

1 **Market quality of late winter/early spring peony after controlled dormancy:**
2 **dummy regression modelling**

3 **Abstract**

4 There is a shortage of herbaceous peony cut flowers in the world market in late winter/early
5 spring. The quality of these prestige flowers, when cultivated in warm climate regions and stored
6 in cooling chambers during dormancy, is influenced by pre-dormancy, dormancy, and post
7 dormancy conditions. In this article, various regimes of peony dormancy with constant and
8 variable temperatures were studied. Containers with plants of cv. 'Sarah Bernhardt' were
9 exposed to a pre-dormancy temperature of 15°C and, after two weeks, transferred to cooling
10 chambers in order to keep dormancy under four constant or diurnal temperature regimes. On
11 three different dates, plants from each treatment were transferred to a greenhouse for release
12 from dormancy and the beginning of sprouting. During commercial harvest, data on height and
13 thickness of flower stems, number of harvested flowers per plant, and dates of harvested flowers
14 were collected. Using these data, the index of market quality of peony flowers was defined and
15 regressed on dummy variables that reflected chilling regimes and dormancy duration.
16 Statistically significant differences in market quality were shown between the treatments with the
17 lower storage temperatures 2⁰C, 2-10⁰C, and 2-15⁰C, and the reference treatment with a storage
18 temperature of 2 - 20⁰C. Statistically significant differences were also shown between the
19 treatments with the shorter storage period of 6 weeks, 4 days or of 8 weeks, on the one hand, and
20 the reference treatment with the storage of 9 weeks, 3 days, on the other. Close results were
21 obtained for the treatments with the constant temperature of 2⁰C and with the diurnal alternating
22 temperature of 2-10⁰C. Therefore, growers can expect economic gains from saving energy during
23 dormancy under a suitable temperature regime.

24 *Key words* peony; dormancy; cooling chambers; market quality; dummy regression

25 **1. Introduction**

26 *1.1. Market for cut flowers*

27 The world market for cut flowers has undergone substantial growth in the last few decades
28 - by tens of percent in developed countries, and by tenfold in developing countries. In Europe,
29 the value of the market for cut flowers has been \$26 - 31 billion in recent years, or more than
30 half of the world's cut flower production ([1], [2]). The global value of cut flower exports
31 accounted for \$17 billion in recent years [3]. In the fast growing economy of India, there has
32 been tremendous growth in the floriculture industry in terms of area, production and export. Cut
33 flower production in this country increased by 138 times from 1993-94 to 2012-13, and
34 amounted to 77 billion units ([4], [5]). In China, the volume of export of cut flowers amounted to
35 16.1 billion units in 2015 [6]. For Kenya, Ecuador, and Ethiopia, countries that take the first
36 three places in the supply of cut flowers from developing countries to the EU, the total export
37 value in recent years amounted to \$760 million. The export of cut flowers from Ethiopia, for
38 example, accounted for 11% of the total exports from this country. In addition to cut flower
39 farms, developing countries have built supply chains for transportation production, mainly, to the
40 flower auctions in Europe [7].

41 *1.2. Marketing of peonies. Production in countries with warmer climates*

42 The aforementioned growth in production and export of cut flowers was stimulated by an
43 increased demand for prestigious cut flowers year-round due to the growth of globalization.
44 Peonies that were studied in this research belong to such prestigious flowers. Their prices in the
45 Netherlands FloraHolland, the world largest flower auction, rose by 26% in 2009-2012. By the
46 end of this period, peony prices reached a level of 209% of the average flower price per piece in

47 this auction and occupied the 15-16th position (55 million pieces) among all cut flowers sold in
48 this auction. Peony prices in Plantion - a market in the Netherlands that operates on a smaller
49 scale than FloraHolland - also showed a tendency to increase at the rate of 10% in 2011-2013
50 ([8], [2]).

