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Study on Effective Methods for Reducing the Alternate Bearing in Golden Delicious Apple Cultivar

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ABSTRACT

The effects of nitrogen application (Urea, 46% N), fruit thinning and ringing on flower bud formation of "Golden Delicious" apple trees were studied in two independent experiments in 1992 and 1993. In the first experiment, the effects of nitrogen application and fruit thinning at levels of 0, 25, 50 and 75% on flower bud formation were studied in full-bearing trees. In the second experiment, the effects of nitrogen application and ringing on flower bud formation were studied in poor-bearing trees. The results showed that full-bearing fertilized and unfertilized apple trees produced almost the same flower buds, but the thinning treatments at levels of 50 and 75% produced higher flower bud formation as compared with controls (P< 0. 0 1). For poor-bearing trees, both ringing and application of nitrogen together or alone showed an increase in flower bud formation in the following year compared to the controls (P< 0. 0 5).

Keywords: Alternate bearing, Apple, Full-bearing, Poor-bearing, Ringing, Thinning.

INTRODUCTION

Alternate bearing is a common phenomenon to many fruit trees, with varying intensity. But this phenomenon emerges at high intensity in some apple cultivars especially in 'Golden Delicious' (5). The yield decreases dramatically in the subsequently year as a result of this phenomenon which in turn is caused by the lack of meristem differentiation in the full-bearing year (5, 9).

Organogenesis and regular differentiation of meristems depend on the genetic nature of the cultivar, climatic conditions, carbohydrate reserves and the growth vigour of the tree (12,14,17). Although nitrogen application in spring is essential for tree growth, the plant obtains the necessary nitrogen from the nitrogen stores available in the roots and woody limbs in the early growth stages. Early nitrogen application recompenses for the use of nitrogen reserves (8,10) and, consequently, a balance needed for organogenesis is brought about between carbohydrate reserves and nitrogen in the course of gradual growth. One essential factor for organogenesis and bud-break completion is amplified and mature foliage, since the fruits are consumers of photosynthetic materials, there should exist enough foliage in the form of mature leaves on trees for the satisfactory growth of every fruit. Studies indicate that 25 to 42 mature leaves are needed for the satisfactory nutrition of every apple fruit on 'Golden Delicious' trees under normal climatic conditions (10). This amount of foliage per fruit is created via suitable vegetative growth and especially punctual nitrogen application and also indirectly trough pruning, thinning and reduction of the number of fruits (6,17,22). Synthesis of chemicals out of indigene hormones (GA) has a negative effect on the following year's organogenesis through seeds whereas the production of a sensible amount of these chemicals together with other hormones bears a positive impact

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on organogenesis and particularly on meristem mitosis (2). The amount of hormonal substances extracted from the seeds of cultivars with alternate bearing is 60% more than the level of hormones extracted from the seeds of constant-bearing cultivars, and this high density acts definitively as an effective inhibitor to organogenesis.

In apple trees, flower induction occurs 4 to 6 weeks after full bloom (4). This phenomenon will be decreased when the amount of gibberellin in the pre-June drop phase is high. In cultivars susceptible to alternate bearing, the conveyance of gibberellin through growing seeds in the third and fourth weeks following full bloom contracts of the auxins and interrupts organogenesis, leading finally to a decline in fruit production (7). Maximum gibberellin production has been observed 45 to 60 days after full bloom (16,18,19). Therefore, high gibberellin synthesis and its proinhibitive effects caused by high bearing should be prevented. The maintenance of the carbon/nitrogen (C/N) relationship in the tree, early and timely fruit thinning (3,11) and interventions for the increase of carbohydrate reserves in trees are all very effective in this respect (20).

Trunk or branch girdling and different cuts on trees are effective in adjusting of vegetative growth and increasing crop yield. Ringing at the beginning stages of growth precipitates growth and increases flowering for the next year (1). Despite its satisfactory storage capability the prevailing cultivar in Iran, the 'Golden Delicious' is very prone to alternate bearing (13). The objective of this work was to study nitrogen application together with fruit thinning in full-bearing trees and nitrogen application and ringing on poor-bearing trees on this cultivar, in order to reduce alternate bearing.

