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III Effects of Potassium Foliar Spray on Olive, Peach and Plum. Part 2: Peach and Plum Experiments

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Royal Glory peach orchard at flowering period. Photo taken by M. Ben Mimoun.

Introduction

The fruit tree industry is one of the most important agricultural sectors in Tunisia, with more than 2 million hectares planted mainly with olive (1.5 million ha), almond (257,000 ha), pistachio (44,000 ha) and palm date (26,000 ha). Citrus and stone fruits are also economically important crops (Table 1). Water scarcity is the main limiting factor for Tunisian agriculture. Foliar application of plant nutrients is helpful in satisfying plant requirements and can be highly efficient (Inglese *et al*. 2002). Potassium is adapted to foliar fertilization since when sprayed on leaves it is quickly translocated to other plant parts (Mengel, 2002). Foliar application is an attractive remedy especially in arid zones under low rainfall conditions where the lack of water in summer drastically restricts nutrient absorption by the tree.

In 2003, IPI Coordination WANA region, with the fruit tree laboratory at Institut National Agronomique de Tunisie (INAT), began a research project to evaluate the effect of potassium foliar sprays (in the form of potassium sulphate) on different fruit crops (olive, citrus, pistachio, peach and plums), and under different growing conditions.

The purpose of this paper is to present some of the results obtained for peach and plums under fertigated orchards.

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Table 1. Fruit and nut production area and productivity in Tunisia (2006).

Fruit tree crop	Area	Yield
	ha	*'000 mt*
Olive	1,560,000	850
Almond	257,000	56
Pistachio	44,000	1.6
Date	32,600	131
Apple	25,500	120
Grape	25,000	54
Peach	23,000	73
Fig	23,000	30
Citrus	18,000	247
Pomegranate	13,000	70
Apricot	11,600	28
Pear	11,000	65
Plums	6,500	15

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Materials and methods

The experiment was made in 2006 using 15-year-old trees in commercial plum and peach orchards in which standard horticultural practices of commercial production were being carried out. The plum cultivar grown was "Black Star" grafted on Mariana rootstocks, with tree planting spaced at 3 x 5 m. For the peach experiment, the mid-season cultivar "Royal Glory" grafted on GF 677 rootstocks was used, the 15 year-old trees being spaced at 4 x 5 m. In both cases, trees were trained to an open vase shape and were drip-irrigated with one drip line per tree row and two drippers per tree, 40 cm from the trunk.

The physiochemical properties of the soil at the experimental site are described in Table 2.

At the beginning of the season, the tree requirement for potassium was estimated for Black Star plum and Royal Glory peach as 102 kg and 90 kg of K_2O/ha respectively from calculations based on the K contents of the expected yields (35 mt/ha and 30 mt/ha) and the pruning wood. The respective amounts for N and P were: plum 90 kg N/ha and 60 kg P_2O_5/ha, and peach 110 kg N/ha and 60 kg P_2O_5/ha.

The fertilization for elements other than potassium was similar for all trees and based on tree requirement.

Three fertilization treatments were compared:

1. Fertigation: the growers' conventional fertilization method used to apply all the potassium tree requirement.

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Table 2. Physiochemical characteristics of the soil at the experimental site.

Parameter	Depth (cm)	
	0-30	*30-70*
Clay (%)	18.25	-
Loam (%)	43.75	-
Sand (%)	23.00	-
pH	8.05	8.18
EC (dS/m^2 at 25°C)	0.65	0.85
Total calcium (%)	23.43	23.88
Active calcium	13.80	13.50
Organic carbon (%)	1.05	0.82
Organic matter (%)	1.85	1.48
Total N	1.38	1.15
C/N	7.78	7.03
Exchangeable potassium (K_2O ppm)	455	397
Available phosphorus (P_2O_5 ppm)	41.00	18.50

2. F100: foliar spray applying 100 per cent of the potassium tree requirement.
3. F50: foliar spray applying 50 per cent of potassium tree requirement.

The fertilizer used was a soluble potassium sulphate (K_2SO_4), both for fertigation and foliar spray application. Fertigation was supplied through the season with one application every three days. The foliar fertilization treatments were applied using a 10 liter sprayer, at a concentration of 3 per cent and a rate of 1000 L/ha, three times during the season as follows:

- May 1, 2006
- May 19, 2006
- June 1, 2006

These dates were chosen based on the tree requirement period for potassium. The first date (May 1st) represents the onset of stage I of fruit growth, the second date (May 19th) the beginning of stage II and the third date (June 1st) was three weeks before harvest.

In the experiment for both sets of fruit trees, treatments were arranged according to a completely randomized block design with three replications. Each replication consisted of nine trees.

Vegetative growth was measured every 15 days until harvest. The decision as to when to harvest was made by the grower and took place on three different dates depending on the fruit maturity of the tree. For each harvest date and treatment, fruit weight, firmness, soluble solids and titratable acidity were determined on 30 fruits. Fruit firmness was evaluated using a penetrometer with an 8 mm plunger on two opposite sides of each fruit having previously removed the skin. Soluble solids were measured using an electronic refractometer with automatic temperature compensation. Titratable acidity was determined by titration with 0.1 N NaOH and phenolphthalein indicator.

