

Original Research Article

Effect of plant growth regulators in the chemical thinning and return bloom of Eva apple trees

ABSTRACT

Aims: The aim of this study was to evaluate the effect of the application of different plant growth regulators, namely naphthaleneacetic acid (NAA), 6-Benzyladenine (BA) e Promalin® (6- benzyladenine (BA) with the gibberellic acid GA₄₊₇, on the chemical thinning and return bloom of Eva apple trees.

Study design: The experimental design used was a randomized complete block design, with four replications, with two plants per treatment in each block, following a one-step scheme with 13 treatments for the thinning factor. Obtained results were submitted to analysis of variance, and means were compared by Tukey test with a 5% probability of error.

Place and Duration of Study: The experiment was carried out in the agricultural years of 2012/2013 and 2013/2014 in a commercial orchard located in the municipality of Morro Redondo, RS, Brazil.

Methodology: Plant regulators were applied in both years as follows: Promalin® was sprayed with 80 % of opened flowers at doses of 0.5, 1.0, 1.5 and 2.0 mL L⁻¹; NAA and BA were sprayed in fruits with 5-7 mm diameter, at doses of 5, 10 and 15 mg L⁻¹ and 50, 75, 100 and 125 mg L⁻¹, respectively, and manual thinning was performed after full bloom.

Results: Number of fruit per plant, density of fruits by the trunk cross-sectional, yield per plant and the return of bloom in the second cycle were evaluated in the field. Pulp firmness, total soluble solids, fruit diameter, fruit length and mean fruit mass were evaluated at Laboratório de Agronomia (LabAgro), Universidade Federal de Pelotas. Promalin® at different concentrations, showed results statistically similar to the manual thinning, being an alternative as moderated thinning.

Conclusion: The plant growth regulator NAA reduced the harvest load, but had a negative response resulting in the formation of pygmy fruits. The BA-based treatments were the most efficient as they reduced harvest load, and increased fruit size and flowering return.

Keywords: Apple; Chemical thinning; 6-Benzyladenine; Naphthaleneacetic acid, Promalin®.

1. INTRODUCTION

Thinning is an important cultural practice which influences fruit productivity and quality. Fruit tree thinning is justified by two main reasons, according to physiological aspects of the plant: to reduce the risks of alternation of production, common in the following cycle in years of excessive load in which the plants were not thinned or the process was inadequately; and to have fruits with increased quality (bigger, more colorful, higher sugar content and more aromatic)[1].

Thinning can be performed manually or chemically, however, manual thinning has some limitations such as the time of execution, labor availability and its cost, so the search for new technologies in chemical thinning becomes important.

In fact, the use of chemical thinning in pomiculture reduces considerable the need of labor and consequently its cost. Besides the economic aspects, orchards treated with chemical

thinning tend to produce fruits with increased quality, increased mean fruit mass and more regular production avoiding the alternation of production [2]. The chemical thinning as a viable alternative to the manual thinning in pomiculture, as it requires less time of execution and reduced labor [3, 4].

Naphthaleneacetic acid (NAA), carbaryl and, more recently, 6-benzyladenine (BA) are among the chemical thinners used in apple tree culture [4, 5]. Another product also used is Promalin® formed by the mixture of two natural plant growth regulators, cytokine 6-BA (benzyladenine) and gibberellins GA4 + 7 [6]. The aim of this study was to evaluate the effect of the plant growth regulators naphthaleneacetic acid (NAA), 6-benzyladenine (BA) and Promalin® (6-benzyladenine (BA) + gibberellins GA4 + 7) on chemical thinning and return bloom of Eva apple trees.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The study was performed in two agricultural cycles 2012/2013 and 2013/2014 in a commercial orchard located in Morro Redondo municipality, RS, Brasil (31° 40' 60" South and 52° 34' 50" West). Seven years old Eva apple trees, grafted on a Marubakaido rootstock and conducted in the central leader system with a density of 2500 ha⁻¹ plants were evaluated.

The following treatments were applied:

- T1) Control = manual thinning, 30 days after full bloom;
- T2) Promalin® 1.25 ml L⁻¹;
- T3) Promalin® 1.5 ml L⁻¹;
- T4) Promalin® 1.75 ml L⁻¹;
- T5) Promalin® 2.0 ml L⁻¹;
- T6) NAA 5 mg L⁻¹;
- T7) NAA 10 mg L⁻¹;
- T8) NAA 15 mg L⁻¹;
- T9) NAA 20 mg L⁻¹;
- T10) BA 50 mg L⁻¹;
- T11) BA 75 mg L⁻¹;
- T12) BA 100 mg L⁻¹;
- T13) BA 125 mg L⁻¹.

