Effects of Naphthalene Acetic Acid, Carbaryl and Accel on Thinning of Apples

G. Ouma[1] and A. Rice[2]

[1]Maseno University, Department of Horticulture, P O Box 333, Maseno, KENYA; [2]Mississippi Cooperative Extension, Box 9555, Mississippi State, MS 39762, U.S.A.

ABSTRACT

Studies were conducted in 1994 and 1995 to investigate the effect of Naphthalene acetic acid (AN), Carbaryl (Naphthylmethyl carbamate) and Accel (N-(phenylmethyl) - (H-purine - 6 - amine (BA)) on fruit set, yield, quality and leaf mineral concentration in 'Paulo Red' apples. The treatments consisted of NAA at 5ppm, 10ppm, 15ppm; Carbaryl at 0.05%, 0.1% and 0.2%, and. Accel at 25ppm, 50ppm and 75ppm and unsprayed control. Thinning trials conducted over two years indicated that Accel and Carbaryl consistently thinned the apples as evidenced by the lower number of fruits per limb cross sectional area on the sprayed trees compared to the unsprayed trees. The treatments reduced yield (total fruit weight per tree) but caused increases in pH, total soluble solids content, percent red color, return bloom and mean fruit weight. The treatments did not influence the number of seeds in the fruit. Accel and carbaryl treatments caused increases in fruit length fruit diameter and fruit length to diameter ratio while NAA had no effect on these parameters.

Leaf mineral composition was affected differently during the two experimental years. NAA reduced N and Ca contents in 1994 and 1995 but increased K contents during those years. In contrast, carbaryl increased N and Ca contents and reduced K contents in both years but reduced Mg contents in 1994 only. Accel increased K and Mg contents, reduced Ca contents but had no effect on N in 1994 while it increased K and Ca contents in 1995. Both N and Mg contents were not affected by Accel in 1995.

KEY WORDS: Thinning, apples

1.0 INTRODUCTION

One of the common practices in apple production is chemical fruit thinning. This practice improves fruit size, quality, increases return bloom and reduce biennial bearing (Williams, 1979; Looney, 1986). The practice of fruit thinning that is, removal of certain flowers or clusters of flowers or individual fruits after fruit set and natural dropping has occurred, has been known for a very long time (Ryugo, 1988 as cited by Valenzuela, 1992). Under optimum conditions, most trees will set more fruit than needed for full crop. Fruit thinning is done to reduce limb breakage, increase fruit size, improve fruit color and quality and stimulate floral initiation for next year's crop (Westwood, 1993).

There are three general methods of thinning namely: hand, mechanical and chemical. Hand thinning involves removing flowers or fruit. Previously fruit were thinned to a predetermined spacing but now size thinning is preferred (Westwood, 1993). Size thinning is the selective removal of small, weak fruit irrespective of spacing with the consideration of the desired degree of thinning (Westwood, 1993). Mechanical thinning may be carried out by using a direct blast of high pressure water from a hand operated sprayer at or slightly post bloom, or use stiff bristled brush to "sweep" off some of the fruits while they are quite small or use a power tree shaker of the type used for mechanical harvest (Westwood, 1993). The force causes the heavier fruits and those closer to the point of impact to separate from the spurs (Westwood, 1993; Byers, 1990 as cited by Valenzuela, 1992). Blossom and fruit thinning of deciduous fruit trees using chemical sprays has been a standard practice in commercial orchards of the world for a long time (Childers, 1983 as cited by Valenzuela, 1992). The advantages of chemical thinning over hand or mechanical thinning are reduced thinning costs, better fruit size and quality and better return bloom on biennial varieties. Possible disadvantages of chemical thinning are: hazard of frost after early sprays, overthinning in some cases, some foliage injury and variable results with trees of different ages and vigor (Westwood, 1993).

Chemical thinning can be accomplished at bloom time and during the early postbloom period. Strongly biennial cultivars may require adequate thinning (Williams, 1979). Some of the postbloom chemicals are hormone types and are used to upset the natural hormone balance of the tree. Others are non-hormone types but cause stress and embryo abortion (Williams, 1979). The mode of action of the postbloom thinning chemicals is not fully understood. Embryo abortion may precede or accompany fruit abscission, but is not considered to be its cause. High temperatures or chemical stress of any kind applied to apple trees during the early postbloom period will increase fruit abscission (Williams, 1979). The post bloom thinning chemicals are generally believed to interfere with the endogenous hormones which control the flow of nutrients to the developing fruit (Williams, 1979).

