b	10.05	2.20
Probability	0.000	0.003	0.749	0.419

[z] Shoot vigor rates as 0 = no growth or sprouting; -1 = sprouted but died back; 1 = some growth, not vigorous (growth < 25 cm; 10 inches); 2 = moderate growth (growth 25 - 50 cm; 10 – 20 inches); and 3 = vigorous growth (growth > 50 cm; >20 inches).
Mean separation using Least Significant Difference test (LSD) at $P \leq 0.05$.

Mature 'Hass' trees on seedling Mexican rootstock (approximately 18 years old) were topped to approximately 4.85 meters (16 feet) in mid-May 2003. Sixty-three trees were selected and broken into 7 blocks of 9 trees each. Within each block the trees were further divided into 3 sets of 3 trees. Each set was randomly assigned one of 3 treatments: 1) control (no treatment, whitewashed); 2) each scaffold painted with an application concentration of 1.15% NAA (Tre-Hold A-112 diluted in water and latex paint; Amvac Chemical Corporation) from 0 – 30 cm (0 – 12 inches) from the cut surface; and 3) each scaffold painted with NAA from 0 – 60 cm (0 – 24 inches) from the cut surface. The NAA was mixed in light brown paint in order to easily identify the treated trees. Treatments were applied on May 22, 2003 (Figure 2). Growth of the topped trees was evaluated on September 30, 2003 (Figures 3 and 4).

At the time of evaluation, the following measurements were made: branch diameter (cm); the number and relative vigor of shoots arising within the treated area (treatments 2, 3); and the number and relative vigor of shoots in non-treated area (0 – 0.5, 0.5 – 1.0 meter; 0 – 1.6; 1.6 – 3.3 feet) subtending the treated area. In the case of the control trees, this was from the cut surface of the branch. For treatments 2 and 3, these measurements were taken below the treated area. Vigor was rated as described above using a -1 to 3 scale. Data was analyzed using CoStat version 6.204 (CoHort Software, Monterey, CA).

Table 2 presents the results from this portion of the study. There was no significant difference between the average branch diameter due to treatment. If we compare the number of shoots and the vigor of these shoots which arose in the NAA treated area of Treatments 2 and 3, there was a significant difference between the number of shoots due to treatment. This is not surprising, however, since the treated area for treatment 3 (0 – 60 cm) was twice as large as the treated area of treatment 2 (0 – 30 cm). There was no statistical difference, however, in regrowth vigor, which was rated overall as not vigorous.

Shoot regrowth and vigor below the treated area (or below the cut surface for the control) was influenced by treatment. There were no significant differences between the control or either treatment for the first 0.5 meter below the treated area. The results for the second 0.5 meter below the treated area, however, show that the 0-60 cm treatment had a statistically significant influence on regrowth and shoot vigor below the treated area. The 0-30 cm treatment was not statistically different from the control in either measurement. If the growth and shoot vigor for the entire meter below the treated area is analyzed, one sees that the 0-60 cm treatment results in significantly fewer and less vigorous regrowth. This suggests that the length of the treated area below a cut is important to assure good results with NAA. Further work is needed to finalize the relationship between shoot diameter and the amount of wood to treat to reduce regrowth.

Figure 2. General view of treated trees in May 2003 following treatment.

Figure 3. Regrowth in January 2004 – Control. Note the vigorous regrowth especially near the cut surface.

Our work demonstrates that NAA applied to topped trees successfully reduced both the amount and vigor of apical growth that occurred in the months following tree pruning. This reduction will allow for better regrowth of the tree in the lower canopy. An additional value of controlling tree size will be that it should allow for more efficient application of pesticides to control the exotic pests which have been introduced into California recent years.

Figure 4. Regrowth in January 2004 – Treatment 3 (0-60-cm; 0-24-in.). Note that there are no new shoots within treated area (painted brown). In the picture on the right, the treated branch has no new growth in the treated area; rather, the new growth is occurring well below the cut.

Table 2. The number of shoots and shoot vigor within the NAA treated area or below for topped 'Hass' avocado trees. NAA treated area either 0 – 30 cm or 0 – 60 cm below limb cut. Trees treated 06/02/03 and evaluated 09/24/03.