Nutritional status (N, P, K, Mg and Ca) was assessed around 105 days after full bloom, by analyzing the nutrient from mid-shoot leaf samples.

Data was analyzed using the Genstat statistical analysis program. Analysis of variance was used and means were separated by Duncan's Multiple Range Test ($p \leq 0.05$).

Results and discussion

Vegetative growth

No difference in vegetative growth for Black Star plum (Fig. 1) or Royal Glory peach (Fig. 2) was observed between the three treatments. This result could be explained by the fact that the fruit is the major sink for carbohydrate (Grossman and DeJong, 1995), especially during the final stage of fruit growth (stage III). In some stone fruit trees such as prune, leaf scorch and shoot dieback are frequently observed resulting from potassium stress because of high mobilization of K by the fruit inducing a lowering of leaf K concentration (Southwick *et al.*, 1996; Weinbaum *et al.*, 1994).

Fruit weight and quality

No effect was observed on fruit yield on either peach or plum (data not shown). Ruiz (2006) on a five-year experiment on nectarine found an effect of K on yield only in a single year characterized by severe drought. However, foliar spray treatment increased fruit weight of Black Star plum (Fig. 3) and Royal Glory peach (Fig. 4). Only the increase of weight on the second harvest date for Royal Glory showed no statistical significant effect. Ruiz (2006) related the higher weight observed on nectarine to the greater flux of K to the fruits. Potassium absorption rates in the fruit rose remarkably during stage III of fruit growth, which coincided with greater increases in dry matter accumulation (Batjer and Westwood, 1957, Tagliavini and Marangoni, 2002). Since with half

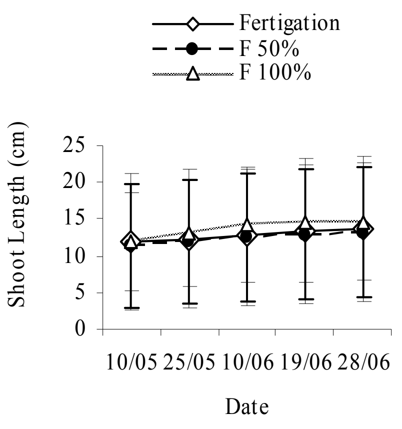

Fig. 1. The effect of fertilization treatments on vegetative growth (cm) of Black Star Plum Cultivar. Error bars indicate standard error.

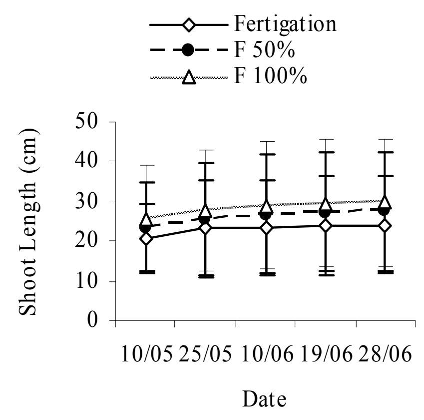

Fig. 2. The effect of fertilization treatments on vegetative growth (cm) of Royal Glory Peach Cultivar. Error bars indicate standard error.

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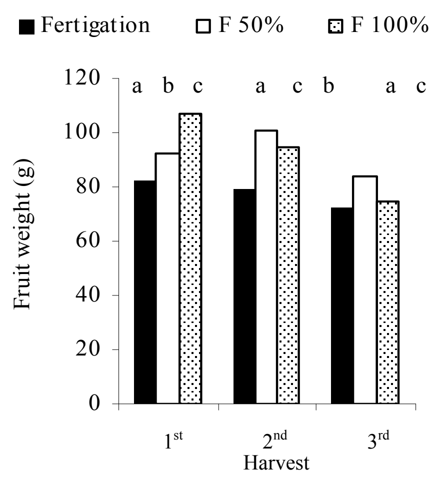

Fig. 3. The effect of fertilization treatments on fruit weight (g) of Black Star plum cultivar for the three harvest dates. Different letters indicated statistical differences among means by Duncan's Multiple Range Test (p≤0.05).

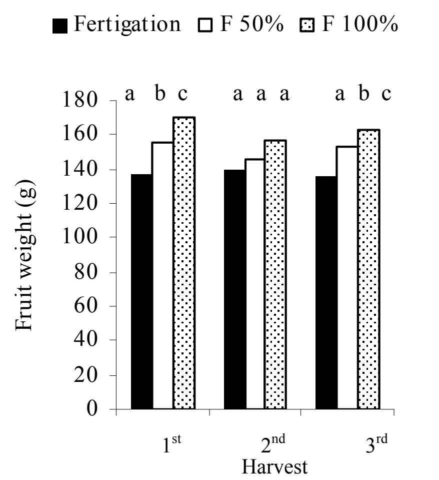

Fig. 4. The effect of fertilization treatments on fruit weight (g) of Royal Glory peach cultivar for the three harvest dates. Different letters indicated statistical differences among means by Duncan's Multiple Range Test (p≤0.05).

quantity of K, the fruit weight was higher, this result could suggest a higher efficiency of foliar spray than fertigation, especially for sprays during stage III, a period of high K demand by the fruit.

