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1 **Hail nets do not affect the efficacy of metamitron for chemical thinning of apple trees**

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16 **Abstract**

17 Hail nets reduce photosynthetically active radiation (PAR) and alter the environment under
18 the netting in apple orchards. Thus, we investigated the effect of nets on the efficacy of
19 metamitron, a short-term photosynthesis inhibitor used for fruit thinning. The objective of
20 this study was to evaluate the effect of the netting and metamitron on thinning efficacy,
21 yield, fruit quality and chlorophyll fluorescence in three apple cultivars. One or two
22 metamitron applications at 165, 248 and 330 g (ai)/ha were applied the tree under different
23 colored nets. The reduction of PAR was highest with black nets (19%-22%), followed by
24 green (13%-15%) and white nets (6%-11%). There were no significant differences
25 ($P>0.05$) in fruit weight or size with or without nets. Double applications of metamitron
26 increased average fruit fresh weight and reduced the fruit set over four experiments. In
27 contrast, single applications were less effective. In two experiments, thinning was
28 associated with lower yields. However, there was no effect in the other two experiments.
29 The double treatments tended to increase the percentage of the crop with fruit larger than
30 70 mm in diameter. All thinning strategies showed similar inhibition in fluorescence, with
31 the only observed significant differences between treatments occurring when using a single
32 or double application. The results show that netting does not affect the response to thinning
33 with metamitron.

34 **Keywords**

35 Brevis, Fluorescence, Quantum yield, PAR, Radiation, Netting

36 **1. Introduction**

37 Thinning can be used in fruit tree to improve overall profitability, which depends on yield,
38 fruit size distribution and fruit quality (color, firmness, sugar, acidity, etc.). Return bloom is
39 another factor that is influenced by fruit load. For all these reasons, fruit thinning is
40 essential for high yields and quality in apple orchards (Byers et al. 1990; Link 2000).

41 Brevis (metamitron 15% SG) is a chemical thinning agent which has been available for use
42 in apple and pear in Spain since 2015. It inhibits photosynthesis and is different from other
43 thinning products. Metamitron disrupts photosynthesis by blocking electron transfer
44 between the primary and secondary quinones of PSII (McArtney et al. 2012). It can be
45 applied at 165 to 330 g active ingredient (ai) per hectare in one or two applications,
46 depending on the cultivar. The response to metamitron is affected by sunlight (Robinson et
47 al. 2016), with a reduction in carbohydrates production as a result of lower photosynthesis
48 under shade enhancing fruit drop. Kviklys and Robinson (2010) conducted a greenhouse
49 study with potted trees and found that low temperatures and high light resulted in less
50 thinning, while high temperatures (especially at night) and low light resulted in more
51 thinning. They demonstrated that temperature and sunlight affected thinning, supporting the
52 role of carbohydrates in the growth of fruitlets (Lakso 2011).

53 Byers et al. (1985) reported that shading 16 to 26 days after full bloom, induced fruit drop
54 in ‘Starkrimson’ apple, demonstrating a relationship between light and carbohydrate
55 production. Shading decreases net CO₂ assimilation and reduces the amount of
56 carbohydrates available for young fruitlets (Grappadelli et al. 1994), but the response is
57 dependent on the cultivar (Mathieu et al. 2016). In other experiments, Greene and Groome
58 (2010) showed that thinning agents such as carbaryl and naphthaleneacetic acid after
59 shading does not modify their effect, but that when the chemicals are applied before
60 shading the effect of thinning is greater. Research on shading has helped to clarify the
61 impact of photosynthesis on fruit abscission (Kockerols et al. 2008; Mathieu et al. 2016).

62 Hailstorms are common in Spain’s apple production zone, causing significant damage.
63 Currently, anti-hail nets are frequently used by Spanish growers. However, netting reduces
64 the incidence of photosynthetically active radiation (PAR) above the trees (Ordonez et al.
65 2016). This situation, led us to consider the effects of anti-hail nets on the efficacy of
66 metamitron. The objective of this study was to evaluate the effect of the anti-hail netting
67 and metamitron on thinning efficacy, yield, fruit quality and chlorophyll fluorescence in
68 three apple cultivars.

69 **2. Materials and methods**

70 **2.1. Study site, plant material, temperatures, chemical application and** 71 **experimental design**

72 The experiments were conducted from 2014 to 2016 in apple orchards at the IRTA
73 Experimental Agricultural Station of Mas Badia (Tallada d’Emporda, NE Spain). The trees
74 were irrigated and fertilized using drip-irrigation. Fertilization, pruning, herbicide and
75 phytosanitary treatments were applied following standards in the region.