The commercial products ANA Técnico (9.5 % active ingredient) and MxCel® (2 % active ingredient) were used as source of NAA and BA, respectively. Promalin® was also used and it is composed by gibberellins GA4 + 7 (1.8 %) and cytokine 6-benzyladenine (1.8 %) [6].

61 The mineral oil Assist® (0.2 %) was added to all treatments. The applications were carried
62 out by spraying with a backpack sprayer using spray medium volume corresponding to 1000
63 L ha⁻¹. Promalin® was applied when 80% of the flowers were opened (FA), NAA and BA
64 were applied when the larger fruits reached 5 to 7mm in diameter.

65 Number of fruits per trunk cross-sectional area (cm⁻²) (TCSA), trunk diameter at 20 cm from
66 the ground, number of fruits per plant, yield per plant (kg) and mean fruit mass (g) were the
67 parameters evaluated in the field. Pulp firmness (N), was performed by removing the peel on
68 two opposite sides of the equatorial region of the fruit, and measured using a Turoni 53205
69 digital penetrometer, with an 11 mm diameter probe. Fruit diameter (mm), fruit length (mm),
70 length/diameter (L/D) ratio and total soluble solids (°Brix), were evaluated in all treatments in
71 the two years of the experiment.

72
73 The return bloom was evaluated for the second agricultural year (2013/2014), estimated
74 using a scale of 1-10, where 1= without flowers and 10= intense flowering, this evaluation
75 was made considering three branches marked in the plant. The experimental design used
76 was a randomized complete block design, with four replications, with two plants per
77 treatment in each block, following a one-step scheme with 13 treatments for the thinning
78 factor. Obtained results were submitted to analysis of variance, and means were compared
79 by Tukey test with a 5% probability of error.

81 3. RESULTS AND DISCUSSION

82
83 A significant influence was observed for the number of fruits per plant for the 2012/2013
84 harvesting when comparing the chemical treatments with the manual thinning (mean value
85 82.75 fruits per plant). Treatments with Promalin® were not statistically different from each
86 other and from the manual thinning. A significant reduction on fruits per plant was observed
87 for the NAA 15 mg L⁻¹ (mean value 51.25 fruits per plant) comparatively to the manual
88 thinning. Treatments with BA resulted in reduced number of fruits per plant as well, with
89 mean values of 40.50, 50.25 and 43.75 fruits per plant for dosages of 50, 100 and 125 mg L⁻¹,
90 respectively, with consequent lower harvest load (Table 1).

91 Results obtained by [5], where BA was applied at 120 mg L⁻¹ in Fuji Suprema fruits (5 to 8
92 mm diameter), also showed a significant reduction on number of fruits per plant
93 comparatively to the manual thinning. In addition, [7] also reported a reduction on the
94 number of fruits per plant in Summerred cultivar treated with BA and NAA. The application of
95 BA increases the competition for carbohydrates between larger fruits in relation to smaller
96 fruits, reducing the number of fruits per plant [8]. The mechanism of action of BA in respect
97 to apple thinning is still theme of discussion on the literature; one of the evidences is the
98 action of BA on the reduction of polar transport of indolacetic acid, resulting in an increase
99 on cells sensibility in the ethylene abscission area [9, 10, 11].

100 A similar behavior was observed for manual thinning and treatments with Promalin® in
101 respect to the number of fruits for the TCSA, both treatments showing the highest values.
102 Nevertheless, treatments with NAA and BA showed a significant decrease on this parameter
103 compared to manual thinning, as well as a reduction on the number of fruits per plant.

104 Regarding pulp firmness, the manual thinning showed the lowest value (59.21N) and BA 100
105 mg L⁻¹ (73.16N) the highest value (Table 1). The application of BA is responsible for the
106 increase of fruit size and also for pulp firmness, as these parameters are related with cell
107 division [12].

In respect to mean fruit mass, it was verified that BA (125 mg L⁻¹), the highest dosage of the cytokine plant growth regulator, presented a mean value of 160.5 g not differing from the manual thinning (Table 1). Once again it was verified that BA influences the fruits size and weight trough the increase of number of cells per fruit due to the stimulation of cell division [13].

