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Thinning Efficiency of Ammonium Thiosulfate and Hydrogen Cyanamid on "Golden Reinders" Apple

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Abstract
Efficacy of ammonium thiosulfate and hydrogen cyanamid on the fruit quality and return bloom in 'Golden Reinders' apple grafted on the M9 rootstock was evaluated in this experiment. Studies were conducted at the Eğirdir Fruit Research Institute for two years on same trees. Three different doses of ammonium thiosulfate (ATS) (1%, 2%, and 3%) and hydrogen cyanamid (0.25%, 0.5%, and 0.75%) (Dormex) were used as the flower thinners at the full bloom period. To compare chemical applications, hand fruit thinning (HFT) at the producer level was performed after June drop. The effect of thinning practices on the fruit quality and yield was found the different year to year. Percentage of large fruit (75-85 mm diameter) increased by hand thinning and ATS 2% in the first year of the study. In the second year, the majority of fruits were into 75-85 mm size category and fruit yield with high commercial value was higher in 3% ATS and 0.75% Dormex. 2%, 3% ATS and 0.75% Dormex were effective applications to partially or even reduce alternate bearing compared to other applications. However, fruit thinning was not effective in reducing biennial bearing severity.

Keywords: *Malus x domestica*, crop load, flower thinning, alternate bearing

INTRODUCTION

Yield and quality are two indispensable important elements for fruit producers. Although productivity comes before fruit quality in fruit growing, the small number of marketable fruits in the yield is inadequate for profitable fruit production. In the modern apple orchard, the rate of merchantable first-class fruits has become more important than the total yield, particularly in the present market system. However, besides quality, the regular crop yield should also be provided in apple. Apple is a fruit species with a tendency to alternate bearing and differences in the tendencies to it is seen among cultivars. Apple producers have focused on cultural practices to both minimize the low yield resulting from alternate bearing and obtain fruits of maximum quality. The most effective of these practices is crop load management [26]. The thinning applications included in crop load management are one of the cultural practices which should be carried out to increase the quantity of marketable crops [24, 16]. Conventionally, hand thinning is performed after June drop in apple culture. Especially, the concerns of producers about guaranteeing their crops and their desire to clearly see the crop load on the trees may be shown as the most important reasons for this practice. Nevertheless, hand thinning of fruits brings about an additional cost for the large-scale producers which perform commercial production since it is an application that requires intensive labor and time. Furthermore, the period when the application of thinning is performed is at the same time the period when buds are programmed for blooming [15]. Hence, an application of thinning to be carried out in this period will not be effective to reduce the intensity of alternate bearing and will have a very minor effect on the fruit size. For these reasons, alternative approaches for the application of hand thinning are adopted to minimize producers' costs particularly in those European countries where labor wages are high. The most important of them is the use of chemical flower or fruit thinners. Chemical thinners have become important particularly in fruit species which produce abundant flowers. There are many thinning substances which consist of plant growth regulators, insecticides, and leaf fertilizers that have been commercially licensed for this purpose. Flower thinners are promising thinning agents, especially for areas where little or no spring frosts are seen. Emphasized as a flower thinner in many studies, ammonium thiosulfate is one of the chemical flower thinners that predominate in organic apple cultivation. Similarly, the effect of Dormex has been proven in many apple varieties, but its use has been banned in some countries.

In this study, the effects of ammonium thiosulfate and Dormex on the fruit quality and alternate bearing of 'Golden Reinders' apples grafted on the M9 rootstock were studied for two years.

MATERIALS AND METHODS

The study was conducted at the Eğirdir Fruit Research Institute for 2 years on same trees. The 8-year-old cultivar 'Golden Reinders' grafted on M9 clonal apple rootstock constituted the plant material of the study. Dormex (0.25%, 0.5%, and 0.75%) and ammonium thiosulfate (ATS) – an environmentally friendly substance – (1%, 2%, and 3%) were used as the flower thinners. The applications were performed by spraying on the predetermined healthy trees by handgun sprayer in the full bloom (70%-80% bloom) period, with all sides of the trees to get wet. To compare chemical applications, hand thinning (HFT) at the producer level was further performed after June drop. Ten fruits for each tree were used for the physical and chemical fruit analyses as fruit length (mm), fruit diameter (mm), fruit weight (g), flesh fruit firmness (lb), titratable acidity (malic acid %) and soluble solids content (%). Yield was evaluated as per tree (kg/tree). Trees were fertilized and sprayed according to the soil analyses. Drip irrigation was used during the trial years.

