

## **Haifa Bonus - HIGHLY CONCENTRATED, ENRICHED POTASSIUM NITRATE, AN OPTIMAL BOOSTER FOR YIELD AND QUALITY OF CITRUS FRUITS.**

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### Abstract

Haifa bonus is a new fully soluble, crystalline formulation of potassium nitrate that has been specifically developed for foliar feeding of a large variety of crops. It is sprayed at concentrations of up to 10% for intensive foliar nutrition and for a prolonged effect, without any phytotoxic effects. Haifa bonus is potassium nitrate enriched with soluble phosphates and a special adjuvant. The moderately acidic pH (4.5-6.0) of the spray solution enables tank-mixing it with numerous pesticides.

Foliar feeding with Haifa bonus has achieved the following in citrus crops:

In Shamouti ("Jaffa") oranges, a single application of 9-10% (w v<sup>-1</sup>) Haifa Bonus, when fruits were 18-22 mm in diameter, increased percentage of fruit above 75 mm in diameter by 75%. Consequently, total yield increased by 14 ton ha<sup>-1</sup> and net grower revenues increased by US\$ 378 ha<sup>-1</sup>. Foliar K in D.M. increased by 0.47%. Shelf life of stored fruit was also significantly enhanced due to a marked increase in potassium content of the rind by 0.44% (in D.M.).

In Newhol navel, a single application of a 10% solution significantly increased total yield by 19%, fruit above 75mm in diameter increased by 28%, foliar K in D.M. increased by 0.33% and net grower revenues - by US\$ 8,500 ha<sup>-1</sup> (!!!).

In Nova tangerine, a single application of a 10% solution significantly increased total yield by 30%, mean fruit weight – by 38.3 g and reduced the incidence of rind creasing by 20%. The grower has increased his net revenues by over US\$ 2,300 ha<sup>-1</sup>. The benefit/cost ratio of this treatment was an outstanding 34 (!).

These results verify that Haifa Bonus is an ideal preparation for intensive potassic feeding that considerably increases total yield, primarily by increasing the size of individual fruit units. Haifa Bonus provides its maximum benefit to the grower when the market pays high premiums for larger fruit units.

Keywords: Citrus, foliar feeding, fruit-quality, fruit-size, potassium nitrate, yield.

### 1. Introduction

Fruit-size is a very important factor in the marketability of numerous crop species used for both fresh consumption and for processing. Most consumers and fruit-processing plants appreciate larger fruit units and are willing to pay premium prices for them.

The application of potassium nitrate by soil dressing and by fertigation is already a common practice employed to increase total yield and fruit quality in numerous crops. Foliar-applied potassium nitrate has been found by many recent studies as a potent tool to increase yields, specific fruit components and individual fruit size of various citrus species (Achilea *et al.*, 2000 and Erner *et al.*, 1993), olives (Dikmelik *et al.*, 2000), wine-grapes

(Altindisli *et al.*, 2000), table-grapes (Ceylan *et al.*, 2000), figs (Irget *et al.*, 2000), apples (Shemian *et al.*, 2001), apricots (Ozturk, personal communication) and coffee berries (Achilea, unpublished data). The effect of foliar- applied potassium nitrate is generally enhanced by combining it with some growth regulators, primarily – auxins (Erner *et al.*, 1993, Tamim *et al.*, 2000 and Greenberg *et al.* 2001).

Insufficient K in the composition of citrus fruit rind causes irregular appearance of the fruit and reduced revenues to the grower. Shamouti orange expresses fruit-rind K -deficiency as SRP (superficial rind pitting) (Tamim *et al.* , 2000), while many tangerine varieties and Valencia orange express K-deficiency in the form of creasing (Raber *et al.*, 1997). Pitting and creasing are linked to reduced shelf-life of the stored fruit (Tamim *et al.*, 2000).

In order to supply the plants with sufficient amounts of potassium nitrate by foliar feeding, the common practice is to spray the groves 2-4 times per season at a concentration of 1.5-4%. Higher concentrations could result in scorching of the foliage. In order to save on the number of spray operations, Haifa Chemicals has recently launched “Haifa Bonus”, specifically designed for foliar feeding at high concentrations. This is a state-of-the-art nutritive preparation with the analysis of 13-2-44, chloride-free and fully soluble fertilizer. This paper describes several experiments carried out in recent years on citrus to enhance yields, fruit quality and grower’s profitability by using a single high concentration spray of Haifa Bonus

## 2. Materials and Methods

All spraying experiments were conducted in recent years in mid-June, in mature (15 years old and above) citrus orchards in central Israel. Sprayings were carried out by automatic or hand-held spray guns until run-off occurred. Experiment conditions are described in Table M. In some experiments, a single Haifa Bonus application was compared with three sprayings of Multi-K (Haifa Chemicals foliar-feeding grade of potassium nitrate) at 4%. Statistical analysis of the results was done by Duncan’s multiple-range test at  $p < 5\%$ .