76 The experimental unit comprised four rows and two guard rows. The rows were divided
77 into two sections (one in front of the other). One half-row section was covered with an anti-
78 hail net, while the other section was kept open (without net). The net was mounted on a
79 fixed structure in the planting year in all rows. Both areas used the same cultivars and
80 management. For all experiments and half-row areas (with and without net), a completely
81 randomized block design was used, with four blocks per treatment. Each replication
82 comprised a four-tree unit with the central trees as the experimental unit and the end trees
83 as guards. Each treatment (chemical thinning and untreated control) was repeated with and
84 without net, with the same experimental design.

85 Meteorological data were collected from the weather station of the official
86 meteorological service of Catalonia, located 50 m in the Tallada d'Emporda orchard of the
87 IRTA experimental agricultural station of Mas Badia. Night temperature was calculated as
88 the average temperature recorded by the weather station between 2000 and 0700 h. Average
89 temperature was calculated as the average temperature recorded by the weather station
90 between 0000 and 2400 h.

91 All experiments used Brevis (ADAMA, Spain containing 15% Metamitron) applied with a
92 customized air blast sprayer, to simulate commercial application. This was equivalent to
93 1000 L/ha of volume applied before run-off.

94 **2.1.1. Experiments 1 and 2**

95 Experiments 1 and 2 were carried out on 'Galaxy Gala' and 'Fuji Zhen[®]', respectively in
96 2014. 'Galaxy' and 'Fuji' were planted in 1994 and 2006, respectively, trained to a central
97 leader and spaced at 3.75 m x 1 m (2,666 trees/ha). 'Galaxy' and 'Fuji' trees were grafted
98 on M.9 PAJAM[®] rootstocks. The netting was white for 'Gala' and green for 'Fuji'. The
99 study analyzed two chemical thinning strategies, with and without nets. One or two
100 applications of metamitron at a 248 g (a.i.)/ha were compared against an untreated control.
101 The first spray was applied when the fruit were 7-9 mm wide and the second when the fruit
102 were 10-12 mm wide.

103 **2.1.2. Experiments 3 and 4**

104 Experiments 3 and 4 were carried out on 'Fuji Zhen[®]' in 2015 and 'Pink Lady' in 2016.
105 'Fuji' and 'Pink Lady' were planted in 2006 and 2004, trained to a central leader and
106 spaced at 3.75 m x 1 m (2,666 trees/ha). 'Fuji' was grafted on M.9 PAJAM[®] rootstocks and
107 'Pink Lady' on M.9T337 rootstocks. Netting was green for 'Fuji' and black for 'Pink Lady'.
108 There were four thinning strategies, with and without nets. One or two applications of
109 metamitron were applied at 248 or 330 g/ha in 'Gala', and 165 or 248 g/ha in 'Pink Lady'.
110 All treatments were compared with an untreated control. The chemical was applied at the
111 same stages as in the earlier experiments.

112 **2.2. Photosynthetically active radiation (PAR)**

113 PAR was measured in an experimental orchard (IRTA-Mollerussa) in 2008 using an SS1-
114 UM-1.05 Sun Scan ceptometer (Delta-T Devices Ltd, Cambridge, UK) with a 64-sensor
115 photodiode linearly sorted in a 100 cm sword. The measurements were taken from other
116 anti-hail net experiments (unpublished data). PAR was measured outside the nets (full

117 light) and under black, green or white nets, 1.10 m above the ground. PAR was measured in
118 spring under full sun at regular intervals, between 1200 and 1500 h.

119 **2.3. Data collection and statistical analyses**

120 The total number of flower clusters per tree was counted at bud break (BBCH 61-65),
121 before the treatments were applied. At harvest, the number of fruits per tree was recorded.
122 Fruit set was calculated as $100 * (\text{No. fruit} / \text{No. flower clusters per tree})$.

123 Fruit were harvested with in a single pick during the commercial harvest for each tree. Fruit
124 weight, total fruit yield (kg per tree) and number of fruit per tree were measured with a
125 commercial apple sorting and packing line (Calinda, Caustier Ibérica, S.A. with Aweta
126 Technology).

127 First class fruit were >70 mm. Fruit size distribution, based on fruit diameter categories of
128 >70 mm, was determined for each tree. Fruit size and coloration were measured with the
129 commercial sorting machine.