Table 1 – Number of fruits per plant, fruits per trunk cross-sectional area, production per plant, mean fruit mass and pulp firmness in different thinning treatments for the first experiment cycle (2012/2013) on Eva cultivar.

Treatments	Number of fruits plant ⁻¹	Fruits cm ⁻² TCSA	Yield plant ⁻¹ (Kg)	Mean fruit mass (g)	PF (N)
T1 Manual thinning	82.75 a-c	7.51 a	13.41 a	162.20 a	59.21 b
T2 Promalin® 1.25 ml	82.00 a-c	7.69 a	10.04 a-	122.50 ef	67.97 ab
T3 Promalin® 1.5 ml L ⁻¹	83.50 a-c	7.68 a	11.14 a-	133.50 cd	71.93 ab
T4 Promalin® 1.75 ml	91.25 ab	8.27 a	12.13 ab	133.12 c-	69.20 ab
T5 Promalin® 2.0 ml L ⁻¹	96.25 a	7.93 a	12.51 ab	130.00 c-	70.77 ab
T6 NAA 5 mg L ⁻¹	55.75 cd	4.54 b	7.56 c-e	135.72 cd	65.66 ab
T7 NAA 10 mg L ⁻¹	66.5 a-d	5.42 ab	8.88 b-e	133.75 cd	66.31 ab
T8 NAA 15 mg L ⁻¹	51.25 d	5.47 ab	5.94 de	115.95 f	68.09 ab
T9 NAA 20 mg L ⁻¹	56.25 cd	4.40 b	7.19 c-e	127.92 de	61.15 ab
T10 BA 50 mg L ⁻¹	40.50 d	3.76 b	5.44 e	134.25 cd	68.20 ab
T11 BA 75 mg L ⁻¹	61.75 b-d	5.50 ab	8.55 b-e	138.75 c	71.82 ab
T12 BA 100 mg L ⁻¹	50.25 d	4.49 b	7.45 c-e	147.75 b	73.16 a
T13 BA 125 mg L ⁻¹	43.75 d	4.01 b	6.99 c-e	160.50 a	71.83 ab
Mean	66.28	5.90	9.02	136.57	68.10
CV (%)	17.98	19.94	18.78	3.15	7.92

Means followed by the same letter do not differ from each other, by Tukey test, at 5% probability (p< 0.05). TCSA– Trunk cross-sectional area. PF– Pulp firmness. CV– Coefficient of variation.

The application of BA increased fruit weight as a result from the reduction of harvest load [14, 15]. [16] Also related the increase on the number of fruits with the acceleration on cell division when BA was applied. Treatments with different doses of NAA were those with the lowest mean fruit mass, being the NAA 15 mg L⁻¹ that with lowest result (115.95 grams) (Table 1).

Different results are reported in the literature for the efficiency of NAA in both the thinning and the fruit weight and size, since the chemical thinning should consider the local climatic conditions as well as the cultivar. reports the NAA as a common compound used for apple thinning, although there are different data on their effectiveness, which can be partly explained by the climatic conditions, mainly the temperature and sensitivity of the variety [17]. The application of high concentrations of NAA provided a negative effect on fruit size [18].

The evaluation of fruit format represented by fruit diameter, length and their ratio (L/D) are presented in Table 2. Both diameter and L/D values were statistically different among

128 treatments, while length was not. Lower diameters were found for apples under NAA
129 treatment, all less than 60 mm, however, it presented a high L/D ratio due to the length,
130 resulting in slightly deformed fruits with consequent lower commercial value.

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Table 2 – Diameter, length, length/diameter ratio and total soluble solids in different thinning treatments for the first experiment cycle (2012/2013) on Eva cultivar.