		Within treated area		0 – 0.5 meters below treated area[z]		0.5 – 1.0 meters below treated area		0 – 1.0 meters below treated area	
	Branch diameter (cm)	Shoot number	Shoot vigor (0 – 3)[y]	Shoot number	Shoot vigor (0 – 3)	Shoot number	Shoot vigor (0 – 3)	Shoot number	Shoot vigor (0 – 3)
Control	9.37	-	-	4.24 ab	2.03 ab	3.71 a	1.68 a	7.95 a	1.86 a
0 – 30 cm	11.25	0.65 b	0.64	5.24 a	2.29 a	2.69 ab	1.60 a	7.93 a	1.95 a
0 – 60 cm	10.11	1.73 a	0.78	3.16 b	1.75 b	1.81 b	0.83 b	4.90 b	1.27 b
Probability	0.051	0.020	0.533	0.039	0.021	0.003	0.000	0.000	0.000

[z] For control below the cut surface.
[y] Shoot vigor rates as 0 = no growth or sprouting; -1 = sprouted but died back; 1 = some growth, not vigorous (growth < 25 cm; 10 inches); 2 = moderate growth (growth 25 - 50 cm; 10 – 20 inches); and 3 = vigorous growth (growth > 50 cm; >20 inches).
Mean separation using Least Significant Difference test (LSD) at $P \leq 0.05$.

The use of NAA after shoot tip pruning

The following questions were posed for this study. Does application of NAA to shoot tips after pruning impact the pattern of vegetative re-growth? Can NAA be used to help shape and maintain tree structure in a hedgerow management scheme?

Mature 'Hass' trees on Mexican seedling rootstock (planted in 1975) were stumped to approximately 1.8 meters (6 ft.) in 2001, and allowed to regrow. Selective shoots on the trees were pruned in mid-April 2003, to a lateral branch (Figures 5A, 5B, 6A, 6B) in an effort to train the trees into a hedgerow planting design. Following pruning, the trees were divided into 2 groups. In one group, the pruned shoots were painted with an application concentration of 1.15% NAA (TreHold A-112 diluted in water and latex paint; Amvac Chemical Corporation). In the other group, the pruned shoots were painted with white latex paint. Following painting, 1 to 5 shoots per tree were selected for monitoring. Shoots were selected based on approximate diameter. Seventy-three shoots were selected from the NAA treated trees (36 trees), and 70 shoots from 30 trees were used as control shoots. Treatments were applied within a week of pruning. Regrowth was evaluated on June 30, 2003.

The following parameters were visually evaluated at the time of evaluation (Figures 5A, 5B, 6A, 6B).

Shoots on the primary shoot axis (treated branch) were categorized as follows:

No growth, Just starting; weak, Only at tips of axillary shoots, Multiple bud break on primary axis, Vigorous shoot growth with axillary buds growing, Growth on primary and secondary axis.

Shoots on the secondary shoot axis (within 0.5 meter of treatment) were likewise evaluated:

No growth, Just starting; weak, Only at tips of axillary shoots, Multiple bud break on primary axis, Vigorous shoot growth with axillary buds growing, Growth on primary and secondary axis.

The average length of new growth on the primary and secondary shoots were estimated and categorized as follows:

>0 to 15 cm, 15 – 30 cm, 30 – 60 cm, >60 cm (>0 to 6”, 6 – 12”, 12 – 24”, >24”).

The number of shoots with new growth on the primary and secondary shoots were estimated and categorized as follows:

0, 1 to 5, 5 to 10, 10 to 15, >15.

In the case of the NAA treated shoots, we observed that growth was inhibited at the point of pruning. Each shoot (control and treated) was rated for the length along the primary axis where growth was inhibited as follows:

>0 to 15 cm, 15 – 30 cm, 30 – 60 cm, >60 cm (>0 to 6”, 6 – 12”, 12 – 24”, >24”).

Categorization of shoot growth

Figure 7 shows the relative growth on the primary shoot axis (the shoot treated). Note that in the NAA treated shoots, virtually no growth has occurred. In the control shoots, extensive regrowth has occurred; clearly, application of NAA slows regrowth of the shoots. Figure 8 illustrates the type of regrowth present on the secondary shoot axis that were present at the time of pruning. Note that the NAA treatment delays shoot development of subtending branches.