130 Chlorophyll fluorescence was measured in Experiments 1 and 2, for ‘Galaxy’ and ‘Fuji’.
131 Measurements were made on three recently fully-expanded leaves per control tree (6 leaves
132 per block and 24 leaves per treatment), under full daylight in the shaded of the tree part
133 between 1000 and 1600 h and at a height of 1-1.5 m. The measurements were taken once
134 per week until values stabilized at 90% of the control.

135 QY (quantum yield) was measured with a handheld portable fluorimeter (FluorPen FP100,
136 Photon Systems Instruments, Czech Republic) to provide an indication of the effect of the
137 chemical on the maximum potential quantum yield efficiency of PSII.

138 Each experiment was analyzed individually because the nets were different colours and
139 average PAR values were different. The cultivars and application doses were also different.
140 Statistical analyses were performed in SAS 9.3 (SAS Institute Inc., 2009). Means were
141 separated with the general linear model using Duncan’s multiple range tests at $P < 0.05$ by
142 one-way or factorial analysis of variance (Proc GLM), considering netting and chemical
143 application as the main factors.

144 **3. Results**

145 **3.1. Photosynthetically active radiation (PAR)**

146 Netting reduced PAR values in comparison with the controls (Table 1). The reduction of
147 PAR was highest with black nets (19%-22%), followed by green (13%-15%) and white
148 nets (6%-11%).

149 **3.2. Temperatures**

150 Temperatures were highest in 2015 (fruit 5 mm after 4 days) than in 2014 (fruit 5 mm after
151 5 days) and 2016 (fruit 5 mm after 8 days). Moreover, fruit growth was positively related to
152 temperatures because the days between applications were different. That is, when
153 temperature was higher, fruit growth was faster. In 2014 and 2015, average daily and night
154 temperatures increased after the fruit had a diameter of 12 mm. This situation increased the
155 efficacy of the second application. In 2016, average daily and night temperatures during the

156 second application (12 mm) were highest. This situation also increased the efficacy of the
157 second application.

158 3.3. Growth, yield and fruit quality

159 Thinning had no significant ($P > 0.05$) effect on flower production in any of the
160 experiments (data not presented). The effect of netting on flower production was small,
161 with significantly more flowers under the nets (188 flower clusters per tree) than in the
162 control (159 flower clusters per tree) but only in the 2016 experiment with ‘Pink Lady’ (P
163 < 0.05). There was no significant ($P > 0.05$) interaction between thinning and netting on
164 flower production in any of the experiments (data not presented).

165 There were mixed effects of thinning on fruit production and fruit set (Table 2). In the 2014
166 experiments with ‘Gala’ and ‘Fuji’, metamitron decreased fruit production and fruit set
167 compared with the controls, with a greater response with the double applications in the first
168 experiment. In the 2015 experiment with ‘Fuji’ and the 2016 experiment with ‘Pink Lady’
169 only the double applications decreased fruit production and fruit set (Table 2). Netting had
170 only a small effect on fruit production and fruit set, with netting increasing these
171 parameters compared with the control no net plots only in the 2014 experiment with ‘Gala’
172 (Table 2). There was no significant ($P > 0.05$) interaction between thinning and netting on
173 fruit production and fruit set in any of the experiments (data not presented).

174 There were mixed effects of thinning on total yield and average fruit fresh weight (Table 3).
175 The double applications of metamitron decreased yields compared with the control in the
176 first two experiments, whereas there was no significant ($P > 0.05$) of the chemical in the
177 last two experiments. The single applications of the chemical increase average fruit weight
178 compared with the control in the first and second experiments (two out of two cases), while
179 the double applications of the chemical increased average fruit fresh weight in five out of
180 six cases in all the experiments (Table 3). There was no significant ($P > 0.05$) effect of
181 netting on total yield and average fruit weight, and no interaction between thinning and
182 netting (data not presented).

183 There were significant ($P > 0.05$) negative relationships between fruit weight and the
184 number fruit per tree in the experiments. There was a negative relationship between fruit
185 weight and the number of fruit per tree (Fig. 2). Fruit weight decreased as fruit production
186 increased.

187 The effect of thinning on the yield of premium fruit and the percentage of total yield that
188 included fruit greater than 70 mm varied in the different experiments (Table 4). The double
189 applications increased premium yield compared with the controls in all experiments except
190 the last, while the single applications increased premium yield only in the second
191 experiment. Thinning increased the percentage of total yield in the larger fruit category in
192 seven out of twelve cases (Table 4). There was no significant ($P > 0.05$) effect of netting and
193 no interaction between thinning and netting on premium fruit production in any of the
194 experiments (data not presented).