The chemical thinners for apples are ethephon (Jones *et al.*, 1983, 1989; Knight and Espencer, 1987), gibberellins (Cohen and Greene, 1988), benzyladenine (Elfving and Cline, 1993a, 1993b); naphthalene acetic acid (Williams, 1993; Nielsen and Dennis, 1993), cppu (N-2-chloro 4-pyridyl (N-phenylurea) (Bound *et al*, 1991; Byers and Carbaugh, 1991) and accel (Hull *et al.* 1993).

Most of the studies on chemical thinning of apples are still not conclusive. In addition the studies are specific to particular apple cultivars and different ecological and environmental conditions. Accel, one of the chemical thinners used in this study is new and needs to be tested under different environmental conditions and different apple cultivars. Therefore, a two year study was conducted to investigate the effects of naphthelene acetic acid, accel and carbaryl on apple fruit set and yield and quality of 'Paulo Red' apple fruits.

2.0 MATERIALS AND METHODS

Two similar experiments were conducted on a block of ten-year apple trees (*Malus domestica* Borkh CV 'Paulo Red') trees growing on MM 106 rootstock in a commercial orchard in Pontotoc County, Mississippi State, U.S.A. The trees were growing in North-South rows and were trained to a conventional central leader form (Westwood, 1993). They were planted at a spacing of 5 x 3.5m and were about 4m high. The first experiment was initiated on April 30th 1994 and terminated on August 18th 1994. The second experiment was initiated on May 19th 1995 and terminated on August 25th 1995. The different dates of application in the two years was due to the fact that the optimal sizes of the fruits required, i.e. 10-12mm diameter, before application of thinners was attained at different dates. The treatments comprised application of naphthalene acetic acid (NAA) at concentrations of 5ppm, 10ppm and 15ppm; accel (N-(phenylmethyl) – (H-purine-6 amine) benyladenine (BA)), at concentrations of 25ppm, 50ppm and 75ppm and carbaryl (Naphthylmethyl Carbamate) at 0.05%, 0.1% and 0.2%. All the chemicals were applied to the trees as dilute sprays using a hand sprayer (Food Machinery Corp; Jonesboro, Ark) and were sprayed on calm, clear and dry days from 11.00 hours to 16.00 hours G.M.T. The control trees were sprayed with water only. The treatments were replicated three times in a completely randomized block design.

The surfactant 'Tween' 20 at 0.1% was mixed with the chemical thinners to act as a wetting agent. The trees were sprayed to dripping point. Recommended cultural practices for commercial apple production, i.e., fertilization, weed control, pest and disease control (Westwood, 1993) were applied. The harvesting of fruits was carried out in August and number of fruits, fruit set, return bloom, percent red colour, yield and other fruit characteristics determined on trees which had been marked earlier.

Fruit set

Before bloom four representative limbs 12cm to 15cm in circumference were tagged on each tree for use in bloom and fruit set counts (Forshey and Elfving, 1979; Lombard *et al.* 1988). Total blossom clusters, fruit set after June drop and return bloom were then determined. The number of fruits were counted after June drop (i.e. one month after application of chemicals) and expressed as the number of fruit per limb cross sectional area. Bloom and total blossom clusters were determined in a similar manner.

Yield, fruit length and diameter

At final harvest the total number and weight of fruit on each tree were recorded. Twenty fruit per tree were sampled for length, diameter and weight. Fruit length and diameter were measured by laying the fruit end-to-end and side-to-side in a V-shaped trough and measuring total length and diameter in centimetres.

Soluble solids, pH and percent red color

Juice was expressed from 10 fruits using a Mullinex juice extractor (DLC-10; Cuisinunart, East Windsor, N. J.) and filtered through a 28-mesh screen. Total soluble solids contents was determined using a bench type Bausch and Lomb optical refractometer (Fisher Scientific, Springfield, N.J.) and expressed in degrees Brix (^{0}Brix). The pH of the expressed juice was determined using an Accumet laboratory meter, Fisher Scientific, Springfield, N.J.) The percentage red color on the surface of the fruits was determined by estimating the proportion of red surface to the nearest 10%.

