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The effect of potassium applied by drip irrigation on growth, fruit quality and storage of apples on a soil with marginal Mg content

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Summary

The effects of 0, 180 and 360 kg/ha K_2O as KCl applied to apples from plantation, followed by 0, 270 and 540 kg/ha to trees in bearing were tested on a heavy (38% clay) soil in the Hula Valley. Yield of Jonathan and Granny Smith was increased by the highest dressing, although non significantly in Granny Smith. There was no yield response in Golden Delicious. There were no effects on trunk growth. In the absence of K, leaf K content declined to 0.9% in bearing trees and potassium fertigation improved this to 1.2 - 1.3%, inducing marginal Mg deficiency which was corrected by two sprays of 1% magnesium nitrate. Applying K widened the K/Ca ratio of fruit peel and flesh but without adverse effect on incidence of bitter pit or other storage disorder. It was concluded that the requirement of apples on this soil is for 540 kg/ha K_2O applied by drip irrigation.

Introduction

When applied by sprinkler to correct K deficiency in apple on high pH soils high in clay very high dressings were needed. Applying similar high rates by drip irrigation resulted in excess K and Mg deficiency. The present experiment was set up in 1973 on a newly planted orchard to evaluate the optimal dose for drip irrigation.

The trial was sited in Upper Galilee on soil with about 38% clay in the top metre. Three rates of KCl (0, 300 and 600 kg/ha) for the 5 years from planting and 1.5 times these rates thereafter were applied though 8 l/h drippers spaced at 1.25 m in the line. Urea (150 kg/ha N per year) was applied with 3 prophylactic Zn sprays. 1% $MgNO_3$ sprays were used in the last 3 years. In the young orchard, fertigation lasted 6-8 months and after the trees came into bearing (4th year) application ceased for 2-3 months before harvest and resumed immediately afterwards.

Trunk growth and yield were recorded and soil, leaf, and fruit analysis with assessment of maturity (pressure and TSS at harvest) were carried out during 1979-81. Fruit was stored for 3-4 months and then graded for size (1979-81), bitter pit, rot, sun scald incidence and colour (1979-80).

Results

These are presented in Table 1 and Figures 1 to 3.

Trunk growth. Potassium fertigation did not affect trunk growth though there was some evidence of a slight effect after trees came into bearing. Positive effects have been recorded only in severe K deficiency (Barden and Thompson, 1962; Forshey, 1959).

Leaf analysis.

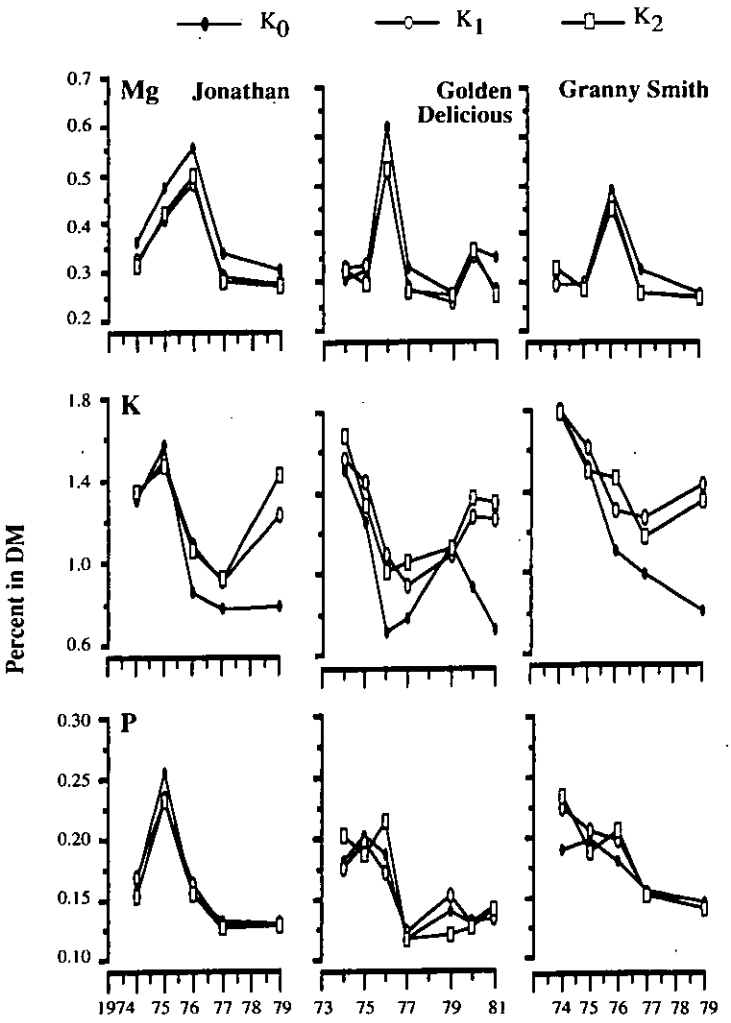

Fig. 1. Mg, K, and P concentration in leaves (% in dry matter)