195 Thinning had no significant ($P > 0.05$) effect on the yield of fruit that were highly coloured
196 (60% of fruit surface coloured) (Table 5). There was no consistent effect of thinning on the
197 percentage of yield that had coloured fruit. The double applications of metamitron

198 increased the percentage of coloured fruit compared with the control in the first and third
199 experiments, while none of the applications had an effect in the second experiment (Table
200 5). Netting had at best a small effect on fruit colour development (Table 5), while there was
201 no significant ($P > 0.05$) interaction between thinning and netting (data not presented).

202 **3.4. Chlorophyll fluorescence**

203 The netted and un-netted control trees tended to have similar values of quantum yield (QY)
204 over the experiments (Figs. 3 and 4). In contrast, the trees sprayed with the thinning agent
205 had lower values for most of the experiments, and recovered fully or almost fully after
206 about 35 or 40 days. The maximum inhibition was three days after first application in any
207 of the experiments. The maximum inhibition was maintained for a longer period (11 days)
208 in all strategies with double applications than with single applications (3 days) (Figs. 3 and
209 4).

210 **4. Discussion**

211 Netting can modify plant water status, light interception, photosynthesis and carbohydrate
212 accumulation in crop plants (Mupambi et al. 2018). The response of the leaves and the
213 canopy to light is the major factor affecting carbohydrate production in apple trees (Lakso
214 1994). For a whole canopy, as well as total light, the distribution of light between direct and
215 diffuse components may be important since many leaves may be dependent on diffuse light
216 (Lakso 1994). At Girona, the PAR was reduced by 19%-22% by black nets, by 13%-15%
217 by green nets and 6%-11% by white nets. These values were similar to those reported by
218 Dussi et al. (2005), Iglesias and Alegre (2006), Blanke (2009) and Ordonez et al. (2016).
219 While this would not affect leaf photosynthesis on sunny summer days, photosynthesis
220 under the nets would be reduced in autumn, spring or on overcast days (Widmer 2001).

221 Many authors have reported that temperature plays an important role in chemical thinning
222 (Kviklys and Robinson 2010; Lakso et al. 2006; Li and Cheng 2011; Lordan et al. 2019;
223 Parra-Quezada et al. 2005; Pretorius et al. 2011). Typically warm nights increase
224 respiration during the night, decrease overall carbon balance of the tree (Costa et al. 2018),
225 and increase the efficacy of thinning. Metamitron was generally more effective after the
226 second application under warmer weather. Byers (2003) indicate that the efficacy of a
227 chemical depended on the diameter of the fruit, application dose, cultivar and weather.

228 Double applications of metamitron tended to reduce fruit set and number of fruit per tree
229 more than single applications as shown previously (Dorigoni and Lezzer 2007; Stern 2014).
230 Single application typically reduce fruit set compared with control untried, again
231 concurring with earlier studies (Deckers et al. 2010; Dorigoni and Lezzer 2007; Lafer 2010;
232 Reginato et al. 2017).

233 In 2014, thinning was associated with lower yields whereas these were no effect in 2015
234 and 2016. McArtney et al. (2012) reported that thinning decreased yields in ‘Gala’ in New
235 Zealand. Average fruit weight trended to increase with thinning as shown by Brunner
236 (2014), Maas and Meland (2016) and McArtney et al. (1996). These authors reported a
237 negative relationship between average fruit weight and the number of fruit per tree. Fruit
238 size moved to the larger category as the number fruit per tree decrease, as shown by Bergh
239 (1990), Dorigoni and Lezzer (2007), Lafer (2010) and Mathieu et al. (2016).

240 Netting generally had no effect on production, fruit size or fruit quality as demonstrated by
241 Iglesias and Alegre (2006) and Ordonez et al. (2016). Netting also had no effect in the
242 response to the thinning agent. Shade provided by nets has been shown to reduce net CO₂
243 assimilation, increase vegetative growth and, therefore, reduce yield and fruit size in apple
244 (Amarante et al. 2011; Amarante et al. 2007; Middleton and McWaters 2002; Romo-
245 Chacón et al. 2007). Moreover, there was a fewer and smaller cell in the fruit of apple
246 under net, leading to a lower fruit size count (Amarante et al. 2011).

247 Metamitron disrupted the photosynthetic apparatus for 41 to 43 days after the chemical was
248 applied, although this differs from some published studies in which shorter inhibition
249 periods have been reported (McArtney et al. 2012; Stern 2014; Stern 2015). Quantum yield
250 decreased rapidly for the first three days, and the maximum inhibition of QY values were
251 recorded for three to ten days after the treatment, depending on the number of applications.
252 These results concur with earlier observations by Brunner (2014) and McArtney et al.
253 (2012).