Leaf mineral composition

Four weeks after the application of the chemicals, leaf samples were collected for the determination of N, K, Ca and Mg contents. The samples were cleaned by dipping in detergent solution and tap water and rinsed with distilled water. Leaf samples were dried at 60^0C and ground to pass through a 1-mm screen, in a steel mill. All samples were analyzed for N, K, Ca and Mg contents. The Kjeldahl procedure (Nielsen and Sommers, 1972) was applied to determine N contents while K, Ca and Mg contents were analyzed by an ICP emission spectrophotometre (Model 975; Psalma Atomcomp by Thermo Jarrell Ash; Franklin, Mass) (Dahlquist and Knoll, 1978).

Statistical Analysis

The effectiveness of treatments was determined based on the following variables: percentage fruitset, fruit length and diameter, number of fruits thinned, total soluble solids content, pH, percent red color. Treatment means were separated for significant difference using S.A.S. general linear models procedure (SAS Institute Inc. Cary. N.C.) Regression analysis was also done.

3.0 Results

1994:

Fruitset and number of fruit per tree were reduced in response to increased concentrations of the thinners but were affected more strongly by NAA (Table 1). Yield per tree was reduced similarly by the thinners. Both fruit length and diameter were increased by Accel and carbaryl while NAA had no significant (P 0.05) effect.

Neither length to diameter ratio (L : D ratio (average value 6.3) nor number of seeds per fruit (average value 6.3) (Data not shown) was affected by any of the thinners. Return bloom which was reflected by the number of blossom clusters per cross sectional limb circumference was not significantly ($P \leq 0.05$) affected by carbaryl but was increased by NAA and Accel (Table 1).

Mean fruit weight increased as the concentrations of the chemical thinners was increased but NAA had a stronger effect. pH was increased by NAA. ($P \leq 0.05$). Conversely, total soluble solids content was increased by all the chemical thinners. NAA reduced N and Ca contents while it increased K contents and reduced Ca contents, and had no significant effect on Mg contents. In contrast, carbaryl increased N content and reduced K contents, increased Ca and reduced Mg contents. Accel had no effect on N contents but it increased K and Mg content and reduced Ca contents . Percent red color was significantly increased ($P \leq 0.05$) by the thinners as their concentrations increased but carbaryl had the strongest effect.

1995:

Similarly to 1994 fruit set and number of fruit per tree and yield were reduced by the thinners. Fruit length and diameter were increased by carbaryl and Accel while NAA had no effect ($P \leq 0.05$). The fruit length to diameter ratio (average value 6.2) (Data not shown) were, however, unaffected by the chemical thinners. Return bloom was increased by all thinners (Table 2). Mean fruit weight increased as the concentrations of the chemical thinners increased with NAA having a stronger effect as in 1994. (Table 2). The chemical thinners had variable effects on the leaf mineral concentrations of N, P, Ca and Mg. NAA reduced N, Ca and Mg contents but increased K contents while accel had no effect on N contents, reduced K and N contents, increased Ca contents, and had no effect on Mg contents (Table 2).

Percentage red color was significantly ($P \leq 0.05$) increased by the thinners as their concentrations were increased and Accel had the strongest effect. pH was increased only by NAA while the rest of the chemical thinners had no effect. Conversely, total soluble solids content was increased by all the chemical thinners.

Table 1. Effects of Naphthalene acetic acid (NAA), carbaryl and accel on the fruit set, return bloom, yield, fruit characteristics and leaf nutrient status of 'Paulo Red' apple trees grown at Pontotoc farm, 1994 experiment