Nitrogen was always above the critical level (2%) with some minor fluctuations.

Potassium was high for the first 3 years and unaffected by K application. When trees came into bearing leaf K on the K_0 treatment declined from 1.5-1.8% to 0.7-0.9% due to K consumption by fruit (Forshey, 1969, Klein *et al.*, 1989). Low soil K and penetration of roots to depth where soil K was lower may have contributed to the steep decline before the orchard reached full production. Applying K increased leaf K but there was no difference between K_1 and K_2.

Phosphorus declined abruptly as trees reached maturity, coinciding with increased fruit production in Jonathan and Golden Delicious; it remained above the critical level (0.1%).

Magnesium in young orchard (except in Jonathan and Granny Smith in 1979 and in the K_0 treatment) was above the critical level (0.3 %). K application reduced leaf Mg slightly from 1977 especially in Jonathan.

Yield. (Table 1) Potassium increased total fruit yield over 7 years in Jonathan and showed signs of doing so in Granny Smith; it did not affect yield in Golden Delicious a heavier yielding cultivar (cf. Barden and Thompson, 1962), In the case of Jonathan, where K_2 increased yield in 5 of the 7 years, the K_1 treatment had no effect.

Table 1. Effect of K fertigation on cumulative yield (t/ha) over 6* or 7** years.

	Jonathan**	Golden Delicious**	Granny Smith *
K_0	167 b	263 a	176 a
K_1	179 b	278 a	169 a
K_2	220 a	277 a	207 a

Fruit size (Figure 2) was affected by K in Jonathan (higher yield on account of larger fruit) and Golden Delicious (fewer fruit and no yield increase) in 1980-1981. These effects were evident only in the last two years when K deficiency had become more marked and Mg deficiency was corrected by spraying. Magnesium deficiency causes fruit drop. (Forshey, 1959, 1963)