254 **5. Conclusions**

255 Double applications of the thinning agent metamitron typically increased average fruit fresh
256 weight in apple trees over four experiments in Spain. In contrast, single application were
257 less effective. The double treatments also tended to increase the percentage of the crop with
258 fruit larger than 70 mm in diameter. These treatments had lower total yields than the control
259 in the first two experiments, and similar yields as the controls in the last two experiments.
260 Overall, netting that decreased PAR by up to 22% had no effect of yield, fruit size or fruit
261 quality. Netting also did not affect the response to thinning. It can be concluded that double
262 applications of metamitron can be used to increase fruit size in apple trees growing under
263 hail nets.

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401

402 **Table 1:** Effect of netting on photosynthetic active radiation, PAR ($\mu\text{mol m}^{-2} \text{s}^{-1}$) over four
 403 experiments in apple in Girona, Spain. Data are the means of 24 measurements per
 404 treatment.

	1200 h	1300 h	1400 h	1500 h
Control	1576 (100%)	1770 (100%)	1901 (100%)	1900 (100%)
White	1402 (89%)	1657 (94%)	1767 (93%)	1746 (92%)
Green	1335 (85%)	1536 (87%)	1646 (87%)	1611 (85%)
Black	1248 (80%)	1377 (78%)	1540 (81%)	1521 (80%)

405

406 **Table 2:** Effect of thinning and netting on fruit production and fruit set (final number
 407 fruit/100 flower clusters) in apple trees in Girona, Spain. There was no significant ($P<0.05$)
 408 interaction between thinning and netting on fruit production as fruit set.

Treatment	Gala 2014		Fuji 2014		Fuji 2015		Pink Lady 2016	
	No. of fruit per tree	Fruit set	No. of fruit per tree	Fruit set	No. of fruit per tree	Fruit set	No. of fruit per tree	Fruit set
Control	415 a	132 a	379 a	134 a	360 a	173 a	214 a	128 a
165 g/ha							181 ab	109 ab
248 g/ha	307 b	96 b	221 b	76 b	328 a	162 a	171 ab	102 abc
330 g/ha					302 a	150 a		
165+165 g/ha							162 b	94 bc
248+248 g/ha	156 c	50 c	170 b	59 b	211 b	103 b	132 b	77 c
330+330 g/ha					219 b	107 b		
Nets	295 a	92 a	254 a	94 a	285 a	135 a	173 a	95 a
Control	242 b	78 b	260 a	84 a	283 a	144 a	171 a	109 a

Means within a column followed by different letters are significantly different (Duncan's range test at $P<0.05$).

409

410 **Table 3:** Effect of thinning and netting on yield and fruit weight in apple trees in Girona,
 411 Spain. There was no significant ($P<0.05$) interaction between thinning and netting on yield
 412 as fruit weight.

Treatment	Gala 2014		Fuji 2014		Fuji 2015		Pink Lady 2016	
	Yield (kg/tree)	Fruit weight (g)	Yield (kg/tree)	Fruit weight (g)	Yield (kg/tree)	Fruit weight (g)	Yield (kg/tree)	Fruit weight (g)
Control	47 a	113 b	38 a	101 c	31 a	87 b	26 a	125 b
165 g/ha							25 a	136 ab
248 g/ha	39 a	125 b	33 ab	149 b	30 a	90 b	24 a	142 ab
330 g/ha					29 a	98 b		
165+165 g/ha							23 a	144 ab
248+248 g/ha	26 b	168 a	29 b	177 a	28 a	138 a	20 a	156 a
330+330 g/ha					29 a	134 a		
Nets	38 a	135 a	33 a	142 a	29 a	106 a	23 a	139 a
Control	33 a	143 a	35 a	146 a	30 a	112 a	23 a	142 a

Means within a column followed by different letters are significantly different (Duncan's range test at $P<0.05$).

413

414 **Table 4:** Effect of thinning and netting on fruit size (yield >70 mm in percent and kg of
 415 total) in apple trees in Girona, Spain. There was no significant ($P<0.05$) interaction
 416 between thinning and netting on fruit size.