Treatments[a]	Fruit [b]PCLA	No. of fruit per tree	Yield per tree (kg)	Fruit length (cm)	Fruit diameter	Blossom chasters[b] PCLA (return bloom)	pH	Soluble solids (°Brix)	Foliar Micronutrients				Mean fruit weight (g)	Percent red color
									N ppm	K ppm	Ca ppm	Mg ppm		
1. Control	8.0	700	94	5.9	7.0	1.1	5.2	8.2	2.20	1.31	0.99	0.31	114	70
2. NAA 5ppm	6.3	600	89	6.5	7.5	2.0	5.1	9.6	2.00	1.36	0.86	0.32	130	70
3. NAA 10ppm	3.3	352	70	7.0	8.0	4.9	5.3	10.8	1.90	1.52	0.84	0.30	200	71
4. NAA 15ppm	3.0	256	58	7.2	7.3	5.3	5.9	12.9	1.72	1.72	0.70	0.29	280	95
5. Carbaryl 0.05%	5.9	654	90	7.3	7.4	1.2	5.3	10.5	2.37	1.10	1.01	0.24	150	86
6. Carbaryl 0.1%	4.1	600	76	7.9	7.8	1.0	5.5	11.9	2.40	1.06	1.14	0.19	170	88
7. Carbaryl 0.2%	4.3	510	64	8.7	8.6	0.9	5.7	13.4	2.56	0.86	1.34	0.10	195	96
8. Accel 25ppm	6.2	640	95	6.3	7.5	3.2	5.1	10.2	2.22	0.92	0.90	0.31	124	70
9. Accel 50ppm	4.6	576	78	6.9	8.8	4.5	5.3	11.7	2.20	1.44	0.62	0.39	140	88
10. Accel 75ppm	3.3	468	69	7.7	9.3	5.6	5.4	13.6	2.15	1.42	0.36	0.49	182	90
Significance														
NAA	L**	L**	L**	NS	NS	L**	L**	L**	L**	L**	L**	NS	L**	NS
Carbaryl	L**	L**	L**	L**	L**	NS	L**	L**	L**	L**	L**	L**	L**	L**
Accel	L**	L**	L**	L**	L**	L**	NS	L**	NS	L**	L**	L**	L**	L**
S. E. = ±	0.10	16.20	2.10	0.50	0.32	0.30	0.80	0.01						2.36

[a] Each mean has 4 observations; L = Linear effect by regression analysis;- ** Significant at $p \leq 0.05$; [b]PCLA = per square centimetre of limb cross sectional area; NS = Not significant at $p \leq 0.05$

Table 2. Effect of Naphthalene acetic acid (NAA), carbaryl and accel on fruit set, return bloom, yield, leaf nutrient status and fruit characteristics of 'Paulo Red' apples trees grown at Pontotoc farm, 1995 experiment

Treatments[a]	Fruit [b]PCLA	No. of fruit per tree	Yield per tree (kg)	Fruit length (cm)	Fruit diameter	Blossom chasters[b] PCLA (return bloom)	pH	Soluble solids (^{0}Brix)	Foliar Micronutrients				Mean fruit weight (g)	Percent red color
									N Ppm	K ppm	Ca ppm	Mg ppm		
1. Control	8.2	680	99	6.6	7.3	2.8	5.3	10.2	2.60	1.30	0.99	0.30	99	67
2. NAA 5ppm	6.3	562	80	6.8	7.6	3.7	5.5	11.9	2.50	1.52	0.80	0.29	155	79
3. NAA 10ppm	5.9	310	71	7.1	7.8	7.8	5.7	12.3	2.30	1.69	0.64	0.26	165	85
4. NAA 15ppm	4.2	250	50	7.4	8.1	8.4	5.9	13.8	2.12	1.78	0.41	0.22	310	89
5. Carbaryl 0.05%	6.1	500	75	6.9	7.6	3.6	5.0	10.5	2.14	1.24	0.90	0.30	160	75
6. Carbaryl 0.1%	5.6	374	56	7.7	7.9	4.8	5.3	11.6	2.59	1.01	0.95	0.31	185	80
7. Carbaryl 0.2%	4.2	260	32	8.6	8.3	6.6	5.6	13.0	2.71	0.90	0.99	0.30	190	88
8. Accel 25ppm	5.9	472	78	7.0	7.4	3.3	5.4	10.7	2.16	0.91	1.10	0.25	130	79
9. Accel 50ppm	4.6	466	62	7.8	7.8	5.9	5.6	11.9	2.20	1.55	1.20	0.30	155	90
10. Accel 75ppm	3.3	265	40	8.6	8.9	6.8	5.8	13.1	2.15	1.72	1.40	0.31	175	96
Significance														
NAA	L**	L**	L**	NS	NS	L**	L**	L**	L**	NS	L**	L**	L**	L**
Carbaryl	L**	Q**	L**	L**	L**	L**	NS	L**	L**	Q**	L**	NS*	L**	L**
Accel	L**	L**	Q**	L**	L**	L**	NS	L**	L**	Q**	NS	L**	L**	L**
S. E. = ±	0.30	12.20	1.50	0.60	0.42	0.36	0.56	0.72	0.06				8.20	1.20

Each mean has 4 observations; L = Linear effect by regression analysis; ** Significant at $p \leq 0.05$; [b]PCLA = per square centimetre of limb cross sectional area; NS = Not significant at $p \leq 0.05$; Q = Quadratic effect by regression analysis

4.0 DISCUSSION AND CONCLUSION

The experiments were conducted over two years to investigate how the different weather and soil conditions prevailing would influence the efficacies and activities of the three chemical thinners. Although the above conditions were not determined they were assumed to affect the results to be obtained.