Table M: Main characteristics of experiments conditions.

Year	Fruitlets diameter (mm)	Spray volume (liter ha <sup>-1</sup> )	Haifa Bonus spray concentration	Variety	Experiment reference
1997	12-15	3,500	10%	Shamouti orange	Exp. #1
	14; 35; 50	3,500	3 x 4%		
1998	18-20	4,000	9%	Shamouti orange	Exp. #2
1998	15-20	3,500	10%	Newhol navel orange	Exp. #3
1997	12-15	2,500	10%	Nova tangerine	Exp. #4
2000	18-20	4,500	10%	Shamouti orange	Exp. #5
	19; 40; 50	4,500	3 x 4%		

## 3. Results

### 3.1. Foliar nutrients contents

In almost all experiments, foliar feeding with Haifa Bonus has resulted in statistically significant increased foliar nitrogen content. P content was not generally

affected by this treatment, and K was invariably substantially increased by Haifa Bonus. There was no difference between the effect of Haifa Bonus and 3 x Multi-K regarding N and P contents. Three sprayings of Multi-K were less effective in one experiment and more effective in another, in increasing foliar contents of K, compared to Haifa Bonus (table 1).

### 3.2. Contents of the fruit

Foliar feeding of Shamouti trees with Haifa Bonus has statistically significantly increased K content of fruit rind. N and P were not affected by this treatment. There was no appreciable difference between a single spray of Haifa Bonus and three sprays of Multi-K (exp #5, table 2).

An unclear response of juice content to Haifa Bonus was found in the two experiments carried out with Shamouti oranges. In one experiment juice content rose by 2.7% while in the other, it decreased by 3.7% (table 2). Total soluble solids and acids percentage were not changed by the spray treatment (data are not shown).

### 3.3. Total yield and gross revenues of the growers

Foliar feeding with Haifa Bonus and with three sprayings of Multi-K substantially and statistically increased total yields for both oranges varieties, and for Nova tangerines (Table 3). The mean increases in Shamouti, Newhol and Nova were 32.9%, 18.9% and 28.9%, respectively.

### 3.4. Size distribution of the fruit

Foliar feeding with Haifa Bonus invariably increased the proportion of larger fruits, and reduced the amount of the smaller fruits (Figures 1 & 2). Similar results were obtained in all experiments, for all varieties tested (results are not shown). Three sprayings with Multi-K at 4% resulted in a size distribution pattern very similar to the one obtained by a single spray of Haifa Bonus.

In all varieties tested, there is a dramatic price differentiation between the fruit sizes, reflecting customers preference for larger fruit size (Table 4).

### 3.5. Fruit-rind blemishes

Foliar feeding with Haifa Bonus invariably reduced the incidence of rind blemishes in both Shamouti oranges and Nova tangerines. Spraying Shamouti oranges drastically reduced SRP, while creasing of Nova tangerines was halved by this treatment (Table 5). The end-result in both varieties was, therefore, a considerable increase in the proportion of class I fruit with associated premium prices. The grower benefited from the treatment by obtaining a larger percentage of more profitable fruit due to two factors:

1. Preferential size distribution.
2. Better skin finish.

## 4. Discussion

The series of experiments carried out in recent years proved once again that foliar application of potassium nitrate is essential for high production and fruit quality in citrus.

The common practice of 3 applications per season produced agronomical and economic results markedly superior to the unsprayed control in terms of nutrient contents in the leaves and fruit rind, total yield, fruit-size distribution and grower revenues (Tables 1-4 and Figure 1). But the principal message of this paper is that a single spray of a unique potassium nitrate preparation, that was developed and optimised for this purpose, can now replace the customary 3 sprayings procedure. Haifa Bonus applied at 10% w v<sup>-1</sup> at a high spray volume to run-off, (to ensure proper wetting of the foliage), at the precise time when fruitlets are 18-22 mm in diameter, showed similar results to those obtained with Multi -K. Moreover, Haifa Bonus remarkably enhances external appearance of the fruit and its storability (Table 5). These two factors improved the class-1 proportion of the fruit. The other factor that highly contributes to the profitability of the grower was the clear shift in fruit-size distribution towards bigger sizes that receive considerably higher market prices. A considerable saving in field operations stems from the fact that the moderately acidic pH of the solution enables tank-mixing with numerous pesticides, compatible with potassium nitrate preparations.