Shoot length

Figure 9 presents the range in average shoot length on the primary axis approximately 3 months after treatment. Note that the untreated control has a much higher percentage of shoots that are longer. Additionally, the sample size in the NAA treated branches is greatly reduced (only 2 of the 73 shoots having noticeable growth). Figure 10 presents similar data with the exception that this is a rating of length of growth on the secondary shoot axes. A similar trend is observed with the amount of growth reduced on the NAA treated branches.

Figure 5A. Control shoots. Note the vigorous regrowth on both the primary axis and axillary shoots subtending the pruning cut.

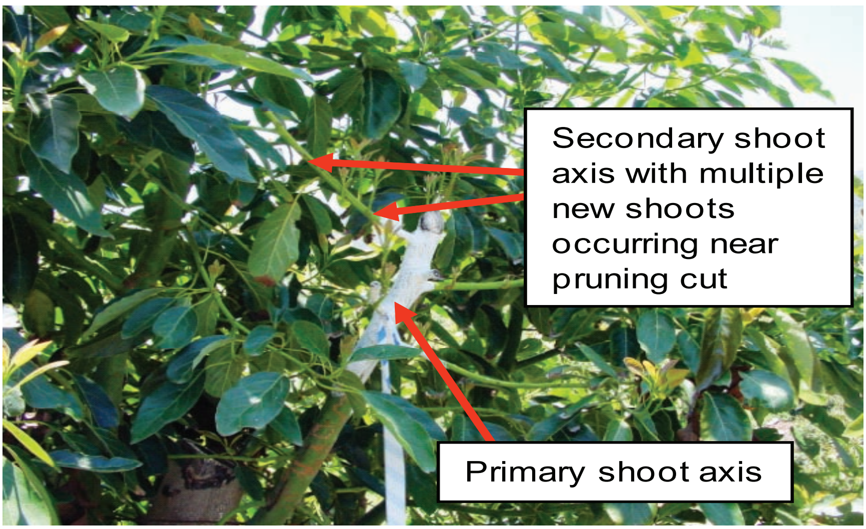

Figure 5B. Control shoots. Note the vigorous regrowth on both the primary axis and axillary shoots subtending the pruning cut.

Figure 6A. NAA-treated branches. Note the inhibition of growth especially near the pruning cuts especially on the primary shoot axis. The growth on the secondary shoots is also inhibited and occurs mainly at the shoot tips.