51 Because of the long period of cold temperatures needed for flower production, *Paeonia*
52 spp. produced for the cut flower market are grown mostly in field production [9]. Growing
53 peonies in countries with various climates allows the supplying of the flowers to the market
54 during most of the year. Peonies are sold from April (supply from Southern France, other
55 Southern Europe countries) to November-December when the flowers are supplied from
56 countries from the southern hemisphere - Chile (where peony is the most important ornamental
57 flower exported from the country [10]), New Zealand. Owing to the high prices of peony, New
58 Zealand has developed an efficient transport network producing highly perishable peonies in the
59 South Island, getting them to Auckland overnight and to overseas markets within 24 hours [11].
60 In Alaska, peonies are currently the only agricultural export. Peonies bloom in this state from
61 mid to late summer - July and August. Researchers claim that, in this northern region, peony
62 production is poised to move into containerized controlled environments. Shortening the
63 dormancy period is just one of the advances that has led to indoor cultivation ([9], [12]). For
64 subtropical climates, the molecular mechanism of bud dormancy in peonies was studied in the
65 article of Zhang et al. [13]. They noted that bud dormancy is a crucial developmental process that
66 allows peonies to survive unfavorable environmental conditions.

67 As a result of extensive market studies, a high potential market for peony flowers in the
68 international markets in early spring was recommended [14]. The high economic value of peony
69 motivated agro-technical research aimed at filling this market niche in countries with warmer

70 climates. At the experimental farm in Suwon, Korea (lat. 37° N), dormant rootstocks bloomed
71 from late February to March, after being exposed to a temperature of 0°C for 6 weeks from
72 November 6 [15]. In Israel, the effects of chilling and subsequent growth conditions on peony
73 development and flower quality were studied during the last 15 years. The best chilling (constant
74 temperatures) and subsequent growth conditions for peony cv. 'Sarah Bernhardt' determined in
75 the article by Kamenetsky et al [16] enabled reducing the period between dormancy release and
76 flowering to 53-54 days. One of the studied methods of growing peony in warmer climates was
77 the forcing of dormancy in tunnels (when plants were grown in natural soil) or in chilling
78 chambers (with plants grown in containers) under constant or diurnal temperature regimes ([17],
79 [18]). Artificial cooling can also facilitate the management of crops with chilling requirements
80 under conditions of climate warming. It was confirmed in the study of Ogundeji and Jordaan [19]
81 on deciduous fruit.

82 ***1.3. Aims and stages of the study***

83 As was argued in the article of Cohen et al [25]: (1) in peony, internal mechanisms
84 interconnect with chilling requirements for dormancy release; (2) chilling accumulation under
85 diurnal fluctuations of natural soil temperatures might consist of two stages: the major one
86 occurring under low soil temperatures at night, while the second stage responding positively to
87 moderate higher day temperatures. The present article is aimed at modeling and examining
88 statements (1) and (2) using agro-technical and phenology data for various regimes of dormancy
89 - with constant and alternating temperatures, and of different duration. In this work, market
90 quality of peony flowers was estimated for various dormancy regimes. The estimated 'quality'
91 was used as a dependent variable in regression models. This allowed us to exploit the new data
92 obtained in this work for every studied peony plant and for four important quality parameters of

93 flowering: growth and thickness of flower stems, date of harvest, and number of flowers.
94 Production variables like "number of flowers" have been used for various crops in regression
95 models with explanatory climatic variables: for example, with air and soil temperature in the
96 study of cotton [20]. Additional plant characteristics (growth and thickness of flower stems, and
97 date of harvest) important for market quality and valuation of peony flowers are added to this
98 important production variable. Using these data, we calculate an index of market quality of
99 peony and develop a novel model of dummy regression of market quality on dormancy
100 conditions and duration.

101 The model's parameters are estimated using the data for 96 flowering plants. The analysis
102 of data obtained for treatments that differ only in their temperature regime – say, under constant
103 low temperature throughout the day and under diurnal alternating temperatures that demand less
104 electricity – might have a practical implication for farmers. Besides the new data obtained in this
105 work, the novelty of this study of market quality of late winter/early spring peony lies in: (1)
106 suggesting an index of market quality of peony flowers; (2) developing a dummy regression
107 model of the influence of dormancy conditions on this index and interpreting the results of the
108 estimation of the model's parameters in terms of the differences in market quality.