Treatments	Diameter (mm)	length (mm)	L/D	TSS °Brix
T1 Manual thinning	65.75 a	70.50 ns	1.07 ab	13.17 ns
T2 Promalin® 1.25 ml L ⁻¹	65.25 ab	71.75	1.09 ab	13.47
T3 Promalin® 1.50 ml L ⁻¹	61.5 a-d	70.25	1.14 ab	13.05
T4 Promalin® 1.75 ml L ⁻¹	62.25 a-c	70.75	1.13 ab	13.32
T5 Promalin® 2.0 ml L ⁻¹	56.97 c-e	70.25	1.22 ab	13.02
T6 NAA 5 mg L ⁻¹	59.97 c-e	70.50	1.27 a	12.57
T7 NAA 10 mg L ⁻¹	55.70 de	67.00	1.19 ab	12.55
T8 NAA 15 mg L ⁻¹	59.12 de	66.25	1.11 ab	12.75
T9 NAA 20 mg L ⁻¹	53.75 e	67.75	1.26 ab	13.15
T10 BA 50 mg L ⁻¹	61.50 a-d	68.00	1.10 ab	13.45
T11 BA 75 mg L ⁻¹	63.25 ab	69.00	1.08 ab	13.17
T12 BA 100 mg L ⁻¹	62.75 a-c	67.25	1.06 b	12.95
T13 BA 125 mg L ⁻¹	62.62 a-c	68.00	1.08 ab	13.20
Mean	63.36	69.05	1.14	13.05
CV (%)	2,87	6,57	6,91	6,06

Means followed by the same letter do not differ from each other, by Tukey test, at 5% probability. ns- not significant ($p < 0.05$). TSS– Total soluble solids; CV – Coefficient of variation.

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134 Formation of fruits with diameter less than 60 mm occurs due to the stop in growth until
135 harvest after the application of products with auxin, reported in the literature as the formation
136 of pigmy fruits. One disadvantage reported in the literature for NAA is its negative effect on
137 fruit growth, although its thinning and decreasing harvest load effect, this plant growth
138 regulator is not capable of increase fruit size [15, 19, 7]. [20] Reported that high
139 concentrations and late applications of NAA depress fruit size. The remaining treatments
140 were not statistically different from the manual thinning that showed the lowest diameter
141 (Table 2).

142 Apples treated with NAA 5 mg L⁻¹ and BA 100 mg L⁻¹ showed a statistically different L/D
143 ratio. Although values of length were not statistically different, it can be observed that
144 Promalin® resulted in longer fruits, thus with a good L/D ratio (Table 2). These results are in
145 accordance with those obtained by [21] once authors found that Promalin® treatment
146 increases fruit length, although they were not statistically different. [22] Also obtained an
147 increase on fruit length, with a consequent increase on L/D ratio after the treatment of Royal

148 Gala cultivar with Promalin®. Total soluble solids (° Brix) were not statistically different
149 among treatments, with a mean general value of 13.05 ° Brix (Table 2).

150 A similar behavior was observed when comparing the first (2012/2013) and second
151 (2013/2014) experiment cycles regarding the number of fruits per plant. The manual thinning
152 showed the highest values of this parameter and plants treated with Promalin® (T2, T3, T4
153 and T5), were statistically similar. Nevertheless, a significant reduction was observed for
154 NAA and BA treatment, being the BA treatment at dose 50 and 125 mg L⁻¹ those with lower
155 mean of fruits per plant (44.5) (Table 3). [23] Also observed a significant reduction on the
156 number of fruits per plant with NAA 7.5 mg L⁻¹ (8 DAPF) for the Gala cultivar. In addition,
157 [24] tested different volumes of NAA (10 mg L⁻¹) and BA (100 mg L⁻¹) and observed the
158 same behavior for Jonagold cultivar. According to [23], optimum fruit load varies from 6 to 9
159 fruits per cm⁻² from the TCSA, or 1 to 1.5 kg cm⁻² TCSA.

160 Overall, the results obtained for this variable was similar for the two experiment cycles
161 (Tables 1 and 3), showing that the manual thinning (T1) and Promalin® (T2, T3, T4 and T5)
162 were not statistically different and presented higher values. Treatments with NAA and BA
163 showed the highest reduction, with values lower than those reported by [25] demonstrating
164 the effect of these plant growth regulators. However, [23] reported a high effective
165 fructification when 7.38 fruits cm⁻² TCSA was obtained.

166 Results for the production per plant (Kg) demonstrated that all dosages of BA were
167 responsible for the highest reduction compared to the manual thinning. Manual thinning
168 showed an average production of 9.23 Kg whereas the mean value for BA (50 mg L⁻¹) was
169 5.06 Kg per plant. BA (T13) showed the best results concerning the mean fruit mass (130.71
170 g) while the lowest values were observed for Promalin® 1.75 ml L⁻¹ and NAA 20 mg L⁻¹ with
171 83.63 g and 82.76 g, respectively. A small and significant difference was observed for pulp
172 firmness in the second experiment cycle, being NAA 10 mg L⁻¹ that with high value (84.65 N)
173 (Table 3).