The treatments were arranged in a randomized complete block design, with three replications, three trees were used for each treatment. Statistical procedures were performed

using statistical analysis systems (SPSS) software version 13. Duncan's multiple range test was used for means separation at a significance level of 5%.

RESULTS AND DISCUSSION

Ammonium thiosulfate (ATS) has been tested in recent studies on the apples, pears, cherries, plums and peaches because of its environmental friendliness and effective thinner [25, 17, 20, 22]. Dormex is not as widespread as ATS as a flower thinner but is seen as a promising flower thinner because of its thinning effects and give consistent results over the years [9, 23].

In our study, the results of the thinning practices on fruit quality traits are given in Table 1. In season 1, hand fruit thinning was not statistically significant but it was the most important application to increase fruit weight compared to control and chemical thinners. The fruit weight remained below 200 gr in Dormex 0.5%, 0.75% and control trees (Table1).

Table 1. Comparison of thinners for fruit quality

Treatments	Fruit weight (g)		Fruit diameter (mm)		Fruit length (mm)	
	Season 1	*Season 2*	*Season 1*	*Season 2*	*Season 1*	*Season 2*
Control	172.87^{ns}	0.00*	71.16	0.00	69.57	0.00
HFT	216.93	0.00	78.21	0.00	73.49	0.00
ATS						
1%	205.78	220.95ab	76.18	74.09d	72.75	74.19b
2%	210.36	222.37ab	76.49	76.80cd	74.31	73.41b
3%	210.11	238.96a	76.66	80.15ab	72.13	78.39a
Dormex						
0.25%	208.10	201.72abc	77.24	76.15cd	72.81	71.64b
0.50%	180.97	211.77ab	72.66	77.68bc	69.71	74.96b
0.75%	180.17	241.79a	70.92	81.13a	69.69	78.73a

**Means in columns followed by the same letters are not significantly different at the P 0.05 level by Duncan's multiple range test

ns: not significant

Golden Delicious is biennial bearing variety. As a matter of fact that, in season 2, a sufficient number of fruits could not be obtained for analysis from control and hand thinning. ATS 3% and Dormex 0.75% were applications that increase fruit weight. In general, it is seen that the effect of ATS applications on fruit weight is higher than Dormex applications. Similar findings have been founded by Bound and Wilson, 2007 [4]. Basak, 2004 [1] express that the effect of ATS on fruit diameter, fruit weight and fruit color in 'Jonagold' and 'Gala' varieties was not significant. In another study from Byers et al. (2003) [8] indicated that only one ATS application did not show an adequate thinning effect during prolonged periods of the flowering, and thus increased the thinning effect of ATS recommend twice, in the 30% and 95% flowering period.

Percentage of large fruit (75-85 mm diameter) increased by hand thinning and ATS 2% in the first year of the study. In season 2, the majority of fruits were into 75-85 mm size category and fruit yield with high commercial value was higher in 3% ATS and 0.75% Dormex (Figure 1).