Over the concentration ranges used in this study, NAA, carbaryl and accel reduced fruit set and increased fruit weight to the same or greater extent than each other. Yield is mainly a function of fruit number (Forshey and Elfving, 1977). Thinning with NAA, carbaryl and accel reduced yield in the two years tested. The large fruit weight increase induced by the thinners in this study was insufficient to offset the effect of fewer fruit per tree on total yield. The increase in fruit weight associated with the chemical thinner treatments suggest significant improvement in the fruit size distribution in the crop. This is a very important factor in determining the consumer preferences of 'Paulo Red' apples.

The fact that NAA had no effect on fruit length and diameter while carbaryl and accel increased them imply that they have variable effects on fruit shape. Accel and carbaryl however, did not affect length to diameter ratio, indicating that they increased the two parameters equally. Cell division is most active in apples at bloom and continues for 2 to 3 weeks after which the rate declines substantially (Denne, 1963). The largest increase in length to diameter ratio occurred when GA_{4+7} was applied near bloom (Greene, 1989). The thinners in the present study were applied two weeks after bloom. It is logical to attribute these latter findings to the fact that cell division in 'Paulo Red' apple trees takes place immediately after bloom hence the thinners applied could not have had an effect on fruit shape.

The effect of chemical thinners on percent red color was slightly influenced by the year of experimentation, i.e. carbaryl had the strongest effect on it in 1994 while accel had the strongest effect in 1995. The different environmental condition which may have occurred in the two years apparently caused the observed differences. Percent red color is a determinant of fruit maturity hence the different environmental factors in 1994 and 1995 may have influenced the efficacies, activities and Metabolism of trees differently. The chemical thinners therefore advanced the ripening of the fruits. Growth regulators such as accel and carbaryl also advance ripening of other apple cultivars (Ouma, 1996).

The thinners also increased the total soluble solids content of the fruits. It could be argued that the thinners' thinning activity altered the leaf to fruit ratio so that there were more leaves to support fruit growth (Greene, 1989). It is necessary, however, for and experiment to be carried out to quantify shoot and leaf growth to prove this claim. It appears that as the soluble solids content increase in the fruit pH increased according to the present study. Therefore, the thinners by increasing soluble solids also increased pH because the two parameters are apparently related in determining fruit quality. Since the thinners used in this study advanced maturity of the fruits the above relationships can be explained, i.e. as a fruit matures the soluble solids content increases while its acidity decreases.

The effects of all chemical thinners on foliar nutrient concentrations primarily reflected crop load induced changes in foliar levels of N, K, Ca and Mg. Increased foliar N contents from carbaryl application may have caused lower levels of K and Ca from the leaves. The effect of thinners on the leaf mineral nutrients was however, strongly influenced by the year of experimentation. In most cases the thinners affected the leaf mineral contents very differently in the two years. It is most probable that the different environmental conditions prevailing in the two years particularly immediately, at, and after the thinners were applied affected their efficacies, uptake, activities and metabolism of the trees to influence the crop load induced changes. Also the nutrient levels in the plant tissues and soil before application of thinners could have affected the nutrient composition of the leaves. It is recommended that further studies on these chemical thinners be conducted with the above issues in consideration.

Fruit size which was reflected in mean fruit weight was increased by the thinners. This observation may be attributed to the fact that reducing fruit set by the thinners reduced the number of sinks, i.e. fruitlets causing less competition for the assimilates and resulting in big sized fruits.

Return bloom which is reflected in the number of blossom clusters per cross sectional limb area was increased linearly by the thinners. This finding confirms the fact that thinning fruits can reduce the incidence of biennial bearing as reported previously (Forshey and Elfving, 1987; Looney, 1986).

Finally, it must be accepted that the different dates of treatment application in the two years may have influenced the occurrences of some differences in the results.

The chemical thinners were applied based on the attainment of particular sizes of the fruitlets. This time occurred at different dates in 1994 and 1995 hence the different application dates. Another area which should be tested in a future experiment is the date of application of the thinners in relation to thinning efficacy.

From the results of this study it can be concluded that the application of NAA, carbaryl and accel reduce the fruitset of 'Paulo Red' apples and also affect the fruit quality parameters such as percent red color, total soluble solids, pH, leaf mineral nutrient status, and fruit length. It can also be concluded that the thinners reduce yield per tree but increase return bloom and fruit size as reflected in mean fruit weight.

