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Chemical and Defoliation Effects on Fruitset of Apple (*Malus domestica*)

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Abstract: Experiments were carried out at Klein Altendorf station in 2001 and 2002 with the objectives of finding the effect of the chemicals and defoliation on yield, fruit set and quality of apples and investigate how photosynthesis and transpiration are affected by one of the chemical thinners (i.e., Azolon). At a dose of 10 mg ai/Li Ethrel (Flodimex) thinned better than at 5 mg ai/Li in 2001 while at 3 mg/Li in 2002 it achieved the required fruit set by thinning before June drop 62 and 15%, respectively after June drop compared to 49% of the unsprayed control and improved fruit size while yield per tree was reduced by 31% by Ethrel at 10 mg ai/Li but not Ethrel at 5 mg i/Li which had no effect on yield. Mean fruit weight was unaffected by the treatments. The foliar urea based fertilizer Azolon fluid at 75 mg ai/Li applied at full bloom, resulted in 61% fruit set before and 17% after June drop in 2002, slight leaf yellowing, killing and epinasty 7 days after treatment application which disappeared 14 days later but probably started earlier and a slight reduction in leaf photosynthesis and transpiration rates. However, Azolon fluid (i.e., methylene urea or urea formaldehyde) yielded smaller fruit than Ethrel (Flordimex), but larger fruits than the untreated control trees, without affecting fruit yield. The partial and gradual defoliation of selected primary spur leaves reduced fruit set to 50% before and 14% after June drop. These results provide evidence that reductions in photosynthetic rate or photosynthetic leaf area during the period of flowering is sufficient and can successfully induce thinning with a commensurate efficacy of the chemical thinners.

Key words: Azdom fluid, methylene urea, chemical thinners

INTRODUCTION

Fruit trees develop many more fruits than they can support through to maturity. Hence, fruits are subjected to abscission at three stages of fruit ontogeny. The first early or flower drop shortly after anthesis is followed by June drop and a further drop before harvest (Denis, 2000). Abiotic and biotic stresses such as late spring frosts or over cropping can disturb these regulatory mechanisms and cause biennial bearing. Fruit thinning has become a relevant management practice to produce apples of high quality including a particular fruit size, (red) coloration, firmness and soluble solids. Thinning is also a relevant measure to overcome biennial bearing.

Information on photosynthesis with respect to thinning is scarce (Bangerth and Quilan, 2000). Chemical thinners such as ammonium thiosulphate (ATS) or urea caused phototoxic effects ranging from leaf yellowing to leaf burn and reduced apple photosynthesis by 6 to 33% over 3-7 days, measured either by warburg apparatus (Groschowska and Lubinska, 1973), porometry (Stopar, 1997) or whole canopy gas exchange (Untiedt and Blanke, 2001). Hence, the involvement of fruit thinning has been postulated, but not investigated or proven. The aim of this study was to give evidence that temporary reductions in photosynthetic rate is the cause of fruit thinning. The overall objective was to investigate the effect of the treatments on fruitset, yield, quality and finally on the photosynthetic and transpiration rates of Azolon (methylene urea) application.

MATERIALS AND METHODS

Experiments were carried out in the year 2001 and 2002 at Klein Altendorf Experimental Station near Bonn, Germany to investigate the effect of different chemical and defoliation treatments on apple fruit set. The treatments applied in 2001 were unsprayed control, Amidthin 0.2 mg ai/Li plus Ethrel at 2.5 mg ai/Li, Ethrel at 5 mg ai/Li and 10 mg ai/Li, at early flowering stage, Ammonium Thiosulphate (ATS) at 400 g a.i/Li at petal fall and 280 g a.i/Li plus Telmion at 1.5 mg ai/Li at 20-30% open bloom stage. In the year 2002 the treatments applied were Azolon fluid (urea formaldehyde or methylene urea) at 75 mg ai/Li, Ethrel (Flordimex) at 3 mg ai/Li, Azolon at 75 mg ai/Li plus 3 mg ai/Li all applied at full bloom, partial defoliation comprising removing one third of primary spur leaves removed at early and one half at full bloom and unsprayed control.

