

## Response of Balady Mandarin Trees to Girdling and Potassium Sprays under Sandy Soil Conditions

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**Abstract:** Ten years old Balady mandarin trees grown under sandy soil conditions were treated with girdling before blossoming (late Dec.) and sprayed with 1 or 2% potassium nitrate or di-potassium hydrogen phosphate twice at the beginning of April and ten weeks later (mid June). Results concluded that girdling plus potassium sprays specially potassium nitrate at any concentration had a positive effect on nitrogen and potassium percentages, total carbohydrate, total chlorophyll and chlorophyll (a) content in the leaves, which reflected on increasing fruit weight, number of fruits per tree and finally yield weight per tree. Also such treatments enhanced fruit volume, soluble solids content and SSC/acid ratio. On the other hand, the same treatments reduced juice percentage in the fruit and had no effect on phosphorus and chlorophyll (b) content in the leaves, acidity and vitamin C in juice of the fruit.

**Key words:** Balady mandarin, girdling, potassium nitrate, di-potassium hydrogen phosphate

### INTRODUCTION

Girdling has been, and is still, worldwide used for centuries in citrus, grape, peach and other fruit tree crops, mainly to increase flowering, fruit set and fruit size. Girdling consists of removal of a strip of bark from the trunk or major limbs of a fruit tree, thereby blocking the downward translocation of photosynthates and metabolites through the phloem. The best-known effects of girdling are presumably brought about by accumulation of assimilates above the girdle<sup>[1,2]</sup>. Cytokinin and gibberellin content of shoots is also modified by girdling<sup>[3,4]</sup>. On the upper part of girdling leaf N content, C/N ratio and carbohydrate were improved. Therefore, flowering and fruit set were increased<sup>[1,5-9]</sup>. The precise biochemical changes resulting from girdling have been studied only in some particular cases and a detailed interpretation of the physiological effects of girdling is still lacking<sup>[10]</sup>. On the other hand, spraying potassium using different forms had a positive effect on leaf mineral content, fruit set and yield as number or fruits weight of citrus trees<sup>[11-13]</sup>.

The purpose of this work is to study the effect of girdling and the form of potassium sprays on leaf mineral content, yield and fruit quality of Balady mandarin trees grown under sandy soil conditions.

### MATERIALS AND METHODS

The present study was carried out during 2002 and 2003 seasons (on year seasons) on 10 years old Balady

mandarin trees budded on sour orange rootstock and spaced 3.5×3.5 meters apart. Trees were grown in sandy soil at "El-Mansoria" Giza governorate.

The experiment was arranged in a complete randomized design with three replicates, each consisted of three trees.

The experiment involved the following six treatments:

1. Control (untreated trees).
2. Girdling.
3. Girdling + 1% potassium nitrate.
4. Girdling + 2% potassium nitrate.
5. Girdling + 1% di-potassium hydrogen phosphate.
6. Girdling + 2% di-potassium hydrogen phosphate.

Girdling was carried out before blossoming (late Dec.) with about 3mm width around trunk using a girdling knife without injure the wood layers.

Each tree was sprayed twice with di-potassium hydrogen phosphate or potassium nitrate at the beginning of April and ten weeks later (mid June) in each season with 10 liters of solution which was sufficient for thorough wetting. Triton B at 0.1% was used as a wetting agent for all spraying solutions.

In July of each season leaf samples were taken randomly from non-fruiting and non-flashing terminal shoots, washed with tap water then with distilled water, dried at 70°C until constant weight, ground and finally digested. The digested solution was used to determine N, P, K percentage in leaves, which estimated by standard

procedure according to Wilde *et al*<sup>[14]</sup>.

At harvest time (first week of January), the yield expressed in weight (kg) and number of fruits per tree was recorded. Ten fruits were randomly collected from all sides of the trees under treatments and both physical and chemical characteristics were determined by the methods described in A.O.A.C<sup>[15]</sup>.

Leaf chlorophylls were determined according to the methods described by Arnon<sup>[16]</sup>.

Leaf carbohydrate were extracted and determined according to the method described by Malik & Singh<sup>[17]</sup>.

All the obtained data were statistically analyzed according to Snedecor & Cochran<sup>[18]</sup>.

## RESULTS AND DISCUSSIONS

**Leaf mineral contents:** Data in Table (1) show the effect of girdling and potassium foliar sprays on leaf mineral content. As for nitrogen, it is clear that all treatments significantly increased N% in the leaves comparing with the control. In this respect, presence of potassium nitrate especially the higher concentration (2%) with girdling recorded the highest nitrogen content in the leaf, followed by di-potassium hydrogen phosphate treatments + girdling, while as the untreated trees, gave the lowest value in both studied seasons.

Regarding potassium content in the leaves, it is observed that the results tack the same trend of nitrogen percentage in the leaves, since the higher value was obtained with potassium nitrate treatments + girdling followed in decreasing order by di-potassium hydrogen phosphate + girdling then girdling treatment solely, while the untreated trees were recorded the lowest K%. This was true during both studied seasons.