For the plum experiment, total soluble solids were higher in the fruit from the 100 per cent requirement foliar spray, especially for the first and second harvest dates, but lower at the 3rd harvest (Table 3). No consistent effects were measured for fruit firmness, except a higher firmness for the 50 per cent requirement foliar spray and a lower firmness for the 100 per cent foliar spray during the first harvest date.

For the peach experiment, fruit soluble solids content was affected by fertilization treatment only for the first harvest dates (Table 3). For that date fruits from the 100 per cent requirement foliar spray treatments were higher in total soluble solids. Ruiz (2006) observed no effect of K fertilization on fruit soluble solids. No differences in fruit firmness were measured between any of the treatments or dates of harvest. Tagliavini and Marangoni (2002) observed a benefit from efficient K supply as evidenced by increased fruit size, sugar content and improved fruit color. The higher TSS in the first date harvest in both experiments for the 100 per cent spray indicates that the fruit maturity was earlier with the foliar application. In both the experiments and for all harvest dates, the fruit quality was considered as good for the varieties' standards.

Table 3. The effect of fertilization treatments on total soluble solids concentration and fruit firmness of Black Star plum cultivar and Royal Glory peach cultivar for the three harvest dates. Different letters indicated statistical differences among means by Duncan's Multiple Range Test (p≤0.05).

Species	Harvest	Treatment	Soluble Solids	Firmness
			% Brix	*kg/0.5 cm²*
Black Star plum	1	Fertigation	13.5 a	3.90 ab
		F 50	15.0 b	5.72 a
		F 100	15.0 b	2.96 b
	2	Fertigation	14.0 a	7.08 a
		F 50	14.0 a	6.94 a
		F 100	15.0 b	6.56 a
	3	Fertigation	15.2 c	6.56 a
		F 50	15.0 b	4.68 a
		F 100	14.0 a	5.98 a
Royal Glory peach	1	Fertigation	11.0 a	5.78 a
		F 50	11.0 a	5.10 a
		F 100	11.5 b	5.44 a
	2	Fertigation	12.5 b	4.52 a
		F 50	11.5 a	5.88 a
		F 100	12.5 b	5.14 a
	3	Fertigation	12.0 a	5.04 a
		F 50	12.0 a	5.20 a
		F 100	12.0 a	5.64 a

Leaf analysis

No differences were found in leaf analysis between the different fertilization treatments and for either of the species (Table 4). According to Johnson and Uriu (1989), leaf nutrient concentrations were at the optimum level for P, K and Mg, while at sub-optimal concentration for N and Ca for Black Star. For Royal Glory peach, leaf nutrient concentrations were at the optimum level for P and K for all the treatments, while at sub-optimal concentration for N, Ca and Mg.

The absence of differences in leaf analysis between the treatments could be explained by the fact that the fertigation programme of the orchard used during these experiments was adequate and based on the tree requirement, which prevented the appearance of nutrient deficiency symptoms. The experiment is also in its first year and, as mentioned by Inglese *et al.* (2002), the effects of fertilizer treatments are not observed until three years after application.

Conclusions

In this field experiment the use of potassium foliar fertilization in comparison with fertigation increased fruit weight of Black Star plum and Royal Glory peach at harvest. Some aspects of fruit quality were also improved by the 100 per cent

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Table 4. The effect of fertilization treatments on nutrient concentration of Black Star plum cultivar and Royal Glory peach cultivar leaves. Different letters indicate statistical differences among means by Duncan's Multiple Range Test ($p \leq 0.05$).

Species	Treatment	N	P	K	Mg	Ca
		------	------	*% in DM*	------	------
Black Star plum	Fertigation	2.29 a	0.10 a	3.15 a	0.34 a	0.90 a
	F 50	2.13 a	0.10 a	3.32 a	0.29 a	0.82 a
	F 100	2.54 a	0.10 a	3.21 a	0.39 a	0.83 a
Royal Glory peach	Fertigation	2.61 a	0.13 a	2.65 a	0.24 a	0.97 a
	F 50	2.47 a	0.12 a	2.97 a	0.20 a	1.02 a
	F 100	2.37 a	0.14 a	3.16 a	0.34 a	0.84 a

requirement foliar spray treatment for the plum experiment during the first and second harvest date. These results were obtained under conditions of high K leaf concentration in all the treatments.

These findings indicate the importance of K foliar spray in increasing fruit weight since the fruit price is based on it. The foliar spray is a significant method of fertilization especially during stage III of fruit growth. Some authors suggest the importance of K during this period as there is an intense mobilization of potassium from leaf to fruit, and K uptake by tree roots may be inadequate to meet the demand of this nutrient by the tree as indicated by Weinbaum *et al.* (1994).

Acknowledgements

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