This combination of increased fruit size and enhanced external and internal fruit quality is also beneficial to other crops (e.g. mango, peaches and coffee). This improvement has profound economic implications whenever customers are willing to pay premium prices for larger and more aesthetic fruits.

The unique performance of Haifa Bonus stems from its special composition of nutrients and adjuvant that provide the plant with a long term supply of nutrients without scorching foliage – a condition that exists with other mineral nutrients sprayed at comparable concentrations. The extended nutritional effect stems from the fact that most of the product is precipitated on the leaves, where it serves as an ongoing reserve, and from diurnal changes in ambient relative humidity. Full uptake by the leaves requires several nights, during which time it is gradually re-dissolved by dewdrops. Further experiments conducted in tropical regions indicate that considerably lower concentrations of Haifa Bonus should be used where leaf cuticle is less developed resulting in higher sensitivity to defoliation. Small-scale local trials are advocated prior to commercial-scale treatments.

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Table 1: The effect of Haifa Bonus on leaf contents of main nutrients in Shamouti orange.

<u>K</u>		<u>P</u>		<u>N</u>			
(% in D.M.)						Experiment reference	Variety
a	0.60	a	0.038	a	150 ppm nitrate	Exp.#1, Control	Shamouti orange
	1.31 b	a	0.049		460 ppm nitrate b	Exp.#1, Haifa Bonus	
	1.11 b	a	0.039		300 ppm nitrate b	Exp.#1, 3 x Multi-K	
a	1.17	a	0.041	a	300 ppm nitrate	Exp. #2, control	
	1.62 b		0.052 b		680 ppm nitrate b	Exp. #2, Haifa Bonus	
a	0.74	a	0.119	a	2.25	Exp. #5 control	
	1.00 b	a	0.124	a	2.16	Exp. #5, Haifa Bonus	
c	1.25	a	0.121	a	2.32	Exp. #5, 3 x Multi-K	
a	1.18	a	0.076	a	170 ppm nitrate	Exp. #3, control	Newhol
	1.52 b	a	0.08		270 ppm nitrate b	Exp. #3, Haifa Bonus	navel orange
a	0.95	a	0.048	a	360 ppm nitrate	Exp. #4, control	Nova
b	1.75	a	0.048		840 ppm nitrate b	Exp. #4, Haifa Bonus	tangerine

Table 2: The effect of Haifa Bonus on fruit contents in Shamouti.

Juice content (%)	Fruit-rind nutrients contents (% in dry matter)			Experiment reference
	<u>K</u>	<u>P</u>	<u>N</u>	
47.7	0.81 a	0.075 a	1.32 a	Control
44.0	1.25 b	0.059 a	1.42 a	Haifa Bonus
	1.52 b	0.073 a	1.44 a	Multi-K x 3
45.9				Control
48.6				Haifa Bonus

Table 3: The effect of Haifa Bonus on total yield and grower's revenues of Shamouti and Newhol oranges, and Nova tangerines.

Revenue (US\$ x ha <sup>-1</sup> )		Yield (MT x ha <sup>-1</sup> )		Experiment reference	Cultivar checked
Haifa Bonus	Control	Haifa Bonus	Control		
840	400	50.1 a	36.4 a	Exp. #1	Shamouti
748.3	488.8	49.2 b	38.4 a	Exp. #5, Haifa Bonus	Shamouti
796.4		48.0 b		Exp. #5, 3 x Multi-K	
20,720	11,970	76.5 b	64.3 a	Exp. #3	Newhol
16,800	10,050	71.0 b	55.1 a	Exp. #4	Nova tangerine

Table 4: Differential revenues of Shamouti orange to the grower, as related to fruit size.

40	48	56	64	75	88	100	113	Fruit size*
5.36	5.36	4.48	4.21	2.98	1.83	1.45	0.64	Revenue (US\$ per crate)

\* Number of fruit units per standard crate of 15 kg net fruit weight.

Table 5: The effect of Haifa Bonus on rate of rind blemishes in Shamouti oranges and Nova tangerines.

Rate of damage		Rind blemish	
Haifa Bonus	Control		
4 % b	24 % a	SRP after 14 d. storage at 25 C	Shamouti, Exp. #2
19 % b	40 % a	Creasing at day of harvest	Nova, Exp. #4

Figure 1: The effect of a single spray of Haifa Bonus and of three sprays of Multi-K on size distribution of the fruit in Shamouti.

Figure 2: The effect of Haifa Bonus on size distribution of the fruit in Newhol.