Phosphorus percentage in the leaves was not affect by any treatments and no trend was detected among the treatments in the two studied seasons.

The obtained results are in agreement with those reported on Washington navel & Valencia oranges<sup>[19]</sup>, on Hamlin orange<sup>[12]</sup> and on Balady mandarin<sup>[13]</sup>, since spraying potassium from several forms i.e.  $\text{KH}_2\text{PO}_4$  or  $\text{K}_2\text{HPO}_4$  or  $\text{KNO}_3$  raised N and K levels in the leaves. On the other side, it was found that girdling improved N and K content in the leaves<sup>[7,20,21]</sup>.

**Carbohydrate and chlorophylls contents in the leaves:** Table (2) showed total carbohydrate and chlorophylls contents in the leaves. As for total carbohydrate percentage in the leaves, it is observed that different treatments significantly raised this parameter than the control, since the untreated trees recorded the lowest significant value and the total carbohydrate contents were enhanced gradually with girdling treatment followed in ascending order by di-potassium hydrogen phosphate treatments + girdling, while spraying trees with potassium

nitrate treatments especially the high concentration + girdling recorded the higher percentages of total carbohydrate.

Regarding chlorophylls (total, a and b) content in the leaves, it is observed that all treatments significantly increased both total and chlorophyll (a) compared with the untreated trees and the increment lacked significance between different treatments. This was true for both parameters. While as chlorophyll (b) in the leaves, no significant differences were detected among the treatments during the two studied seasons on this parameter.

In this respect, an increase in leaf carbohydrate on the upper part of girdling line was found<sup>[6,8]</sup>.

**Yield:** Yield as weight (kg) and number of fruits/tree are shown in Table (3). Yield weight per tree was significantly increased by all treatments either as girdling alone or with potassium sprays at any form and any concentration. However, yield was gradually increased by girdling than the control then the range of increase was higher when trees treated with girdling + di-potassium hydrogen phosphate and reached the maximum with girdling + potassium nitrate treatments especially the high concentration (2%) which gave the highest yield (kg) per tree (65 and 64.7 kg) for the first and second seasons, respectively. On the other hand, yield as number of fruits per tree gave the same previous trend since treated trees with girdling + potassium nitrate at higher concentration gave the maximum number (412 and 425 fruits/tree) in the first and the second seasons, respectively. While as the untreated trees (control) gave the minimum value (348 and 350 fruits/tree) for the two seasons, respectively.

In this concern, spraying potassium from several forms ( $\text{KH}_2\text{PO}_4$  or  $\text{K}_2\text{HPO}_4$  or  $\text{KNO}_3$ ) enhanced fruit-set and increased yield of orange and mandarin trees<sup>[11-13, 19, 22, 23]</sup>. On the other hand, girdling application increased yield by about 25-37%<sup>[21,24-26]</sup>.

**Fruit properties:** Data in Table (4) showed the effect of girdling treatments with or without potassium sprays on physical and chemical properties of Balady mandarin fruits. As for weight and volume of fruits, it is clear that both parameters gave more or less the same trend, since all treatments significantly increased weight and volume of fruits comparing with the control. In this respect, presence potassium sprays with girdling showed more increment in these parameters than girdling solely. Juice weight/fruit was significantly decreased with different treatments comparing with the untreated trees (control), which recorded the highest juice weight/fruit.

Concerning soluble solids content in the fruit juice, treatments significantly increased this parameter especially with potassium sprays. However, girdling + 2% di-potassium hydrogen phosphate and girdling + 1%

**Table 1:** Effect of girdling and different forms of potassium sprays on leaf mineral content of Balady mandarin trees during 2002 and 2003 seasons.

Treatments	First season (2002)			Second season (2003)		
	Nitrogen%	Potassium%	Phosphorus%	Nitrogen%	Potassium%	Phosphorus%
Control	2.26	1.56	0.13	2.29	1.57	0.12
Girdling	2.35	1.60	0.13	2.26	1.62	0.13
Girdling+ 1%KNO <sub>3</sub>	2.50	1.72	0.12	2.52	1.74	0.13
Girdling+ 2%KNO <sub>3</sub>	2.53	1.75	0.13	2.55	1.76	0.13
Girdling+ 1% K <sub>2</sub> HPO <sub>4</sub>	2.41	1.66	0.14	2.40	1.57	0.13
Girdling+ 2% K <sub>2</sub> HPO <sub>4</sub>	2.45	1.69	0.13	2.45	1.70	0.14
LSD at 5%	0.02	0.02	N.S	0.03	0.01	N.S

**Table 2:** Effect of girdling and different forms of potassium sprays on total carbohydrate and chlorophyll content in Balady mandarin leaves during 2002 and 2003 seasons.