109 **2. Materials and Methods**

110 **2.1. Data**

111 For the treatments used in this study, rhizomes of *P. lactiflora* cv. 'Sarah Bernhardt' were
112 planted in containers. On 4 October 2015, all containers were exposed to a pre-dormancy
113 temperature of 15°C. After two weeks, on 18 October, the containers were divided into four
114 equal groups and transferred to cooling chambers to keep dormancy under four different
115 temperature regimes.

116 Treatment 1 was performed under a constant temperature of 2°C throughout the day. Other
 117 temperature regimes were 2°C for 16 hours, and 10°C, 15°C, or 20°C during the other 8 hours on
 118 diurnal bases: treatments 2, 3, and 4, respectively. A similar experimental design was used in our
 119 previous article, [18] but in that study only data on stem length after dormancy break were
 120 available. The summary of the temperature regimes for various treatments of the current study is
 121 presented in Table 1.

122 Table 1. Temperatures and dates of the dormancy treatments.

Treatment	Begin pre-dormancy	Begin dormancy	Dormancy temperature		Transfer to greenhouse		
			low, 16 hours	high, 8 hours	date 1	date 2	date 3
1	4-Oct-15	18-Oct-15	2°C	2°C	2-Dec-15	12-Dec-15	22-Dec-15
2	4-Oct-15	18-Oct-15	2°C	10°C	2-Dec-15	12-Dec-15	22-Dec-15
3	4-Oct-15	18-Oct-15	2°C	15°C	2-Dec-15	12-Dec-15	22-Dec-15
4	4-Oct-15	18-Oct-15	2°C	20°C	2-Dec-15	12-Dec-15	22-Dec-15

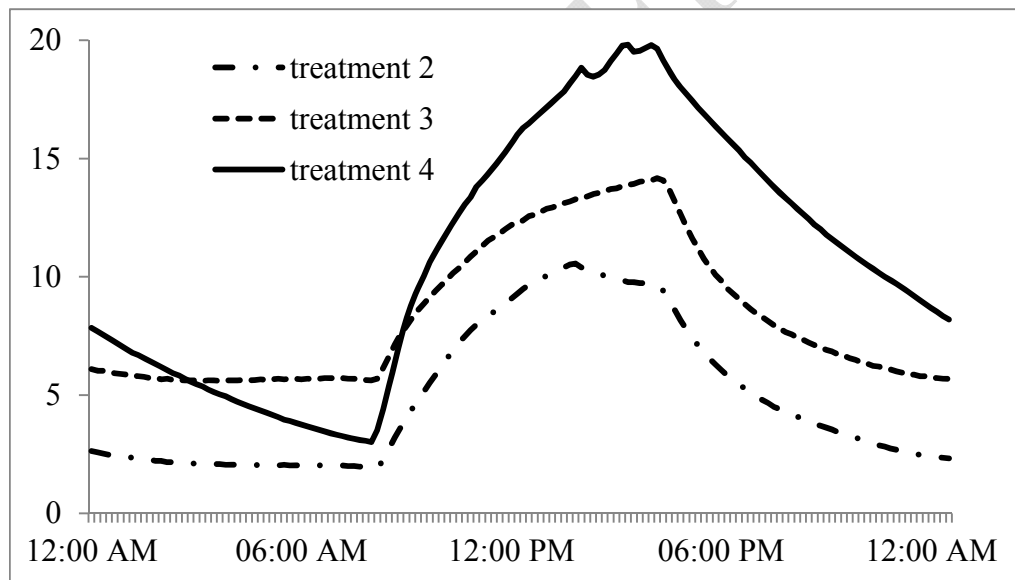
123
 124 The containers stayed in cooling chambers for 46 days for transfer date 1, 56 days for date
 125 2, and 66 days for date 3. For every treatment, air and soil temperatures in the chilling chambers
 126 were recorded every 10 minutes. For treatment 1 the temperature was constant at 2°C. For other
 127 treatments the temperature changed during the day as is shown in Table 2.