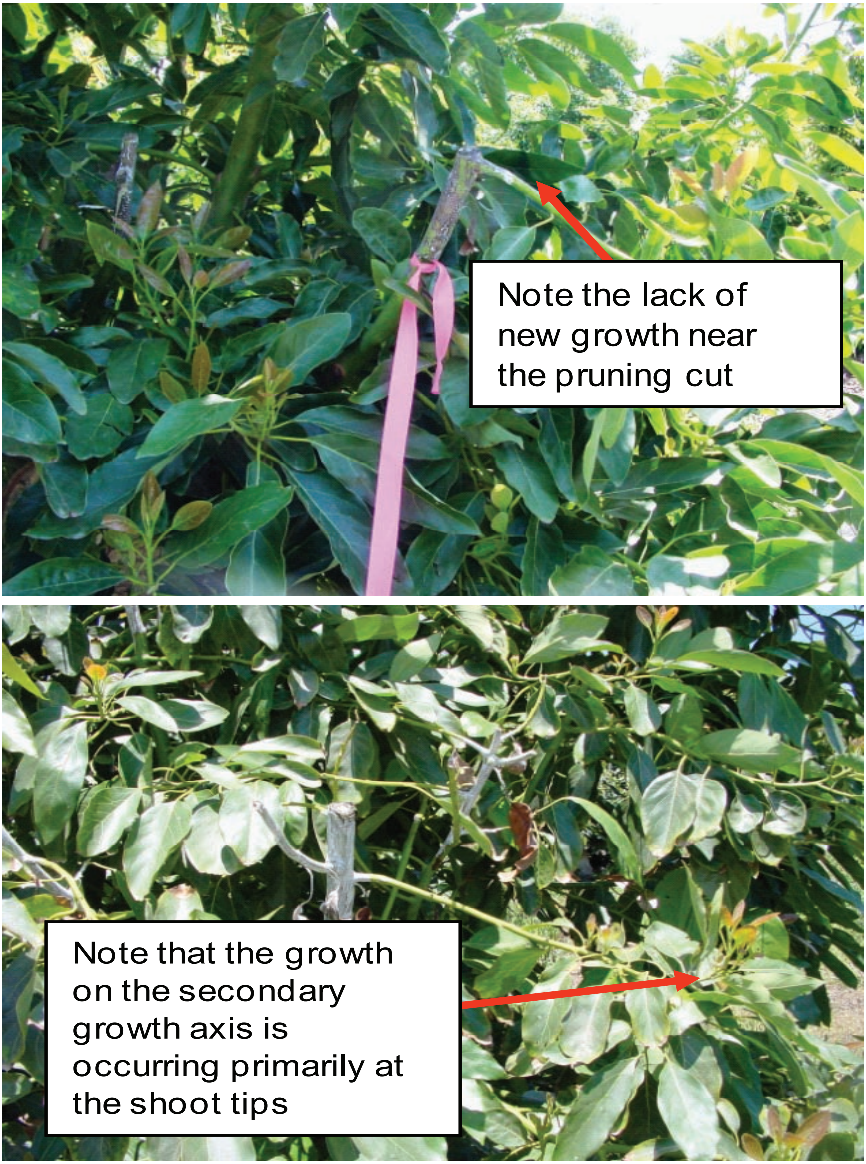

Figure 6B. NAA-treated branches. Note the inhibition of growth especially near the pruning cuts especially on the primary shoot axis. The growth on the secondary shoots is also inhibited and occurs mainly at the shoot tips.

Shoot number

Figure 11 depicts the approximate number of shoots on the primary axis at the time of evaluation. Note that there are no new shoots on the primary axis in the NAA treated shoots. Figure 12 shows a similar trend for growth on the secondary shoots subtending the treated shoot; the number of shoots is greatly reduced in the NAA treatment.

Zone of growth inhibition

Figure 13 presents the approximate zone of vegetative inhibition due to NAA treatment. NAA treatment of the pruned branch resulted in a zone of inhibition for vegetative growth below the treated area. In only 10% of the shoots did growth occur within 6 inches of the pruning cut. In contrast, in the control shoots, no inhibition occurred and growth was observed close to the pruning cut.

Our results with NAA demonstrated that this material can be used for the purpose of controlling regrowth following shoot tip pruning. We were able to show that by painting the tip of the clipped stem, we could shift the growth of the branch to lower branches as well as to the secondary shoot axes.

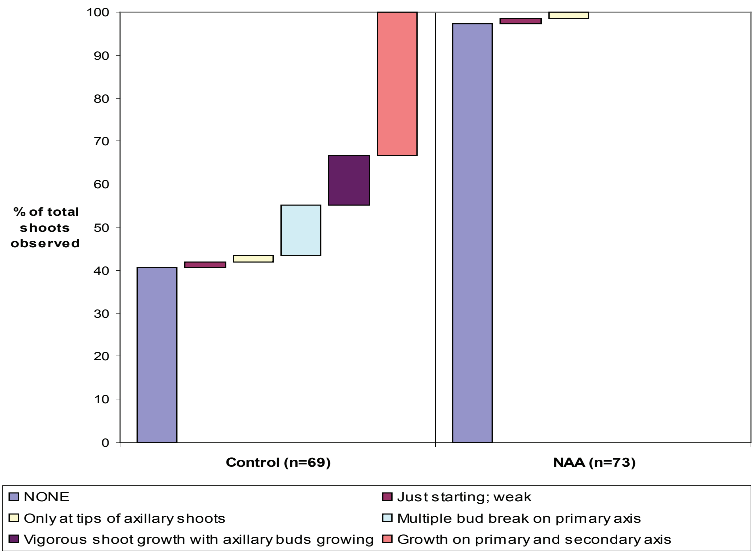

Figure 7. Categorization of shoot growth on the primary shoot axis approximately 3 months following shoot tip pruning.