Treatment	Yield >70 mm							
	Gala 2014		Fuji 2014		Fuji 2015		Pink Lady 2016	
	Percent of total	kg of total	Percent of total	kg of total	Percent of total	kg of total	Percent of total	kg of total
Control	19 c	9 b	8 c	3 b	4 b	1 b	14 b	4 a
165 g/ha							18 b	5 a
248 g/ha	33 b	14 b	59 b	20 a	6 b	2 b	27 ab	6 a
330 g/ha					9 b	3 b		
165+165 g/ha							25 ab	5 a
248+248 g/ha	80 a	20 a	78 a	23 a	47 a	12 a	46 a	9 a
330+330 g/ha					43 a	13 a		
Nets	45 a	15 a	50 a	16 a	20 a	5 a	24 a	5 a
Control	54 a	16 a	52 a	17 a	24 a	7 a	28 a	6 a

Means within a column followed by different letters are significantly different (Duncan's range test at $P<0.05$).

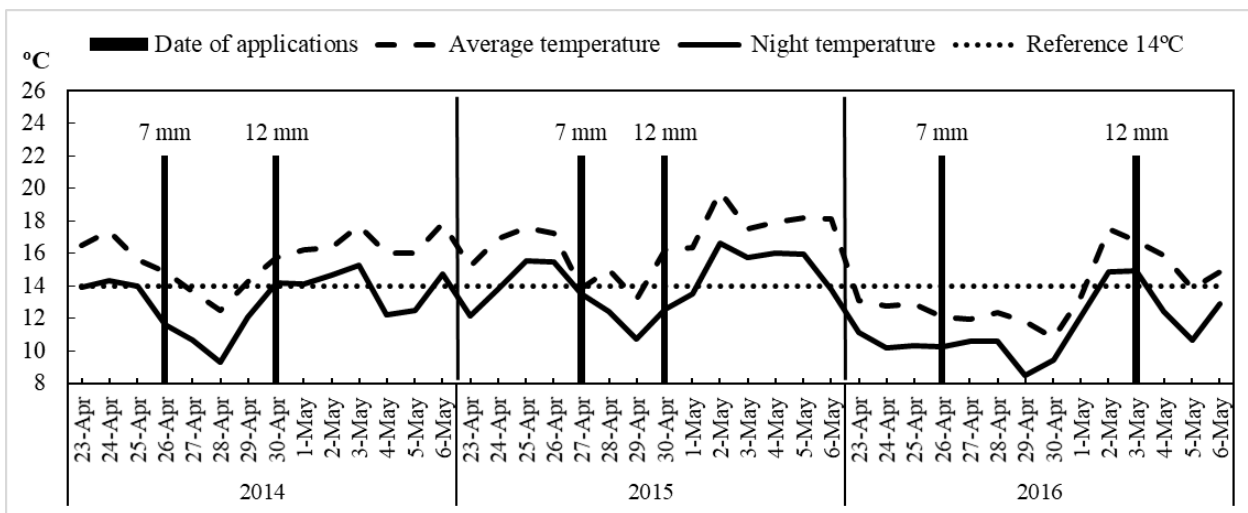
417

418 **Table 5:** Effect of thinning and netting on fruit colour (60% blush area in percent and kg of
 419 total) in apple trees in Girona, Spain. There was no significant ($P<0.05$) interaction
 420 between thinning and netting on fruit colour.

Treatment	Yield > 60% blush area					
	Gala 2014		Fuji 2014		Fuji 2015	
	Percent of total	kg of total	Percent of total	kg of total	Percent of total	kg of total
Control	23 b	11 a	18 a	7 a	10 c	2 a
248 g/ha	31 b	11 a	26 a	9 a	13 bc	3 a
330 g/ha					13 bc	2 a
248+248 g/ha	50 a	12 a	29 a	8 a	23 a	4 a
330+330 g/ha					17 b	3 a
Nets	39 a	13 a	21 a	6 b	14 a	2 b
Control	39 a	11 a	27 a	9 a	17 a	3 a