128 Table 2. Excerpt from air temperatures (collected every 10 minutes) in chilling chambers during
 129 dormancy of peony.

Date and time	Treatment			
	1	2	3	4
12/15/15 12:00:00	2.0	2.6	6.1	7.8
12/15/15 12:10:00	2.0	2.6	6.0	7.7
12/15/15 12:20:00	2.0	2.5	6.0	7.5
...
12/16/15 12:00:00	2.0	2.4	5.7	8.7
12/16/15 12:10:00	2.0	2.4	5.7	8.5
12/16/15 12:20:00	2.0	2.3	5.7	8.3
...

130

131 Every day the temperature in the chilling chamber rose from the lowest value (2°C) to the
 132 highest value. It was different for each one of treatments 2, 3, 4. Each time, the rise or decrease
 133 in temperature took 5-6 hours (Fig. 1).



134

135 Fig. 1. Fluctuations of air temperatures in cooling chambers during dormancy of peony: example
 136 of one of the days of the chilling period.

137 On dates 1, 2, and 3 eight containers from each treatment were transferred to a greenhouse
138 for release of dormancy and the beginning of sprouting. During the period of commercial
139 harvest, from 22 February to 07 April, every day two phenology parameters of peony flowers
140 were measured - height and thickness of flower stems. A total of more than 600 phenology
141 measurements were made for 96 flowering plants. This was besides the number of harvested
142 flowers and the dates the harvested flowers were collected for every plant.

143 *2.2. Modelling market quality of flowers and contingency analysis*

144 For modelling market quality, we used a method of dummy variables of the type Yes/No
145 [21], which is widely used in regression analysis in various fields. These were used as
146 determinants of dormancy conditions related to treatments, and the dates of dormancy release.
147 For every one of four categories of treatments or three categories of dormancy release, the
148 corresponding dummy variable received the value “1” if it belonged to this category or “0” if it
149 did not. More specifically, the three variables of “belonging to a certain treatment” were defined
150 as follows:

151 DTreatI - the plant from treatment I, 1(yes)/0(no), I = 1, 2, 3.

152 Treatment 4 served as a reference treatment for all of these variables: if all three DTreatI
153 received value 0, it meant the considered plant was from treatment 4.

154 Similarly, the two variables of “belonging to a certain date of release of dormancy” were defined
155 as follows:

156 DTrans1 - the plant transferred on date 1, 1(yes)/0(no),

157 DTrans2 - the plant transferred on date 2, 1(yes)/0(no).

158 Date 3 served as a reference date for these variables: if DTrans1 and DTrans2 received value 0, it
159 meant that the considered plant was transferred on date 3.

160 The summary of the explanatory dummy variables of the model is shown in Table 3.

161 Table 3. Explanatory dummy variables of the regression model of market quality.

Characteristics of dormancy	Value of explanatory variables				
	DTreat1	DTreat2	DTreat3	DTrans1	DTrans2
Treatment					
1	1	0	0		
2	0	1	0		
3	0	0	1		
4	0	0	0		
Date of transfer					
1				1	0
2				0	1
3				0	0

162

163 In the regression model, the above described dummy variables were used to explain the
 164 dependent variable of market quality of harvested flowers. The variable of market quality was
 165 defined as an index composed of the following measures:

- 166 • date of harvest: a calendar date;
- 167 • growth stem rate: after transfer from cooling chambers until harvest of the flower,
 168 cm/day;
- 169 • thickness of a flower stem: thickening from level 1 (the least thick) to 3 (the thickest)
 170 after transfer from cooling chambers until harvest of the flower;
- 171 • flowers per plant: how many flowers were harvested for this specific plant.