The treatments were arranged in a randomized complete block design with three replications and three trees per block. Blocking was done against topography.

The experiments were carried out on CV Elstar apple trees in 2001 and 2002 on M9 rootstocks and at a spacing of 3.45×1.5 m. The pressure of the sprayer used to apply the chemicals was 2.5 bars. Spraying was carried out on a non-windy day on 15th April, 2001 between 1100 to 1200 h. The relative humidity was 60% while the temperature was 18°C and a wind speed of 4 m sec^{-1}. The spraying was carried out by a mechanical sprayer. Whole trees were sprayed on a sunny day. The sprayer attached to the tractor was designed for experimental activities and had 4 chambers for spraying the different treatments. The volume of spraying was 600 Li ha^{-1}.

RESULTS

In the year 2001 Ammonium Thiosulphate (ATS 2) sprayed on to flowers of one-year old shoots at petal fall, ammonium thiosulphate (ATS 1) sprayed to shoots older than one year, Amidthin plus Telmion and Amidthin had no thinning effect as compared to the unsprayed controls (Table 1). Conversely, Ethrel sprayed at 500 mL ha^{-1} had a 40% thinning effect as compared to Ethrel sprayed at 1000 mL ha^{-1} which had 67% (Table 1).

In terms of fruit yield Amidthin plus Ethrel reduced yield by 22% while Ethnel 1000 mL ha^{-1} had 30% reduction in yield and Ethrel 500 mL ha^{-1} had no effect (Table 1). Ammonium thiosulphate (ATS 2) had 44% increase in yield while ammonium thiosulphate (ATS 1) had no significant effect ($p<0.05$). In contrast, Amidthin plus Telmion had 50% increases in yield. The treatments did not have any significant ($p<0.05$) effect on the mean fruit weight (Table 1). With respect to fruit size classification (Table 1) according to diameter Amid-thin plus Ethrel, Amid-thin plus Telmion, Ammonium Thiosuphate (ATS 1) and Ammonium Thiosulphate (ATS 2), the percentages of fruits in the preferred fruit diameters for class 1, i.e., 75 to 90 mm were, respectively 71, 70, 68 and 60% (Table 1).

In the year 2002, the fruit set counts before June drop were 62, 63, 80, 58 and 150 for Ethrel (Flordimex), Azolon fluid, Azolon fluid plus Ethrel (Flordimex), defoliated treatment and unsprayed control respectively (Table 2). The chemical and defoliated treatments thinned equally but more than the unsprayed control. Similar trends were observed in fruit set counts after June drop but with lower values (Table 3). Ethrel had the largest fruits followed by Azolon fluid and partial defoliation which had no significant difference between them, in 2002 (Table 2). Transpiration and photosynthetic rates were reduced by 20 and 5% respectively one day after the application of Azolon (data not shown).

Table 1: Effect of chemical treatments on fruit size, fruit lets and yield of apple trees at the Klein Altendorf station, near Bonn, Germany in the year 2001

Treatments	Fruit size (mm)	No. of fruit lets	Yield (kg $tree^{-1}$)
Amidthin + Ethrel	71.0^{b}	14.0^{a}	14.5^{b}
Amidthin + Telmion	70.0^{b}	12.0^{a}	27.0^{def}
ATS 2	68.0^{b}	13.5^{a}	26.0^{de}
ATS 1	60.0^{c}	14.5^{b}	23.2^{d}
Ethrel 10 mg ai/Li	79.0	4.1^{b}	13.3^{ab}
Ethrel 5 mg ai/Li	56.0^{c}	7.5^{b}	8.2^{a}
Control	40.0^{d}	12.5^{a}	19.5^{cd}
LSD ($p\leq0.05$)	7.6	5.0	6.2

Values with the different letter(s) are significant different at $p<0.05$

Table 2: Effect of treatments on the fruit size (mm) and on the initial fruit set of apple trees before June drop at Klein Altendorf station near Bonn, Germany in the year 2002