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Table 3 - Number of fruits per plant, fruits per trunk cross-sectional area, production per plant, mean fruit mass and pulp firmness in different thinning treatments for the first experiment cycle (2012/2013) on Eva cultivar.

Treatments	Number of fruits plant ⁻¹	Fruits cm ⁻² TCSA	Yield plant ⁻¹ (Kg)	Mean fruit mass (g)	PF (N)
T1 Manual thinning	86.25 ab	8.01 ab	9.23 a	107.04 bc	71.27 ab
T2 Promalin® 1.25 ml L ⁻¹	71.00 a-c	5.93 a-c	7.71 a-c	108.72 bc	71.86 ab
T3 Promalin® 1.50 ml L ⁻¹	71.75 a-c	6.44 a-c	6.71 a-c	93.63 de	79.25 ab
T4 Promalin® 1.75 ml L ⁻¹	93.00 a	8.62 a	8.16 a-c	83.63 e	71.46 ab
T5 Promalin® 2.0 ml L ⁻¹	89.00 ab	7.83 ab	9.67 a	108.79 bc	76.39 ab
T6 NAA 5 mg L ⁻¹	55.50 cd	4.75 bc	6.38 a-c	115.38 b	67.71 ab
T7 NAA 10 mg L ⁻¹	67.00 b-d	6.27 a-c	6.27 a-c	93.52 de	84.65 a
T8 NAA 15 mg L ⁻¹	53.00 cd	5.64 a-c	7.28 a-c	115.15 bc	77.57 ab
T9 NAA 20 mg L ⁻¹	70.25 a-c	6.80 a-c	6.82 a-c	82.76 e	76.90 ab
T10 BA 50 mg L ⁻¹	44.5 d	4.21 c	5.06 c	112.13 bc	75.32 ab
T11 BA 75 mg L ⁻¹	59.5 cd	5.35 a-c	6.11 a-c	102.77 cd	78.31 ab

T12 BA 100 mg L ⁻¹	59.5 cd	5.22 a-c	6.39 a-c	107.57 bc	79.46 ab
T13 BA 125 mg L ⁻¹	44.5 d	4.19 c	5.97 bc	130.71 a	74.67 ab
Mean	66.61	6.09	7.06	105.06	75.78
CV (%)	14.59	22	20.56	4.78	8.38

Means followed by the same letter do not differ from each other, by Tukey test, at 5% probability ($p < 0.05$). TCSA– Trunk cross-sectional area. PF– Pulp firmness. CV– Coefficient of variation.

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176 Total soluble solids (° Brix) were higher in those fruits with lower mass (g) and diameter
177 (mm); this fact can be due to low rainfall before harvest (Table 4). Comparing cycle 1 and 2,
178 it can be observed that in a general way, fruits from the second cycle presented lower mean
179 fruit mass and consequently higher firmness, higher concentration of total soluble solids and
180 a reduction on plant load. This fact can be due to the different climatic conditions of the two
181 years of production. It was noticed that a cumulative precipitation was below normal in
182 December, the last month of fruit growth, for the second year, different from the first cycle
183 where the cumulative precipitation was above normal for the same period, fact that may
184 have influenced the size and firmness of the fruit.

185 There are different studies reporting that apple development can be described as expolinear;
186 the first exponential phase corresponds to the cell division, followed by the second phase, a
187 linear growth corresponding to cell expansion until maturation [26]. Nevertheless, normally
188 fruit growth is not affected by cell division, but in the following phase, the fruit growth is more
189 sensitive to hydric stress as it needs to maintain cell swelling to promote cell expansion [27].

190 Fruit diameter values (Table 4) where significantly higher for BA treatments (T10, T11, T12
191 and T13) and T2 (BA 100 mg L⁻¹) and T13 (125 mg L⁻¹), with fruit diameter of 64.8 mm and
192 64.57 mm, respectively, where statistically different from the manual thinning (60.5 mm).
193 This increase on diameter reveals the effectiveness of treatment with the cytokine 6-
194 benzyladenine. Our results are in accordance with those reported by [28] who obtained fruits
195 with diameter higher than 65 mm when BA 100 mg L⁻¹ was applied to Golden Delicious
196 cultivar. In addition, fruits with diameter higher than 70 mm were obtained by [29] for Galaxy
197 cultivar; however, their results were not statistically different from the manual thinning.