172 For each of these four measures, all 301 harvested flowers, from 96 flowering plants, were
 173 ranked by increasing order, from 1 to 301. First place in this order meant the best result: the
 174 earliest harvest date, the highest growth rate, the highest thickness, or the largest number of
 175 flowers per plant. For every flower it was denoted:

176 I1 - rank by date of harvest;

177 I2 - rank by growth rate;

178 I3 - rank by thickness;

179 I4 - rank by number of flowers.

180 Then the dependent variable of the model - the index of market quality IMARKET - was
181 defined as an average rank. Lower values of IMARKET indicate higher market quality of the
182 flower. The following two versions of IMARKET were examined.

183 The simple average of the four ranks:

$$184 \text{ IMARKET} = \text{AVERAGE} (I1, I2, I3, I4) \quad (1)$$

185 The weighted average of the four ranks:

$$186 \text{ IMARKET} = 0.4*I1 + 0.25*I2 + 0.25*I3 + 0.1*I4 \quad (2)$$

187 The weights in (2) were determined using a survey of growers and specialists from
188 agricultural research and extension stations in Israel related to the growth and export of peony
189 cut flowers (an oral questionnaire at the annual meeting of growers was used). As follows from
190 (2), the maximum weight was assigned to the date of harvest, and the minimum weight - to the
191 number of flowers per plant.

192 The regression model of market quality of peony flowers is formulated as follows:

$$193 \text{ IMARKET} = \alpha + \sum_{l=1}^3 \beta_l \text{DTreat}l + \sum_{l=1}^2 \gamma_l \text{DTrans}l + u \quad (3)$$

194 where $\alpha, \beta_l, \gamma_l$ are coefficients of the regression (3) sought, and u is the error term that satisfies
195 the usual assumptions of a linear regression model. The coefficients β_l of the regression show
196 the difference in IMARKET between treatments 1, 2, 3 and reference treatment 4, for the same
197 date. The coefficients γ_l show the difference in IMARKET between the dates 1, 2 and the
198 reference date 3, for the same treatment. Therefore, an estimation of the parameters of the
199 regression model (3) enables concluding regarding the significance of these differences.

200 Before the regression modelling, a contingency analysis was performed between treatments
201 and dates of transfer, on the one hand, and parameters of market quality of peony flowers, on the
202 other. Statistical significance of the differences between treatments (for the same date of transfer)
203 and between dates of transfer (for the same treatment) was assessed by two-sided t tests.

204 **3. Results**

205 All the calculations were made in Excel. The results of the contingency analysis between
206 treatments and dates of release indicate that there were significant differences in the index of
207 market quality IMARKET and physical representation of its measures between different
208 treatments and durations of dormancy. These measures were described in Section 2.2: a harvest
209 date (the number of days after 1st January was used), rate of growth and stem thickness, and the
210 number of harvested flowers per flower. The differences were calculated for various treatments
211 and duration of dormancy. For treatments 1 and 2, dormancy duration affected significantly (at a
212 5% level) the market quality of peony flowers: rows 'treatment 1 IMARKET' and 'treatment 2
213 IMARKET'. For treatment 3 the differences in market quality between various dormancy
214 periods were not significant: row 'treatment 3 IMARKET'. For the same dormancy period, the
215 differences between treatments 3 and 1, treatments 3 and 2 were significant at a 5% level. Close
216 results were obtained for treatments 1 (constant temperature 2°C) and 2 (diurnal alternating
217 temperature: 2°C during 16 hours, 10°C during 8 hours) for every date of dormancy release in
218 terms of IMARKET and most of its components. For each of the four measures of IMARKET,
219 similar differences between treatments and dormancy duration were received (Table 4). In this
220 table, the number of all harvested flowers for every pair treatment-date is presented. This number
221 is the sample size used in the analysis of statistical significance.