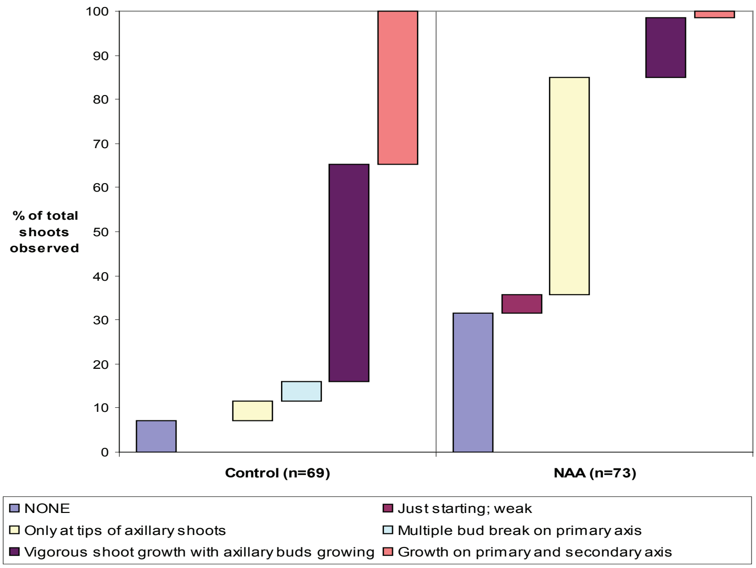

Figure 8. Categorization of shoot growth on the secondary shoot axis approximately 3 months following shoot tip pruning.

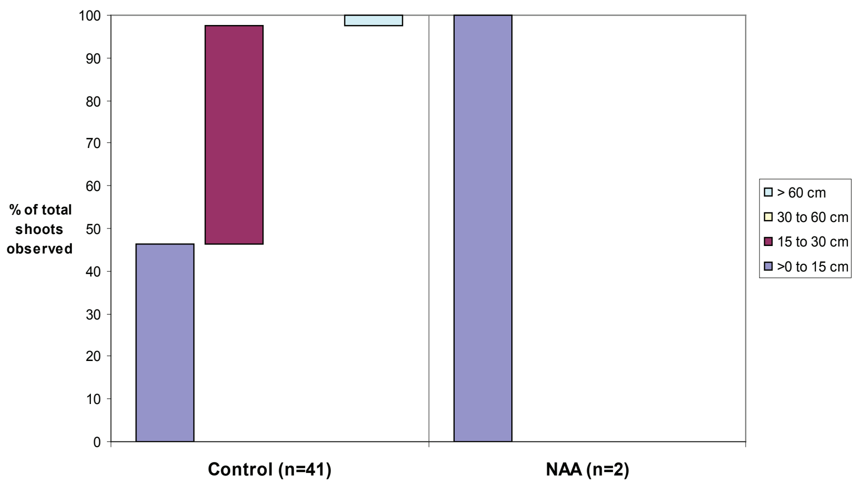

Figure 9. Average shoot length for the primary shoot axis approximately 3 months following shoot tip pruning.

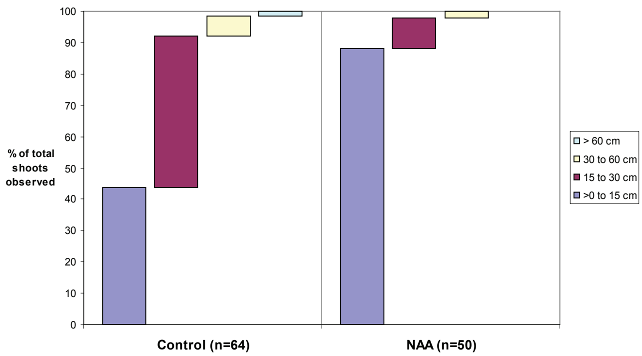

Figure 10. Average shoot length for the secondary shoot axis approximately 3 months following shoot tip pruning.