198 Fruit length was not significantly different among treatments, however higher values were
199 observed for Promalin® treatment, as it happens for the first cycle. A higher variation on L/D
200 ratio was observed in the second cycle where Promalin® 1.5 ml L⁻¹ (L/D=1.12) and
201 Promalin® 1.75 ml L⁻¹ (L/D=1.14) differ from NAA 20 mg L⁻¹ (L/D=0.95) and BA 100 mg L⁻¹
202 (0.94). The increase on L/D ratio for treatments based on BA + GA₄₊₇ has been
203 demonstrated when applied during the flowering period [30, 31 32]. [33] Reported an
204 increase on L/D ratio by Promalin® in Fuji and Imperial Gala cultivars, and [34] found the
205 same behavior when using BA in Fuji and McIntosh cultivars. The increase on fruit size is a
206 consequence of cell division induction and cell elongation, increasing therefore the length of
207 the fruit [35, 36].

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211 **Table 4 - Diameter, length, length/diameter ratio and total soluble solids in different**
 212 **thinning treatments for the second experiment cycle (2013/2014) on Eva cultivar.**

Treatments	Diameter (mm)	length (mm)	L/D	TSS °Brix
T1 Manual thinning	60.5 c-e	61.75 ns	1.01 a-c	12.95 a-c
T2 Promalin® 1.25 ml L ⁻¹	58.87 ef	65.00	1.09 ab	13.45 a-c
T3 Promalin® 1.5 ml L ⁻¹	56.85 fg	63.00	1.10 ab	15.62 a
T4 Promalin® 1.75 ml L ⁻¹	54.62 g	61.50	1.12 a	14.65 ab
T5 Promalin® 2.0 ml L ⁻¹	54.85 g	63.00	1.14 a	12.95 a-c
T6 NAA 5 mg L ⁻¹	61.00 c-e	64.00	1.04 a-c	12.16 bc
T7 NAA 10 mg L ⁻¹	57.85 e-g	59.00	1.01 a-c	12.13 bc
T8 NAA 15 mg L ⁻¹	59.97 d-f	63.25	1.05 a-c	13.26 a-c
T9 NAA 20 mg L ⁻¹	63.75 a-c	61.00	0.95 c	11.83 bc
T10 BA 50 mg L ⁻¹	61.27 b-e	62.50	1.01 a-c	11.33 c
T11 BA 75 mg L ⁻¹	62.95 a-d	61.50	0.97 bc	11.33 c
T12 BA 100 mg L ⁻¹	64.80 a	61.25	0.94 c	11.56 c
T13 BA 125 mg L ⁻¹	64.57 ab	65.5	1.01 a-c	11.60 c
Mean	60.14	62.48	1.03	12.68
CV (%)	2.30	4.96	5.29	9.47

Means followed by the same letter do not differ from each other, by Tukey test, at 5% probability. ns- not significant (p< 0.05). TSS– Total soluble solids; CV – Coefficient of variation.

213

214 Apple cultivation generally presents biennial production cycle, where in one year there is an
 215 excess of flowering and fruit production, affecting the flowering and yield the following year.
 216 One hypothesis for the occurrence of this phenomenon is that the production of gibberellins
 217 by the seed is the cause of the negative effect. There is a close relationship between the
 218 time when the fruit increase the production of gibberellins and the time when the fruit
 219 becomes inhibitors of flower buds formation. Gibberellins possible induce the synthesis and
 220 transport of auxin, 6 to 8 weeks after full bloom, affecting the formation of flower buds [37].

221 However, according to [38] Gala and Eva cultivars, in general, do not present problems with
 222 alternation of production, usually blooming even when excess production occurs. In the
 223 present study the evaluation of flowering return was made in the second cycle of the
 224 experiment (2013/2014) and results are displayed in Figure 1. This evaluation allows
 225 verifying the effectiveness of the plant growth regulators on the alternation of production in
 226 the apple tree crop. The highest flowering return was observed for BA 100 mg L⁻¹ and 125
 227 mg L⁻¹ (5 – 7mm). Promalin® (1.25 and 1.50 ml L⁻¹) and NAA (10 and 20 mg L⁻¹) showed the
 228 lowest index. [7] Obtained the best return flowering for BA and BA combined with other plant
 229 growth regulator for Summerred cultivar.