MATERIALS AND METHODS

Experiment 1: Nitrogen Application and Fruit Thinning Effects on Flower Bud Formation in Full- Bearing Trees.

The experiment was conducted in spring 1992 using split plot design in a randomized complete block design with three replicates. Nitrogen applications were considered as main plots and thinning treatments as subplots. A total of 24 trees used in this experiment were 19 year-old 'Golden Delicious' trees, grafted on the seedling rootstock, planted in alternate lines with 'Red Delicious' trees. They were trained in an espalier at a spacing of 2×5 m. in a sandy-loam soil at the Research Orchard in Khalat Pooshan Station, College of Agriculture, Tabriz University, Tabriz. (latitudes 46°17´ E and longitude 38°5´ N, altitude 1567 m., from 7 km. E. North of Tabriz , Iran).

Urea-type Nitrogen (46% N) was added to the soil, 70 cm. from the tree trunks in both planting lines, on the basis of tree age (19 years-old), planting density (1000 trees / ha with 'Golden'and 'Red Delicious' cvs.) and crop yield (50 tones in "On" year)of two levels: 0 g. for control and 500 g. for every treated tree (200 g. before bud-break , 200 g. after bud-break and 100 g. after setting). Hand fruit thinning was completed 30 to 40 days after full bloom and consisted of four levels of 0, 25, 50 and 75% of the total fruits.

In 1993, at anthesis, the total number of mixed buds on treated trees and controls were counted and their number was determined by multiplying the number of mixed buds number by 5 (average flowers in every inflorescence). The data were analyzed and examined by analysis of variance, using MSTATC software and the means compared using Duncan's Multiple Range Test.

Experiment 2: Nitrogen Application and Ringing Effects on Flower Buds Formation in Poor-Bearing Trees.

The experiment was conducted in 1992, in a randomized complete block design with three replicates in order to study the effects of nitrogen application and ringing on organogenesis in the poor-bearing trees for next year (1993). The twelve 'Golden Deli-

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Table 1. Analysis of variance for nitrogen application and fruit thinning in full-bearing trees organogenesis via espalier training.

Sources of variation	df	MS	F
Fertilization	1	205.6761	$2.2.8^{ns}$
Replicate (Block)	2	2540.9028	28.32^{a}
Error 1	2	90.0243	---
Fruit thinning	3	717.4972	10.79^{b}
Fertilizing x fruit thinning	3	60.2409	0.90^{ns}
Error 2	12	66.7346	

^{a,b} significant at 5% and 1% probability levels.

cious' apple trees were 24 years-old and all uniformly spaced (6x6 m.) and were pruned using an open center method. They were grown in sandy-loam soil at the Research Orchard at Khalat-Pooshan Station, as described in the first experiment.

Urea-type Nitrogen (46% N), was mixed the soil, shaded by a crown of trees, on the basis of tree age (24 years-old), planting density (270 trees/ ha with 'Golden' and 'Red Delicious' cvs.) and crop yield (25 tones in "On" year) at two levels: 0 g. for controls and 2500 g. for every treated tree (1kg. before bud-break, 1 kg. after bud-break and 500 g. after fruit setting). A two mm. ringing of the main branches also was performed uniformly in the trees. In 1993, all the flower buds on the treated and control trees were counted. Finally, data from the number of flower bud formations in treated and control trees were compared by analysis of variance using MSTATC software and the means compared using Duncan's multiple range test.

RESULTS

Experiment 1: Nitrogen Application and Thinning Effects on Flower Buds Formation in Full-Bearing Trees.

There were no significant differences between fertilized and unfertilized full-bearing trees (Table 1). Nevertheless the comparison of the means of flower bud formation of thinned trees with that of the control indicated that thinning applications increased flower formation in full-bearing trees (Table 1).

Higher thinning levels (50 and 75%) showed to be significantly different in comparison with lower flower thinning (25%) and the control (Table 2). The lowest number of flowers were produced by no thinning or low thinning and no fertilization (control) at full- bearing trees of 1992. The higher flower bud formations were produced by nitrogen application with thinning at 50 and 75% levels, and a statistically significant increase in flowering was observed (Figure 1). These results may have benefits in controlling alternate bearing.