ACKNOWLEDGEMENT

We thank the U.S.A.I.D. for the funding of the research, Mississippi State University for the provision of some research equipments and materials, Ms Thelma Merchant for the assistance in data collection and analysis. Typing of the manuscript by Ms. Agatha is also gratefully acknowledged.

REFERENCES

Bound S.A., Jones K. M., Koen T. B. and Oakford M. J. (1991). The thinning effects of BA on red "Fuji" apple trees *J. Hot. Sci.* **66**, 789-794.

Byers R.E. and Carbaugh D. (1991). Effect of chemical thinning sprays on apple fruit set. *HortTech.* **1**, 41-48.

Cohen R.A. and Greene D.W. (1988). GA_4, GA_7. and BA influence fruit set, fruit quality and return bloom of the 'Golden Delicious' apple trees. *HortSci.* **23** (3), 788 - 789.

Denne H. (1986). Fruit development and some tree factors affecting it. *New Zealand J. Bot.* **1**, 265 - 294.

Dahlquist R. L. and Knoll J. W. (1978). Inductively coupled plasma atomic emission spectometre: Analysis of biological materials and major trace and ultratrace elements. *Appl. Spectr.* **39** (1), 1 - 29.

Elfving D.C. and Cline R.A. (1993a). BA and other chemicals for thinning 'Empire' apple trees. *J. Amer. Soc. Hort. Sci.* **118**, 589-598.

Elfving, D.C. and Cline R.A. (1993b). Cytokinins and ethephon affect crop load, shoot growth and nutrient concentration of "Empire' apple trees. *HortSci.* **28**, 1011-1014.

Forshey C.G. and Elfving D.C. (1977). Fruit numbers, fruit size and yield relationship in Macintosh apples. *J. Amer. Soc. Hort. Sci.* **102**, 399 - 402.

Greene D. (1989). Regulation of fruit set with plant growth regulators. *Acta Hort.* **239**, 323 - 334.

Hull J. Jr., Bukovac M.J. and Black B.C. (1993) Effect of concentration and time of Accel application on cropping of selected cultivars. *HortSci.* **30** (4), 365.

Jones K.M., Koen T.B. and Meredith J. (1983). Thinning 'Golden Delicious' apples using ethephon sprays. *J. Hort. Sci.* **58**, 381 - 388.

Jones K.M; Koen T.B., Oakford M.J. and Bound S. (1989). Thinning 'Golden Delicious' apples with NAA in relation to spray concentration, volume and time of day. *J. Hort. Sci.* **63**, 27 - 30.

Knight J. N. and Espencer J. (1987). Timing of application of carbaryl used as an apple fruitlet thinner. *J. Hort.Sci.* **62**, 11 - 16.

Lombard P.B., Callan N.W., Dennis Jr. F.G., Looney N.E., Martin G.C., Renquist A.R. and Mielke E.A. (1988). Towards a standardized nomenclature, procedures, values and units in determining fruit and nut yield performance *HortScience* **23**, 813 - 817.

Looney N.E. (1986). Chemical thinning of apples; some new strategies and important refinements to old procedures. *Acta Hort.* **179**, 597 - 604.

Nielson D.W. and Sommers L.E. (1972). A simple digestion procedure for estimating total nitrogen in soils and sediments. *J. Environ. Qual.* **1**, 423-425.

Nielson J.C. and Dennis F.G. (1993). Thinning 'Delicious' apples. Trials and tribulations. *HortSci.* **28**(5), 484.

Ouma G. (1996). Chemical Thinning Studies of Apples (*Malus pummel mill*) *Ph.D. Dissertation, Mississippi State University, U. S. A.*

Valenzuela J.R.C.(1992). Regulating Blueberry (*Vaccinium asheireade*) Crop. *Ph.D. Dissertation, Mississippi State University, U. S. A.*

Westwood M.N. (1993). *Temperate Zone Pomology. Timber Press. Portland, Oregon* pp 259 - 269.

Williams M. W. (1979). Chemical thinning of apples. In: J. Janick (ed) *Horticultural Reviews,* ***1 270-298.*** Avi Publishing Company, Inc.

Williams, M.W. (1993). Comparison of NAA and Carbaryl petal fall sprays on fruitset of apples. *HortTech.* 3(4), 428 - 429.