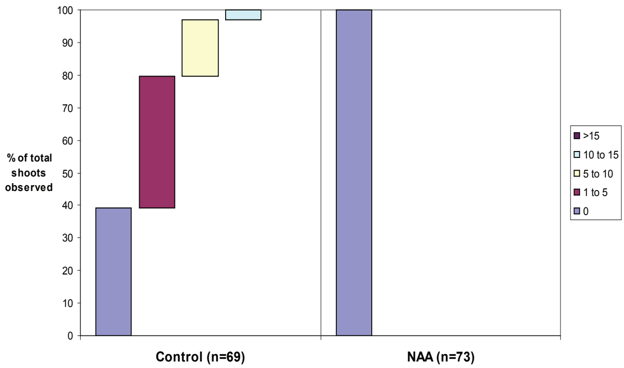

Figure 11. The approximate number of shoots on the primary shoot axis approximately 3 months following shoot tip pruning.

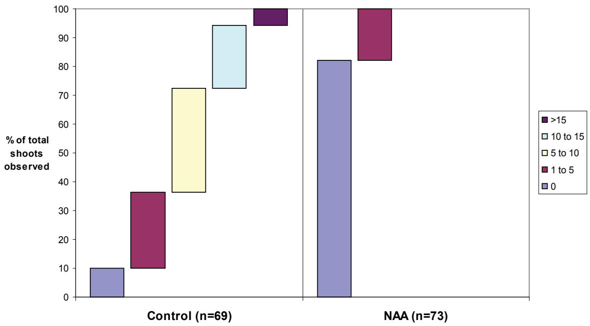

Figure 12. The approximate number of shoots on the secondary shoot axis approximately 3 months following shoot tip pruning.

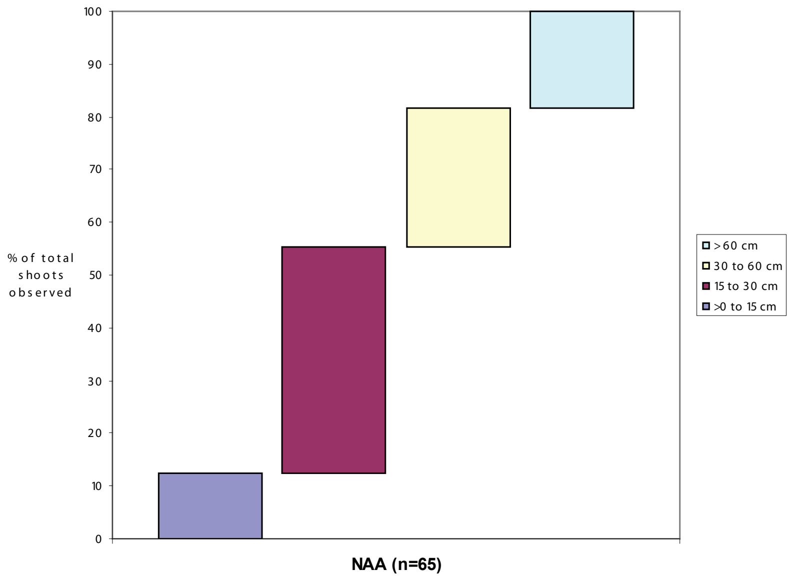

Figure 13. The approximate zone of vegetative inhibition due to the NAA treatment approximately 3 months following shoot tip pruning.

Concluding Remarks

In this study we have demonstrated 3 potential uses of NAA (Tre-Hold A-112) for controlling the vegetative vigor of 'Hass' avocado following tree stumping, tree topping and shoot tip pruning. This research led to the avocado industry and the registrant (Amvac Chemical Corporation) to request further work under the IR-4 program. This work has been completed, and registration has been requested so that all California growers can use NAA for these purposes.

Once TreHold A-112 is registered and available for use, it will be of utmost importance that the label be closely followed. Non-label usage could result in unexpected and undesirable effects on tree growth, flowering, and fruit set. This product, as is true for all plant growth regulators, will be best utilized by growers who closely monitor their orchards and understand how tree performance is influenced by differing management strategies.

References

Boswell, S.B., B.O. Bergh and R.H. Whitsell. 1976. Control of sprouts on topworked avocado stumps with NAA formulations. HortScience. 11(2):113-114.