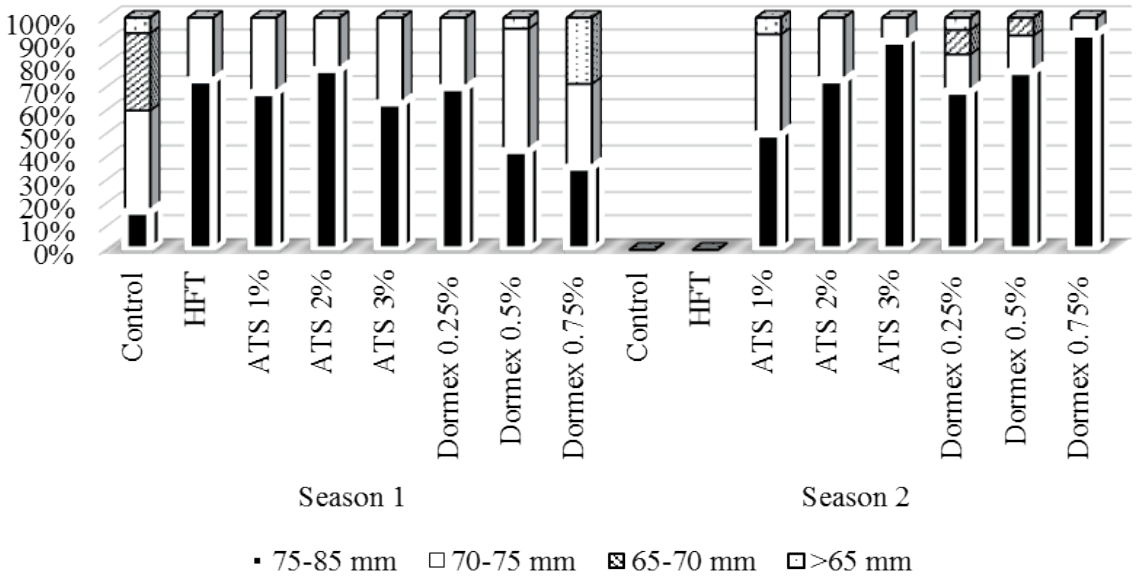

Figure 1. Effects of thinning treatments on fruit size distribution

It has been reported by some researchers that the effects of thinning practices on the physical and chemical properties of apples may vary with years, application dose and variety [14, 5]**.** Among the applications, the difference for the fruit flesh firmness was found to be significant and the lowest fruit flesh firmness was obtained from ATS applications due to large fruit formation at each season. The best treatment on the flesh firmness was hand fruit thinning and control in season 1. Season 2, the highest flesh firmness was obtained in Dormex 0.25%.

Hand fruit thinning and ATS 1% were significantly increased titratable acidity compared to other treatments (Table 2). In this study, the applications on SSC also showed different effects on the basis of years. In season 1, the difference among applications on SSC was found to be insignificant. In season 2, the highest SSC was noticed in

the control, while results from hand fruit thinning, 0.75% Dormex and ATS were close to control. Bound and Wilson, 2007 [4] state that in the 'Hi Early Delicious', SSC increases with increasing doses of ATS. However, a similar effect was not observed in our study. In season 1, 1% ATS was effect on titratable acidity, while other thinning applications and control were in the same group. In season 2, the effect of applications on % TTA was insignificant (Table 2).

Table 2. Effects of thinning practices on fruit flesh firmness, % SSC and % TTA

Treatments	Fruit flesh firmness (lb)		SSC%		TTA%	
	Season 1	*Season 2*	*Season 1*	*Season 2*	*Season 1*	*Season 2*
Control	17.29a*	0.00	12.90^{ns}	0.00c	0.36b	0.00b
HFT	17.50a	0.00	12.93	0.00c	0.43a	0.00b
ATS						
1%	16.08b	16.95ab	13.45	14.50ab	0.43a	0.65a
2%	16.16b	15.98b	12.98	12.70b	0.40b	0.56a
3%	16.15b	16.15b	13.16	13.40b	0.39b	0.62a
Dormex						
0.25%	17.01ab	17.42a	12.66	18.03a	0.39b	0.55a
0.50%	16.55ab	16.46ab	12.66	14.52ab	0.39b	0.55a
0.75%	16.68ab	16.53ab	12.63	14.18ab	0.37b	0.52a

**Means in columns followed by the same letters are not significantly different at the P 0.05 level by Duncan's multiple range test

ns: not significant

Thinning practices affect fruit quality as well as the number of flowers next year [26]. In varieties tend to alternate bearing, flower thinning is reported to be more effective than fruit thinning in decreasing alternate bearing severity [21, 12, 19, 18, 10]. This is particularly important for varieties showing alternate bearing. Brown, 1997 [6] emphasizes that there is a reduction in fruit color development due to excessive crop load in the 'Jonagold' and early thinning is needed to reduce the alternate bearing. It has been determined that Etephon applications in Redchief apple, 3, 6 and 9 weeks after full flowering, increase the flowering rate by 33% in "off year" and decrease by 17% in "on year" [7]. In the York-Imperial apple variety, which showed a middle tendency to alternate bearing, thinning 30 days after full bloom, sufficient flower buds were formed in the next yield period, and thinning after this period did not have a consistent effect on flower bud formation [13]. In this study, 2%, 3% ATS and 0.75% Dormex were effective applications to partially or even reduce alternate bearing compared to other applications. In season 2, no fruit was taken from control and hand fruit thinning (Figure 3).

