Environmentally Friendly and Safe Technologies for Quality of Fruits and Vegetables

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Authors are responsible for content and accuracy of their papers.

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SECTION 2. PRE-HARVEST FACTORS AFFECTING POSTHARVEST QUALITY AND SAFETY

12. FOLIAR FERTILIZATION WITH POTASSIUM, MAGNESIUM AND CALCIUM AND POSTHARVEST FRUIT QUALITY IN PLUMS (*PRUNUS DOMESTICA* L)

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Abstract

Foliar applications of fertilizers are an important part of standard fertilization programmes in apples to optimize the content of nutrients important to growth and fruit quality. In an experiment in plums (*Prunus domestia* L.) a foliar fertilization programme was compared to traditional application of fertilizers on the soil. In another experiment extra magnesium, potassium and the combination of both magnesium and potassium were compared to control trees given a standard foliar fertilization programme. Yield and fruit size was registered. Analyses included fruit quality factors, content of major nutrients in fruits and leaves as well as storability. The effects of the different programmes on yield, fruit size and most fruit quality factors were not significant. Fruits from trees given foliar fertilizers had, however, higher content of nitrogen and significantly lower contents of the other major nutrients. The application of extra potassium and magnesium did not increase the level of these elements, but a significant reduction in the Ca-content was observed. Accordingly a higher K:Ca-ratio was observed in potassium and magnesium sprayed fruits. Even though no differences in fruit firmness were observed between the treatments at harvest, after two weeks of storage the plums from potassium sprayed trees were significantly softer than the controls.
Keywords: fruit analyses, fruit quality, K:Ca ratio, leaf analysis, nitrogen, shelf life

Introduction

It is well known that a good nutritional status is important to grow high quality fruit for the fresh fruit market. In apple growing foliar fertilizers are commonly used to improve the level of important nutrients like nitrogen, calcium, potassium and magnesium (Bertchinger *et al.* 1997). This practice is less common in plum growing.

Calcium is important in cell structures and firmer fruits are obtained by extra calcium treatments (Burns & Pressey 1987). In plums the positive effects on fruit quality and storability by applying calcium as a foliar fertilizer in the growing season, has been shown by Vangdal & Børve (2001) and Plich & Wojcik (2002). Alcatraz-Lopez *et al.* (2003) found that calcium and magnesium applications improved fruit firmness. Magnesium alone had no effect, while a tendency of firmer fruit was observed when the plums were treated by calcium only. The uptake of calcium is influenced by the availability of magnesium and potassium. Hence the ratios between the contents of these nutrients indicate the storability of fruit. (Holland 1980; Huguet 1980; Tomala 1997; Zavalloni *et al.* 2001). High (K+Mg):Ca or K:Ca-ratios are not desirable. However, magnesium is important in photosynthesis and general growth and potassium is important to fruit quality (colour and acidity) (Ystaas & Frøynes 1995). Foliar sprays with calcium are recommended in Norwegian commercial plum growing. In years with heavy crop postharvest sprays with nitrogen (urea-solutions) is recommended. Otherwise few foliar fertilizers are used. In this work the effects of foliar applications of magnesium and potassium on fruit quality in plums were studied.

Materials & Methods

Orchard management

Two separate field experiments were performed in the experimental orchard at Bioforsk Vest Ullensvang in Lofthus, situated in the fjord districts in Western Norway in 2007 and 2008. Eight year old trees of the cultivars 'Avalon', 'Excalibur', 'Reeves' and 'Victoria' were pruned with a vertical axis. Planting distance was

2×4.5 m. A 1 m wide stripe along the tree rows was kept free of weeds by herbicides. Plant protection was made according to standard programme in the area. Fruit thinning was done by hand whenever necessary in June (6 weeks after petal fall) to approx. 20 fruitlets per meter branch length.

Experimental Design

Plum trees of the cultivars 'Avalon', 'Excalbur' and 'Victoria' were fertilized according to a programme including foliar application of N, P, Ca, K, Mg, Cu, B, Mn, S and Zn as shown in Table 1. In addition the trees were given 250 kg/ha 6-5-20 N-P-K mineral fertilizer on the soil in the spring. Control trees were given only mineral fertilizer on the soil. The amount of 6-5-20 N-P-K fertilizer was, however, increased by 60 kg/ha to 310 kg/ha. The total amount of N applied should be approximately the same with and without foliar fertilization programme. The experiment was designed as a randomised block design with 3 replicates and two trees in each plot.

Table 1. The foliar fertilization programme used in the experiments (kg pr ha).