Experiment 2: Nitrogen Application and Ringing Effects on Flower Bud Formation in Poor-Bearing Trees.

The mean of flower bud formation in 1993 as affected significantly by ringing and fertilization in poor-bearing year (1992) is

Table 2. Comparison of mean of flower buds formation by fruit thinning levels in espalier trained full-bearing trees in 1993.

Fruit thinning levels (%)	Means flower buds formation (number)	
75	54.07^{a}	a
50	49.11	a
25	32.15	b
Control	33.87	b

^{a} Different letters show significant at 5% levels probability, according to DMRT.

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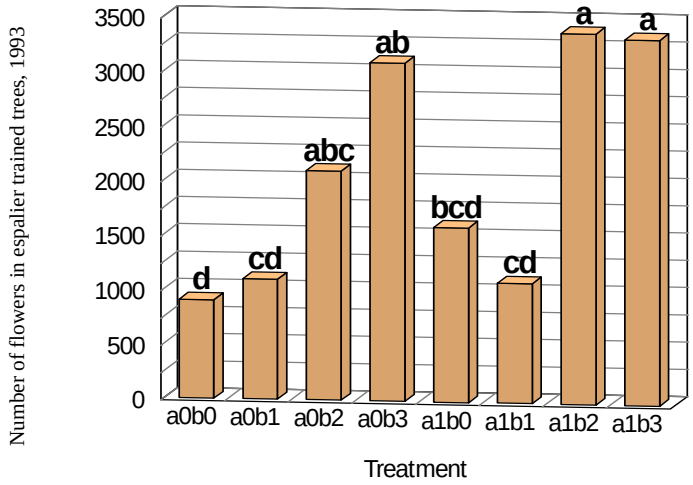

Figure 1. Nitrogen application and fruit thining effects on flower bud formation. Columns with similar letters are not significant at 5% level of probability (DMRT).

given in Tables 3 and 4. Both ringing and fertilization together or alone showed an increase in flower bud formation in the following year as compared with the control (Figure 2).

DISCUSSION

Results from the first experiment showed that early fruit thinning at levels of 50 and 75% in full-bearing trees increased flower

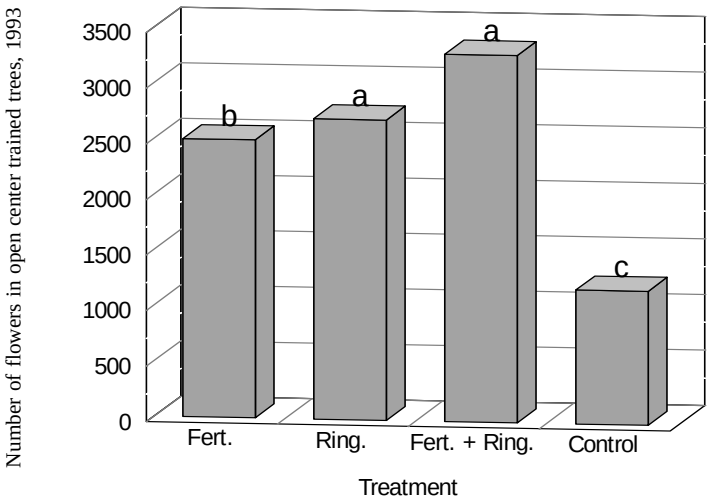

Figure 2. Fertilizing, ringing and fertilizing + ringing effects on poor bearing-year flower bud formation. Columns with similar letters are not significant at 5% level of probability (DMRT).

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Table 3. Comparison of means of flower bud formation by different treatments in poor-bearing trees in 1993.

Sources of variation	df	MS	F
Block	3	1228.566	5.573[a]
Treatment (Fertilizing + Ringing)	3	2585.090	11.720[b]
Error	6	220.397	--

[a , b] Significant at 5% and 1% probability levels.

Table 4. Analysis of variance for ringing and fertilizing in poor-bearing trees organogenesis in 1993.