222 Table 4. Contingency analysis of peony flowers market quality, for various treatments.

treatment and parameters of market quality	dormancy release		
	date 1	date 2	date 3
treatment 1			
days from 1 Jan - harvest	57	65	67
growth rate, cm/day	0.72	0.70	0.72
thickness	1.87	1.89	2.03
harvested flowers	31	36	37
harvested flowers per plant	3.9	4.5	4.6
IMARKET	94 ^a	135 ^b	175 ^c
treatment 2			
days from 1 Jan - harvest	59	62	69
growth rate, cm/day	0.65	0.71	0.70
thickness	1.86	2.06	1.90
harvested flowers	35	49	31
harvested flowers per plant	4.4	6.1	3.9
IMARKET	108 ^{a**}	135 ^{b**}	173 ^c
treatment 3			
days from 1 Jan - harvest	65	69	72
growth rate, cm/day	0.60	0.67	0.56
thickness	1.86	2.15	2.19
harvested flowers	22	27	27
harvested flowers per plant	2.8	3.4	3.4
IMARKET	154 ^{a, b, c}	184 ^{a, b, c}	215 ^{a, b, c}
treatment 4			
days from 1 Jan - harvest	94	96	65
growth rate, cm/day	0.23	0.42	0.74
thickness	1.00	1.00	2.00
harvested flowers	1	4	1
harvested flowers per plant	0.13	0.5	0.13
IMARKET	236	230	162

223

224 ^{a,b,c} Means within dormancy release dates in a row with no common superscripts differ225 significantly ($P \leq 0.05$).226 ** ditto for $P \leq 0.1$.

227 Confidence intervals of the differences in market quality between treatments and dates of
 228 dormancy release, and the most proper specification of IMARKET were obtained using a
 229 regression model (3) (Table 5). For the estimation of this model's parameters the weighted
 230 IMARKET as defined in (2) was used. For this version of the model the received value of RSqr
 231 = 0.37 was greater than the value of RSqr = 0.28 for the version with IMARKET as defined in
 232 (1). The results from Table 5 again show that the differences between treatment 4 and other
 233 treatments, and date of transfer 3 and other dates of transfer are significant: this follows from the
 234 results in columns 'influence ...' and 'confidence interval'. This confirms the results from Table
 235 4. All the regression coefficients are significant at a 95% level besides the coefficient DTreat3
 236 for treatment 3. The latter coefficient is significant at 90% (not detailed in Table 5). Recall that
 237 for this treatment the differences from Table 4 in market quality between various dormancy
 238 durations were not significant. The results for treatments 1 and 2 are almost the same. The results
 239 for transfer dates 1 and 2 are considered significantly different from each other because their
 240 confidence intervals do not intersect.

241 Table 5. Results of the regression analysis (model 1)*.

explanatory variable	coefficient of regression (1)	influence on market quality improvement	confidence interval 95%
DTreat1	-85.0	positive	(-124, -46)
DTreat2	-81.7	positive	(-120, -43)
DTreat3	-36.1	positive	(-75, 3)
DTrans1	-68.5	positive	(-82, -55)
DTrans2	-36.0	positive	(-49, -23)

242 * $R^2 = 0.37$

243 **4. Discussion and conclusion**

244 *4.1. Discussion*

245 In this study the influence of dormancy regimes on market quality of late winter/early
246 spring peony was examined using the suggested index of market quality of peony flowers.

247 The market quality index was regressed on dummy variables that reflected chilling
248 temperatures and duration of the dormancy. Dates and duration of pre-dormancy and dormancy
249 (Table 1) were chosen so that the dates of flower harvest fell in the main within the period of
250 February through March when the supply of peony to the market is not sufficient: Table 4, rows
251 'days from 1 Jan - harvest'. To the best of our knowledge, in the published research on peony
252 dormancy only single measures like the number or length of shoots, or the number of flowers,
253 and other factors were analyzed after dormancy results, and only peony dormancy regimes with
254 constant temperatures were studied (the exception being our previous article [18]). Despite the
255 difference in the approach of modeling and statistical analysis, many of the results in the
256 published research were found consistent with the results of our regression modelling of the
257 index IMARKET (Table 5).