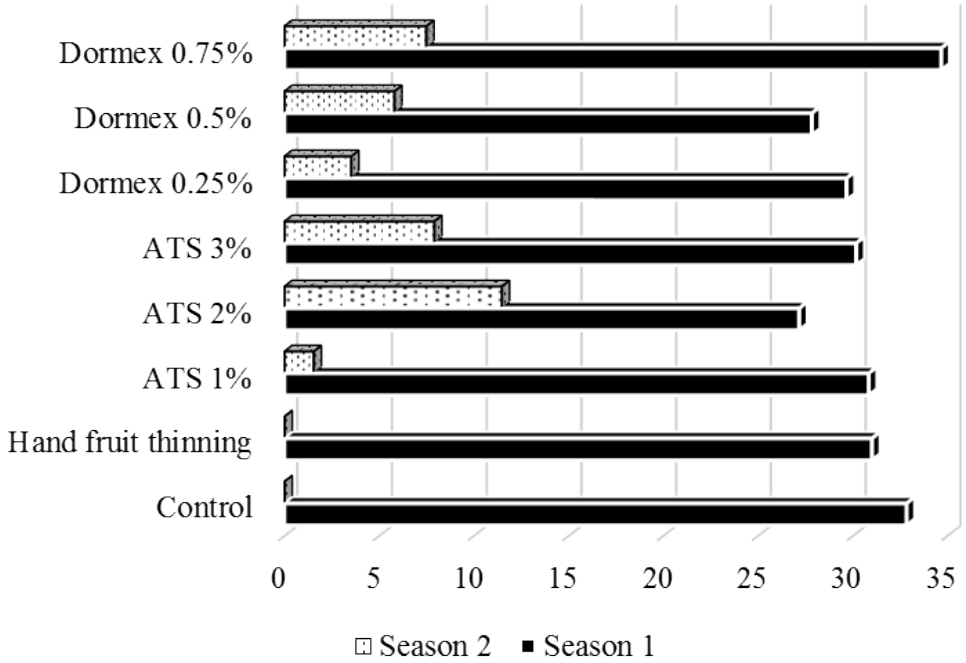

Figure 3. Effects of thinning applications on yield

(Means in columns followed by the same letters are not significantly different *Means in columns followed by the same letters are not significantly different at the P 0.05 level by Duncan's multiple range test, ns: not significant)

Ammonium thiosulfate (0.3%, 1.5% and 4%) used as a flower thinner in the 'Hi Early Delicious' apple variety and 'Winter Cole' pear variety [2], had no effect on flower bud formation in the next year. Similar findings have been reported by Bound and Mitchell 2002 [3] that 2% ATS application significantly reduces crop load in 'Packham's Triumph' pear, 20% and 50% flowering period, but the application has no effect on flower bud formation in the following year. Studies on apples have reported that apple varieties, which tend to alternate bearing, generally do not react to thinners [11]. The 'Golden Reinders' used in our research having an alternate bearing tendency showed a similar situation.

CONCLUSION

Efficacy of ATS and Dormex on the fruit quality and return bloom in 'Golden Reinders' apple was evaluated in this experiment. 2% and 3% ATS have increased the fruit size for each trial years. 2%, 3% ATS and Dormex were reduced alternate bearing severity. But this impact was not economical level. Therefore, second ATS applications or fruit thinning with BA or NAA may give more effective results than the single application on the alternate bearing severity in the varieties showing periodicity such as Golden Reinders. It has been determined that ATS applications give close results to hand fruit thinning to increase important quality components such as fruit weight and fruit diameter.

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