Treatments (%)	Mean flower buds formation (number)	
Ringing + Fertilizing	188.32[a]	a
Ringing	167.20	a
Fertilizing	160.12	a
Control	118.29	b

[a] Different letters show significant difference at 5% levels probability, to DMRT.

bud formation in the next year (P< 0.01). Comparison of the number axillary mixed buds formed in treated and control trees in 1992 with 1993, confirmed that flower bud formation was affected by more than 20%, by the earlier fruit thinning. Conseavently the fruit thinning strategies were effective in regulating alternate bearing with cultivar 'Golden Delicious', which tend to occur every second year and are difficult to regulate.

No positive effects of fertilization on the flower bud formation of full-bearing trees occurred in the next year. It was not possible to avoid alternate bearing by fertilization. This findings confirm those found by others (6,17, 22). However, fertilization is necessary for following vegetative growth and increase growing points and is therefore recommended. (6). On the other hand, thinning at the end of June on apple trees in our experiment reduced alternate bearing. The early thinning always gave the best results in terms of regularity of cropping yield and marketable fruit (15,17, 20). Therefore, it is highly recommended that flower and fruit thinning help to avoid alternate bearing and improved fruit quality (3).

It seems that the lack of nitrogen may cause the inhibition of organogenesis in poor- bearing apple trees. It is possible that the increase total nitrogen in tissues may alter the C/N ratio which in turn increases vegetative growth in poor-bearing apple trees. In 1993, the capability of trees to produce higher flower bud formation caused less alternate bearing. In fact, ringing and fertilization caused more meristem differentiation in the poor-bearing year (P< 0.05). This supports the theories of Gosh, (12); Heink, (14), and Rome and Ferre (21) while the availability of nitrogen in plant tissues in 1993 as shown in our experiments could change some important physiological constraints. These relationships imply that, in general, the sink strength as mentioned by L. C. Ho (15), and IAA exported out of fruit and shoot tips through an increase of vegetative growth as mentioned by Callegas and Bangerth (4), also play a very important role in organogenesis, tissue differentiation and other phenomena that resulted in fruit production in our experiment. On the other hand, the sink strength of trees (shoots and fruits) related to sink size which was increased by nitrogen application and the sink activity in height bearing trees, that increased the transport of IAA, was involved in flower initiation (4) of apple trees in 1992. In fact, nitrogen fertilization and ring-

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ing and even thinning treatment could effect apoplastic unloading or hydrolysis of sucrose or uptake of sugars, all of which increase the tree activity (15). Finally, plant growth substances play an important role in these experiments and we look forward and invite applied research in this regard.

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بررسي روشهاي موثر در كاهش تناوب باردهي در سيب رقم " گلدن دليشس "

و. گريگوريان و س. بيدريغ شارمي

چكيده

در اين آزمايش اثرات كاربرد نيتروژن (اوره تجارتي ٤٦%)، تنك ميوه و حلقه‌زني در تشكيل جوانه‌هاي گل در سيب رقم "گلدن دليشس" در دو بررسي مستقل در طي سالهاي ١٣٧١ و١٣٧٢ مورد ارزيابي قرار گرفت. در آزمايش اول اثرات نيتروژن در دو سطح كوددهي وعدم كوددهي و تنك ميوه در چهار سطح ٠، ٢٥، ٥٠، و ٧٥% در تشكيل جوانه‌هاي گل در درختان پر بار و در آزمايش دوم اثرات نيتروژن در دو سطح كوددهي وعدم كود دهي و حلقه زني در تشكيل جوانه هاي گل در درختان كم بار بررسي شد. نتايج آزمايش‌ها نشان مي‌دهد كه در درختان پر بار كوددهي و عدم كوددهي تقريبا" گل دهي يكساني را موجب گرديد ولي سطوح ٥٠ و ٧٥% تنك ميوه، گلدهي بيشتري را در مقايسه با شاهد نشان داد. ($P< 0.01$). در درختان كم بار، تيمارهاي حلقه‌زني و كود دهي بصورت توام و يا تنهائي براي سال بعد افزايش گلدهي را در مقايسه با شاهد موجب گرديد ($P < 0.05$). در نهايت در اين بررسي مباني و روابط موجود ما بين افزايش اثرات كاربرد نيتروژن و برخي موانع فيزيولوژيكي در ارتباط با اندام‌زايي مورد بررسي قرار گرفت.

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