Stadium	Week	N	P	Ca	Other nutrients
D / 54	16	3 kg urea			1 kg Cu
E2 / 57-58	18	3 kg urea	1 kg MAP[1]		2 kg S + 1 kg Solubor
End of flowering	21	1 kg urea	1 kg MAP		2 kg S + 5 kg $MgSO_4$
After flowering	24	1 kg urea	1 kg MAP	2.5 kg $CaCl_2$	0.5 L Mantrac + 0.2 L Zintrac
	27			2.5 kg $CaCl_2$	
	30			2.5 kg $CaCl_2$	
	31		3 kg MKP[2]		
	33			2.5 kg $CaCl_2$	
Post-harvest	38	5 kg urea	1 kg MAP		5 kg $MgSO_4$ + 0.5 L Mantrac

[1] Monoammoniumphosphate; [2] Monopotassiumphosphate

In another experiment trees of the cultivars 'Avalon', Excalibur' and 'Reeves' were sprayed with extra magnesium and potassium (Table 2) and compared to controls given the foliar fertilization programme shown in Table 1. The experiment was designed as above.

Table 2. Treatments in the experiment with extra foliar application of magnesium and potassium (in addition to the programme shown in Table 1).

Treatment	Week	Magnesium	Potassium
1. Control			
2. 2×Mg	24 and 27	5 kg $MgSO_4$	
3. 2×K	29 and 32		3 kg MKP
4. 2×both Mg and K	24 and 27 (Mg) 29 and 32 (K)	5 kg $MgSO_4$	3 kg MKP

Harvest and Analyses

In late August leaf samples from each plot were collected and analysed by standard methods for N, P, K, Ca and Mg content.

The plums were harvested in week 35-37. Every five days mature plums were picked and brought to the laboratory for analyses. The total weight of the plums and average fruit weight was registered. 3 parallell samples of 10 fruits each were analysed. Trained judges estimated ground colour according to a scale from 1 (=green) to 9 (=yellow) and blush colour as per cent of the fruit surface covered. Fruit firmness was measured by a Durofel Instrument (Copa Technolgie S.S. / CTIFL, France) with a 0.25 cm^2 plunger (Planton 1992). Soluble solids content was measured by refractometer and titratable acidity by titration of diluted juice samples with NaOH-solution to pH=8.1. Fruit

samples from each plot were analysed for content of N, P, K, Ca and Mg by standard methods. Fruit samples of 10 fruits each were stored at 2 and 20 °C for 3 weeks. Every week three samples of each cultivar, treatment and storage temperature were analyzed as described above.

Statistical Analyses

For the statistical analyses of fruit quality average value of three samples of three pickings were used. The data were analysed by ANOVA and paired t-tests using Minitab® and Excel® statistical programmes.

Results & Discussion

Soil analyses showed that the status of the major nutrients in the orchard was within the range recommended in Norwegian plum growing. The leaf analyses showed no statistically significant differences between the treatments (data not shown). However, the tendencies were similar to that observed in the fruit analyses (see below).

Effects of a Foliar Fertilization Program

The effects of the foliar fertilization program on yield, fruit size and fruit quality were not significant. However, the foliar sprayed trees tended to have larger crops and smaller fruits. The fruit analyses showed an increase in N-content and a decrease in the contents in all other measured elements. The decrease was significant for phosphorus, magnesium and calcium. As foliar nitrogen application did not increase fruit weight, the decrease in other nutrients was not a dilution effect. The foliar fertilization programme included application of P, Ca, Mg and K. Still the content of these elements decreased. As the decrease in Ca-content was stronger than the decrease in K-content, the fruits from trees given a foliar fertilization programme tended to have higher K:Ca-ratio.

Table 3. Yield, fruit size and colour of plums treated with a foliar fertilization programme compared to soil fertilization only. Average of three cultivars and two years.

Treatment	Yield (tons/ha)	Fruit weight (g)	Blush colour[1]	Ground colour[2]
Control	11.6	49.7	54	6.9
Foliar fertilizing programme	13.5	47.5	54	6.4
P-value	n.s.[3]	n.s.	n.s.	n.s.

[1] per cent fruit surface covered; [2] Scale from 1 = green to 9 = yellow; [3] n.s. = not significantly different (P>0.05)

Table 4. Firmness and content of soluble solids and titratable acidity in plums treated with a foliar fertilization programme compared to soil fertilization only. Average of three cultivars and two years.

Treatment	Firmness (DUROFEL units)	Soluble solids content (%)	Titratable acidity (%)	SSC: acidity ratio
Control	62	15.2	1.62	9.38
Foliar fertilizing programme	63	15.3	1.62	9.44
P-value	n.s.1	n.s.	n.s.	n.s.

[1] n.s. = not significantly different (P>0.05)

Table 5. Content of major nutrients as percent of dry weight in fruits of plum trees treated with a foliar fertilization programme compared to soil fertilization only. Average of three cultivars and two years.

Treatment	N	P	K	Mg	Ca	K:Ca
Control	0.78	0.17	1.38	0.067	0.123	11.2
Foliar fertilizing programme	0.85	0.13	1.18	0.052	0.088	13.4
P-value	n.s.[1]	0.03	n.s.	0.04	0.03	n.s.