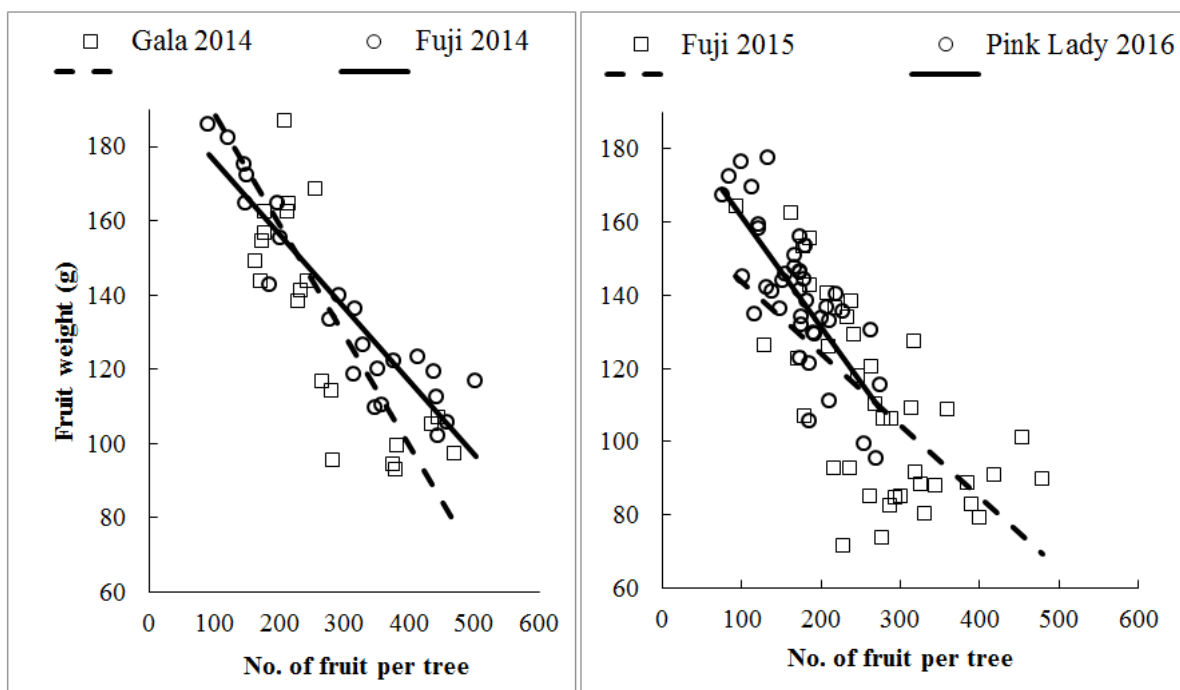
Means within a column followed by different letters are significantly different (Duncan's range test at $P<0.05$).

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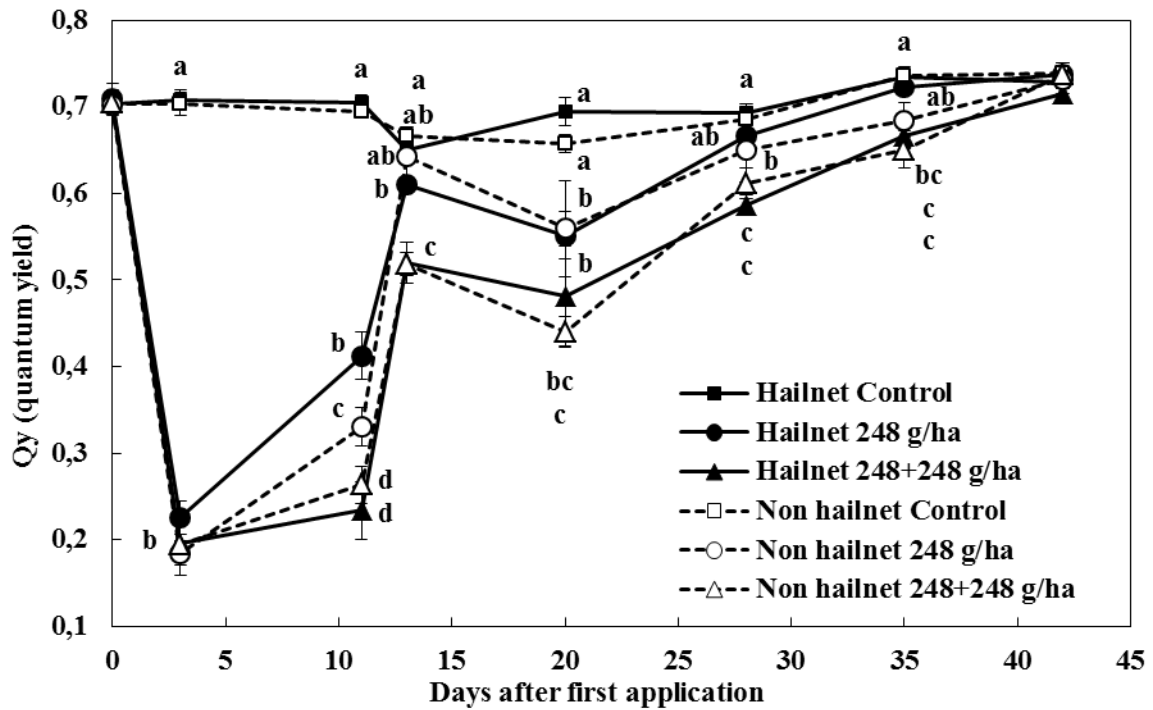
422
 423 **Fig. 1:** Average temperatures, average night temperatures and periods of king fruit diameter
 424 in apple trees over three years in Girona, Spain.