258 In one of the first studies, in which the question of how much chilling is required to break
259 dormancy of peony was examined [22], the author received the first harvest of flowers in
260 February-March after artificial cooling in Davis, California. Byrne et al. concluded that
261 dormancy can be broken by storing dormant plants for a minimum of 4 weeks at 6⁰C. Increasing
262 the storage time to six weeks (in our study, from 6 weeks 4 days and more), or reducing the
263 storage temperature to just above freezing (in our study the best results were obtained for
264 constant 2⁰C and for variable temperature 2⁰C - 10⁰C) increased the total number of shoots that
265 grew after forcing (transferred to a greenhouse).

266 Returning to Table 4, rows ‘days from 1 Jan - harvest’, and to characteristics of the
267 treatments from Table 1, the results can be detailed using the example of treatment 1. The period
268 between transfer from cooling chambers and harvest is 86, 84, and 76 days for transfer dates 1
269 (46 days), 2 (56 days), and 3 (66 days in cooling chamber). But in terms of calendar dates of
270 harvest (as is used in our approach of market quality in this study), the shorter storage time gains
271 the advantage: 26 February, 6 March, and 8 March, respectively.

272 A similar experimental design - storage of dormant peony plants at different temperatures
273 for different duration, and measuring various parameters of plant development in the post-
274 dormancy period, with flowering in February-March - was employed in other research conducted
275 in warmer climates. In the study of Iversen and Weiler [23] the results of peony growing and
276 flowering (treatments on Long Island, USA) after storage at 4.5⁰C and applying a daily
277 photoperiod were compared. The difference in results for 6 and 12 weeks of chilling storage was
278 non-significant for seven of eight studied parameters. In our study, the index of market quality
279 was significantly better for: 1) transfer date 1 (6 weeks 4 days) compared to transfer date 2 (8
280 weeks), 2) both transfer dates 1 and 2 compared to transfer date 3: rows ‘DTrans1’, ‘DTrans2’,
281 ‘DTrans3’ in Table 5. Similarly, in the research of three peony varieties ([24]; Palmerstone, New
282 Zealand) the mean number of shoots and flowers increased as plants were subjected to colder
283 chilling temperatures (1, 4, or 7⁰C), or longer chilling periods (3, 6, 9, or 12 weeks). No
284 significant differences were identified between treatments of 9 weeks or more, for all studied
285 temperature regimes and varieties. Similar results were obtained by Rhie et al. ([15] in Suwon,
286 Korea) for chilling temperatures 0, 5, or 10⁰C regarding plant development parameters of percent
287 of sprouting, number of shoots and flowers, and height during flowering. Under subtropical mild

288 climatic conditions, results of dormancy release were found to be the best for chilling regimes of
289 2⁰C (7 weeks 4 days) and 6⁰C (10 weeks) when higher temperatures were less effective ([16].

290 **4.2. Conclusions**

291 The regression model of the peony flower market quality showed significant differences
292 between the treatments with the lower storage temperatures 2⁰C, 2-10⁰C, and 2-15⁰C, against the
293 reference treatment with storage temperatures of 2 - 20⁰C. The latter temperature was too high
294 for successful storage of dormant plants as compared to the lower temperatures. Similarly, the
295 model showed significant differences between treatments with the shorter storage duration of 6
296 weeks 4 days, and of 8 weeks, as opposed to the reference treatment (less successful regarding
297 market quality) with a storage duration of 9 weeks 3 days. Data of the commercial harvest in
298 February-March were used for the estimation of the model's parameters.

299 Very similar results between treatments with the constant temperature of 2⁰C and with the
300 diurnal alternating temperature 2-10⁰C were obtained in our study. This is in line with the results
301 of our previous article ([25]; obtained in northern Israel) for the same constant and alternating
302 temperatures. In both studies dormancy under diurnal alternating temperatures provided
303 practically the same results in terms of plant development and flower quality as those obtained
304 for constant temperatures. The practical importance of these results lies in the economic gains
305 that farmers can expect due to the saving of energy during dormancy in chilling chambers.

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