Treatments	First season (2002)				Second season (2003)			
	Total Carbohydrate %	Chlorophyll		Total	Chlorophyll Carbohydrate %			
		Total	A			B	Total	A
Control	9.28	346	266	80	9.36	352	270	82
Girdling	10.76	380	300	80	10.88	384	301	83
Girdling+ 1%KNO <sub>3</sub>	11.89	384	301	83	12.48	388	303	85
Girdling+ 2%KNO <sub>3</sub>	12.36	383	300	83	12.59	390	303	87
Girdling+ 1% K <sub>2</sub> HPO <sub>4</sub>	11.50	381	299	82	11.46	387	304	83
Girdling+ 2% K <sub>2</sub> HPO <sub>4</sub>	11.52	382	300	82	11.49	285	303	82
LSD at 5%	0.5	4.5	4.2	N.S	0.5	4.7	3.6	N.S

**Table 3:** Effect of girdling and different forms of potassium sprays on yield per tree and number of fruits of Balady mandarin trees during 2002 and 2003 seasons.

Treatments	First season (2002)		Second season (2003)	
	Yield/tree (kg)	No. fruits/tree	Yield/tree (kg)	No. fruits/tree
Control	40.2	348	39.9	350
Girdling	51.6	380	51.4	378
Girdling+ 1% KNO <sub>3</sub>	63.3	405	63.9	410
Girdling+ 2% KNO <sub>3</sub>	65.0	412	64.7	425
Girdling+ 1% K <sub>2</sub> HPO <sub>4</sub>	57.4	390	57.8	385
Girdling+ 2% K <sub>2</sub> HPO <sub>4</sub>	62.1	400	62.8	396
LSD at 5%	3.7	8.2	1.1	12.8

potassium nitrate gave the higher values of SSC. Acidity and ascorbic acid (vitamin C) in the fruit juice did not recode any significant differences between treatments during the two studied seasons. Regarding SSC/acid ratio, results showed significant differences between treatments in both seasons, since girdling + potassium nitrate treatments gave the higher values followed by girdling treatment alone.

The present results are in agreement with those finding on Hamlin orange, Balady mandarin, Washington navel & Valencia oranges, and Balady orange, since spraying KH<sub>2</sub>PO<sub>4</sub> or K<sub>2</sub>HPO<sub>4</sub> or KNO<sub>3</sub> increased weight and volume of fruit <sup>[11-13, 19, 22]</sup>, while as SSC, SSC/acid ratio and fruit juice acidity was not or slightly affected. Acidity and ascorbic acid were not significantly affected due to potassium treatments on

**Table 4:** Effect of girdling and different forms of potassium sprays on physical and chemical properties of Balady mandarin fruits during 2002 and 2003 seasons.

Treatments	First season (2002)							Second season (2003)						
	Fruit weight (gm)	Fruit vol. (cm <sup>3</sup> )	Juice %	SSC (%)	Acid (%)	SSC acid/ ratio	Ascorbic acid (mg/100ml juice)	Fruit weight (gm)	Fruit vol. (cm <sup>3</sup> )	Juice %	SSC (%)	Acid (%)	SSC acid/ ratio	Ascorbic acid (mg/100ml juice)
Control	115	136	41.9	11.0	1.2	9.1	30.3	114	135	42.8	10.7	1.2	8.9	29.9
Girdling	133	140	39.2	11.0	1.1	10.1	30.9	136	140	39.9	11.3	1.1	10.4	30.8
Girdling+ 1%KNO <sub>3</sub>	156	172	37.1	11.7	1.1	10.4	30.0	155	176	37.4	11.5	1.2	10.2	31.1
Girdling+ 2%KNO <sub>3</sub>	157	173	38.5	11.3	1.1	10.3	30.6	155	173	39.0	11.3	1.1	10.5	31.6
Girdling+ 1% K <sub>2</sub> HPO <sub>4</sub>	147	158	38.3	11.0	1.3	8.9	32.1	150	159	38.9	11.0	1.2	9.5	32.3
Girdling+ 2% K <sub>2</sub> HPO <sub>4</sub>	155	177	36.9	11.7	1.2	9.9	32.7	158	177	37.5	11.7	1.2	10.0	31.7
LSD at 5%	3.6	1.1	1.2	0.3	N.S	0.5	N.S	3.1	3.5	0.5	0.4	N.S	0.3	N.S

Washington navel orange<sup>[27-29]</sup>. Moreover, juice content was decreased as increasing potassium levels in the leaves from 0.3 to 1.9%<sup>[30]</sup>.

On the other hand, girdling treatments improved fruit weight, SSC and did not affect ascorbic acid content in fruit juice of Balady mandarin<sup>[21]</sup>.

From the abovementioned results, it could be concluded that the positive effect of girdling with different forms of potassium sprays specially potassium nitrate at 1 or 2% may be explained by the improving effect of such treatments on nutritional status of the trees specially the relatively higher minerals, carbohydrate, chlorophylls contents in the leaves obtained by these treatments, which certainly reflected on increasing fruit weight, number of fruits per tree and finally yield weight per tree. The common, explanation for the effects of girdling is that the development of the reproductive organs benefits from the higher concentrations of assimilates available in the canopy following girdling<sup>[2]</sup>.

Thus, it could be concluded that spraying trees with potassium nitrate either at 1 or 2% at the beginning of April and ten weeks later (mid June) plus girdling before blossoming (late Dec.) are the promising treatments under such conditions.

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