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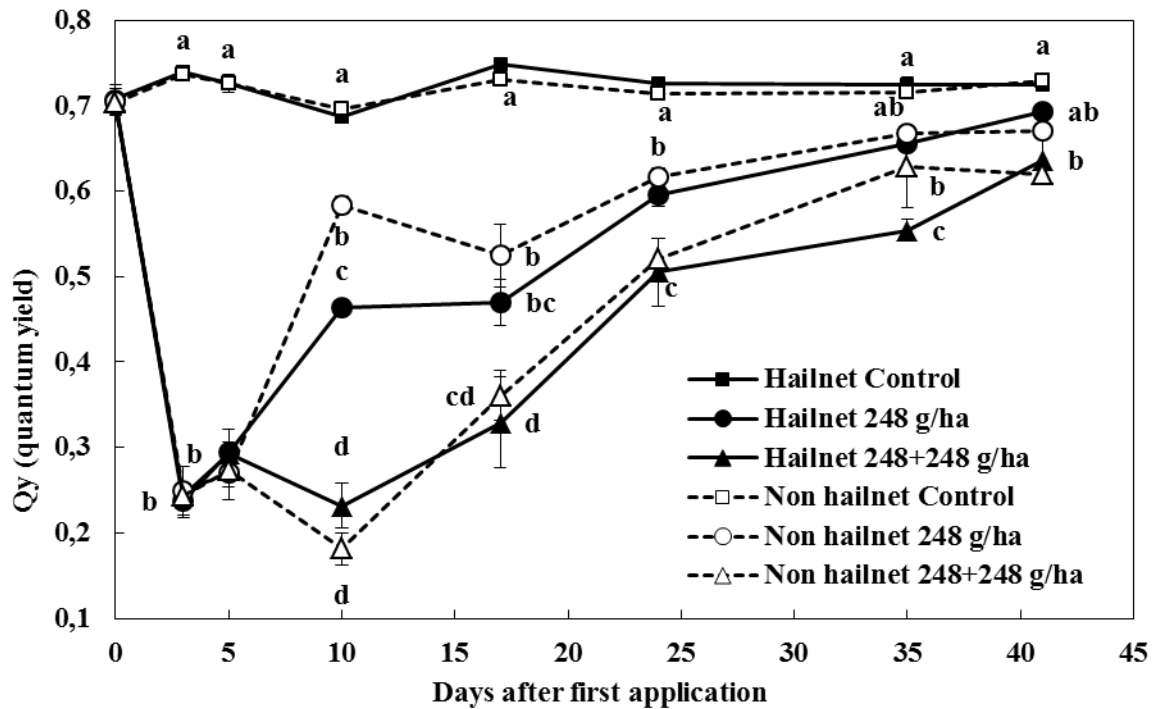


427
 428 **Fig. 2.** Relationships between fruit weight (g) and the number of fruit per tree in apple in
 429 Girona, Spain. Each symbol represents the average fruit weight per tree and number of fruit
 430 per tree. For Gala 2014 $y = -0.30 * \text{No. fruit} + 218$ ($R^2 = 0.71$, $P > 0.001$), Fuji 2014 $y = -0.20 * \text{No. fruit} + 196$ ($R^2 = 0.86$, $P > 0.001$), Fuji 2015 $y = -0.20 * \text{No. fruit} + 163$ ($R^2 = 0.43$, $P > 0.001$) and Pink Lady 2016 $y = -0.30 * \text{No. fruit} + 192$ ($R^2 = 0.58$, $P > 0.001$),

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436
 437 **Fig. 3.** Effect of thinning and netting on quantum yield (QY) of chlorophyll fluorescence
 438 applied in leaves of ‘Gala’ apple in Girona, Spain. Metamitron was applied on 26 April and
 439 30 April. Vertical bars indicate standard error of the means; n = 24. Means at the same time
 440 followed by different letters are significantly different (Duncan’s range test at $P<0.05$).



441
 442 **Fig. 4.** Effect of thinning and netting on quantum yield (QY) of chlorophyll fluorescence
 443 applied in leaves of ‘Fuji’ apple in Girona, Spain. Metamitron was applied on 26 April and
 444 30 April. Vertical bars indicate standard error of the means; n = 24. Means at the same time
 445 followed by different letters significantly different (Duncan’s range test at $P<0.05$).