Treatments	Fruit size percentage of fruit larger than 70 mm	No. of fruitlets clusters before June drop
Ethrel (Flordimex)	77.0^{a}	63.00^{abc}
Azolon (Methylene urea)	67.0^{b}	65.00^{c}
Partial defoliation	68.0^{b}	58.00^{a}
Unsprayed control	60.0^{c}	147.00^{d}
Control LSD ($p\leq0.05$)	9.2	28.35

Values with the different letter(s) are significant different at $p<0.05$

Table 3: Effect of treatments on final fruit set of apples at Klein Altendorf near Bonn, Germany after June drop in 2002

Treatments	No. of fruits per 100 flower clusters after June drop
Ethrel (Flordimex)	14.00^{a}
Azolon (Methylene urea)	16.00^{ab}
Partial defoliation	15.00^{abc}
Unsprayed control	49.00^{d}
LSD ($p\leq0.05$)	7.57

Values with the different letter(s) are significant different at $p<0.05$

DISCUSSION

In the year 2001, the treatments amid-thin plus Ethrel, Ammonium Thiosulphate (ATS 1), Amid-thin plus Telmion and Ammonium Thiosulphate (ATS 2) were not statistically different ($p\leq0.05$). This may have been due to environmental factors, cultivar effects, time of application factor and concentration used (Weaver and Pool, 1971). The weather conditions during the time of spraying and immediately after particularly temperature, humidity and wind velocity have an effect on the efficacy of the chemical thinners. Cultivar effect can influence thinning because there are some apple cultivars, which are difficult to thin and therefore need higher concentrations of the chemicals. The mode of action of Azolon and Ammonium Thiosulphate may be the killing of blossoms and leaves. Whether killing of blossoms is strictly necessary for their thinning is not documented. The fact that the thinning effect may be correlated with the degree of leaf and blossom) induced by higher treatment concentration and higher spray volume could have affected the present results, i.e., the concentrations could have been too low to trigger the above mentioned effects. Ethrel used at the rates of 500 and 10 mg ai/Li thinned the fruits well and this

can be attributed to increased ethylene biosynthesis and reduced basipetal auxin transport to the separation zone (Untiedt and Blanke, 2001). At the Ethrel (Flordimex) concentration of 10 mg ai/Li the tendency for the above conversion increased many-fold.

Most of the treatments applied in 2001 particularly azolon and Ammonium Thiosulphate increased yield. These compounds are also nitrogen containing and they may have increased vegetative growth of the apple trees. The ammonium thiosulphate sprayed to shoots older than 1 year had no effect on yield due to their slower growth rates as compared to current shoots. The treatments increased the fruit diameter classes due to their thinning effects, which lowered fruit counts thus reducing competition for metabolites among the remaining fruit (Quinlan and Preston, 1968). Azolon and Ammonium Thiosuphate did not thin but increased fruit diameter most likely due to their fertilizing effect.

In the year 2002 all the chemical and defoliation treatments thinned the fruits equally but more than the unsprayed control. Following petal fall, fruit growth, leaf area and shoot growth increases rapidly. There is a high demand for energy produced at these multiple centers of metabolic activity (Quinlan and Preston, 1971). Leaf photosynthesis is the main source of carbohydrates for developing fruit. Apple fruit abscission after fertilization and during June drop has been attributed to competition for essential metabolites, including photosynthesis, among individual fruit lets and between fruit lets and vegetative shoots (Knight, 1980). Shading or application of photosynthetic inhibitors such as chemical thinners reduces photosynthesis. Similar results are observed with leaf defoliation as in the present study, which also reduces carbohydrates available causing early fruit abscission (Proctor and Palmer, 1991; Byers *et al*., 1990, 1991). Carbon balance models indicate a potential limitation of carbon availability during the first 5 weeks after bloom, a critical period for fruit set and fruit cell division (Lakso and Grapadelli, 1992).

CONCLUSION

It can be concluded that: the chemical treatments thinned the fruits adequately and were not significantly different from the defoliation method. Fruit size was improved and photosynthetic and transpiration rates were slightly affected after Azolon application.

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