230 Conversely to the results obtained here in, Golden Delicious treated with NAA (20 mg L⁻¹)
 231 had a return flowering index diameter of 10 mm [39]. [34] One of the main reasons of apple
 232 thinning is to assure the return bloom for the next year, he consider that all thinning agents
 233 have potential to increase the flowering return once the thinning is made in young fruits as it
 234 is a primary source of inhibition of flower buds. [40] Reported that the regulation process for

flowering buds is to maintain the balance between the vegetative and reproductive systems, but they stated that an effective thinning program, capable of reducing the number of fruits per plant, increases the probability of the axial terminal meristem of a flower or fruit spurs develop a reproductive structure.

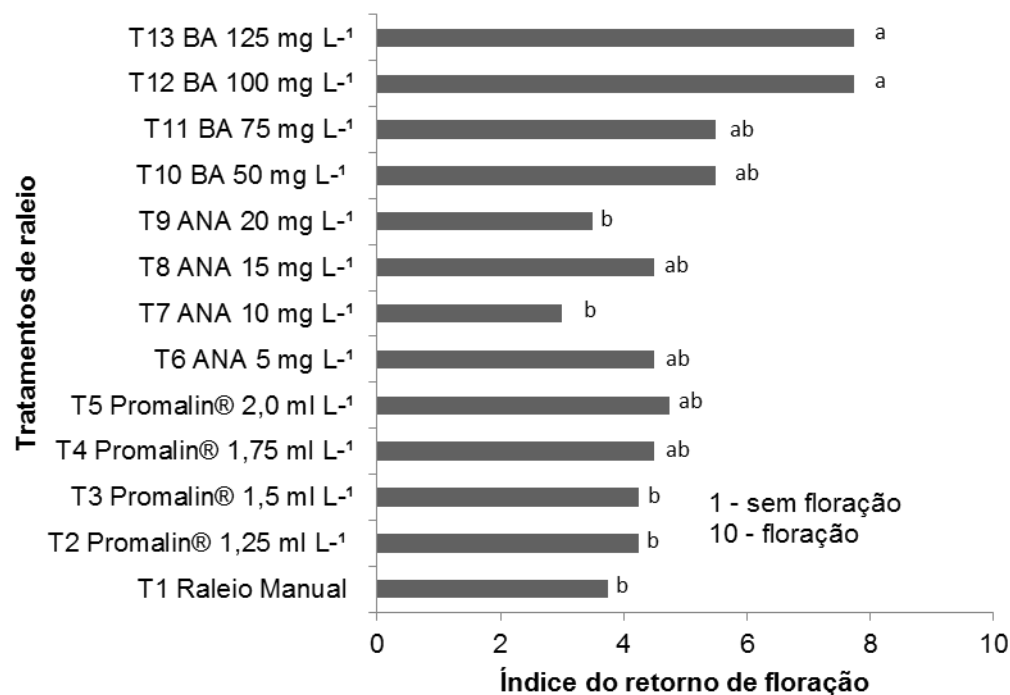


Figure 1- Return flowering index for different thinning treatments for the second experiment cycle (2013/2014) on Eva cultivar. Means followed by the same letter do not differ from each other, by Tukey test, at 5% probability ($p < 0.05$). T1 (Manual thinning); T2 (Promalin® 1.25 ml L⁻¹); T3 (Promalin® 1.5 ml L⁻¹); T4 (Promalin® 1.75 ml L⁻¹); T5 (Promalin® 2.0 ml L⁻¹); T6 (NAA 5 mg L⁻¹); T7 (NAA 10 mg L⁻¹); T8 (NAA 15 mg L⁻¹); T9 (NAA 20 mg L⁻¹); T10 (BA 50 mg L⁻¹); T11 (BA 75 mg L⁻¹); T12 (BA 100 mg L⁻¹) e T13 (BA 125 mg L⁻¹).

4. CONCLUSION

Overall, results obtained with Promalin® were similar to those of manual thinning. A negative effect was obtained for Eva cultivar when using NAA with the formation of pygmy fruits, in addition to low production per plant and poor flowering return. BA was the plant growth regulator with best results, as it increased the mean fruit mass and revealed the highest flowering return index, but with lower fruit load per plant.

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