[1] n.s. = not significantly different (P>0.05)

Effects of Extra Magnesium and Potassium Application

The extra applications of magnesium, potassium or both did not have significant effects on yield and fruit size. The extra Mg and K treatments tended to give fruit with less blush colour. The plums from trees given both extra Mg and K had significantly less blush colour than plums from control trees.

The fruit analyses did not show increases in Mg and K-contents in plums from trees given extra Mg and K. The plums from trees sprayed with potassium had, however, significantly less magnesium than plums from control trees and trees given only magnesium. And the lowest K-content was observed in plums from trees given extra magnesium. The strongest effect of extra Mg and K-application was found in the Ca-content. The decrease in Ca-content was significant in plums trees given additional magnesium and potassium compared to plums from control trees. As a result of the decrease in Ca-content the K:Ca-ratio tended to be higher in plums from Mg and K-treated trees. Plums from trees given extra potassium had significantly higher K:Ca-ratio compared to controls.

During ripening the plums soften, and the limiting factor of storability or shelf life is the firmness (Vangdal *et al.* 2007). Even though no significant change in firmness due to treatments was observed at harvest, after two weeks of storage the potassium treated plums were significantly softer than control plums.

Table 6. Yield, fruit size and colour of plums when treated with extra magnesium and potassium as foliar fertilization. Average of three cultivars and two years.

Treatment	Yield (tons/ha)	Fruit weight (g)	Blush colour$_1$	Ground colour$_2$
1. Control	13.7	58.5	55 b[3]	6.5
2. 2 × Mg	16.9	59.0	55 b	6.7
3. 2 × K	15.7	59.2	53 ab	6.2
4. 2 × both Mg and K	12.3	57.1	51 a	6.1
P-value	n.s.[3]	n.s.	0.05	n.s.

[1] per cent fruit surface covered; [2] Scale from 1 = green to 9 = yellow; [3] n.s. = not significantly different (P>0.05). Numbers followed by the same letter within a column are not significantly different (P>0.05).

Table 7. Firmness and content of soluble solids and titratable acidity in plums treated with extra magnesium and potassium as foliar fertilization. Average of three cultivars and two years.

Treatment	Firmness (DUROFEL-units)	Soluble solids content (%)	Titratable acidity (%)	SSC: acidity ratio
1. Control	67	15.9	1.47	10.82
2. 2 × Mg	67	15.5	1.43	10.84
3. 2 × K	67	15.4	1.41	10.92
4. 2 × both Mg and K	66	15.9	1.48	10.74
P-value	n.s.[1]	n.s.	n.s.	n.s.

[1] n.s. = not significantly different (P>0.05)

Table 8. Content of major nutrients as percent of dry weight in fruit of plum trees treated with extra magnesium and potassium as foliar fertilization. Average of three cultivars and two years.

Treatment	N	P	K	Mg	Ca	K:Ca ratio
1. Control	0.72	0.16	1.38	0.069 b[1]	0.122 b	11.31 a
2. 2 × Mg	0.73	0.15	1.16	0.070 b	0.079 a	14.68 ab
3. 2 × K	0.73	0.15	1.34	0.048 a	0.076 a	17.63 b
4. 2 × both Mg and K	0.72	0.16	1.32	0.057 ab	0.093 ab	14.19 ab
P-value	n.s.[2]	n.s.	n.s.	0.02	0.02	0.04

[1] Numbers followed by the same letter within a column are not significantly different (P>0.05); [2] ns = not significantly different (P>0.05)

Table 9. Firmness (DUROFEL-units) in plums treated with extra Mg and K as foliar fertilizers and stored for two weeks. Average of two temperatures (2 and 20 °C), three cultivars and two years.

Treatment	Weeks in storage		
	0	1	2
1. Control	67	68	55 b
2. 2 × Mg	67	67	53 b
3. 2 × K	67	64	51 a
4. 2 × both Mg and K	66	68	52 ab
P-value	n.s.[1]	n.s.	0.05

Conclusions

A foliar fertilization programme in plums had no significant effects on yield, fruit size and quality compared to control trees were all fertilizers were applied on the soil; Plums from trees given foliar fertilizers tended to have higher content of nitrogen and lower contents of the other major nutrients. The decrease was significant in P, Mg and Ca; Extra magnesium and potassium had no significant effects on yield, fruit size and fruit quality factors, except blush colour. Extra potassium application reduced the amount of blush colour; The extra application of magnesium did not increase the magnesium level in the fruits. However, a significant reduction in calcium was observed in plums from Mg treated trees; Additional application of foliar potassium did not increase the K-levels. The extra K-sprayed trees had fruits with significantly less Mg, Ca and higher K:Ca-ratio. The K-treated plums softened faster than control fruits and accordingly had a shorter shelf life than unsprayed plums.

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