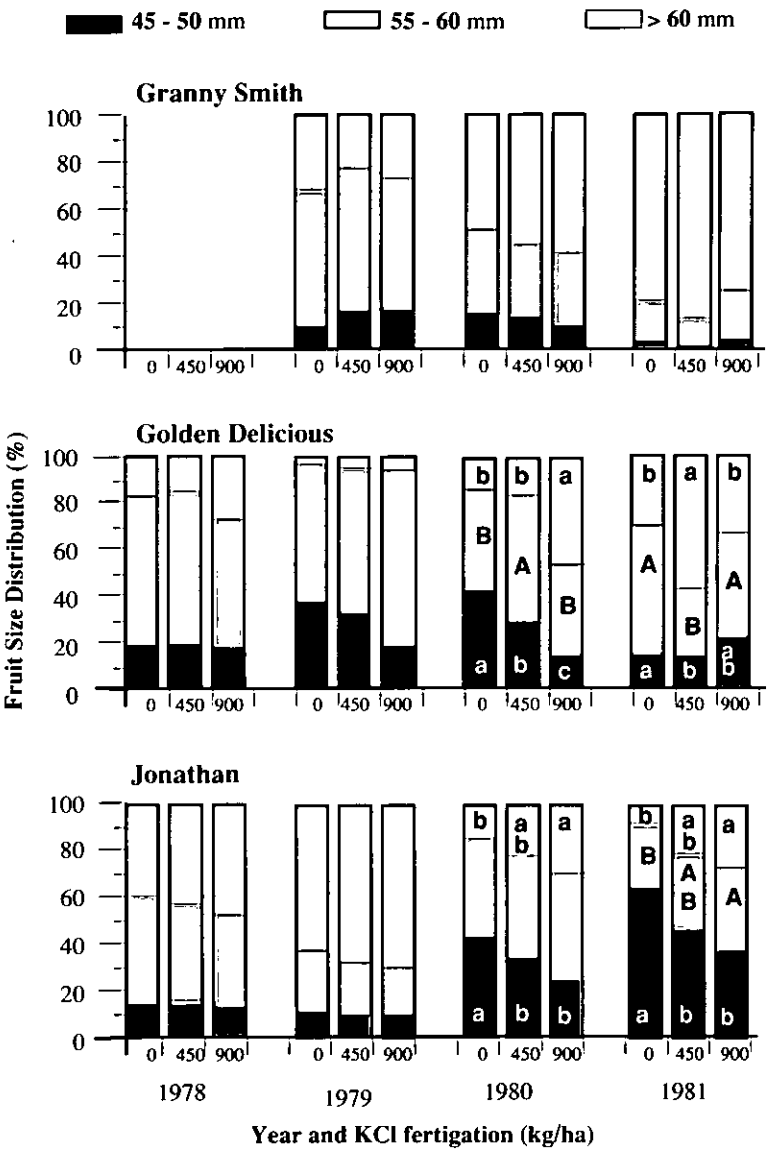

Fig. 2. Fruit size distribution. Different letters indicate statistical significance (p=0.05) differences within size categories. Mean separation by Duncan multiple range test.

Fruit quality and storage. Treatment did not affect maturity but potassium improved colour in Jonathan (1 year) and reduced sun scald in one year in Granny Smith. Fruit stored for 3-4 months were free from bitter pit and there was a low incidence of rot (0-5%).

Mineral composition of fruit (1979-80) (Figure 3). The K_2 treatment raised K and Mg contents of peel and pulp. Except for one case (Granny Smith peel) in 1979, fruit Ca was not affected. The K/Ca of fruit increased (less in Golden Delicious, Fig. 3), but this caused no physiological disorder as has been reported elsewhere (Boon *et al.*, 1966; Cooper and Bangerth, 1976; Cumming and Wilcox, 1968; Faust and Shear, 1968).

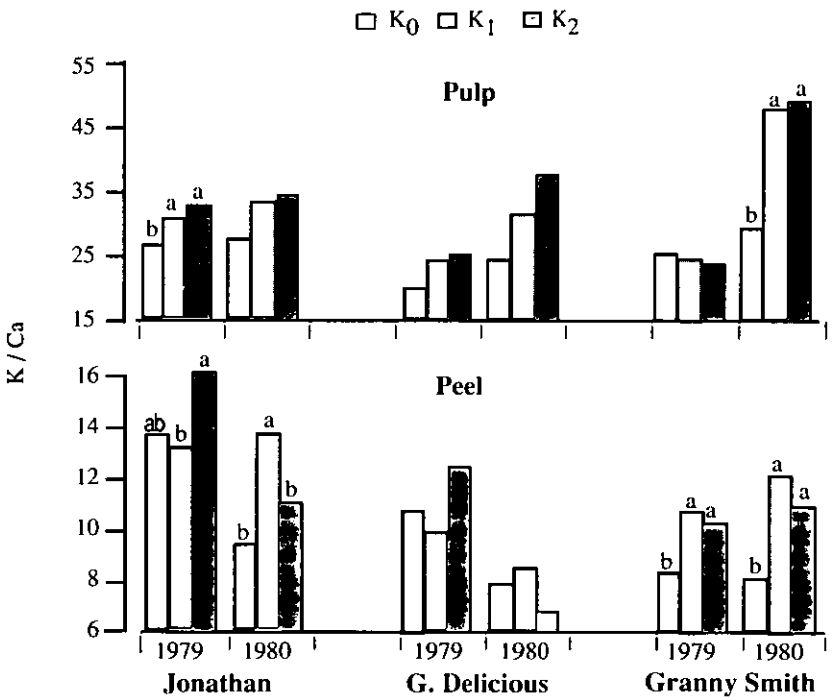

Fig. 3. Effect of potassium on K/Ca ratio in fruit pulp and peel. Meaning of letters see Fig. 2.

Soil analysis at the end of the experiment in 1981 showed that K fertigation increased soil solution K (2-5 ppm under K_0) to around 7 ppm (K_2) up to a distance of 60 cm from either side of the drippers and to 60 cm depth (a soil volume of about 0.9 m^3 per tree), similarly to a previous report (Uriu *et al.*, 1980).

Conclusion

The results indicate that 540 kg/ha K_2O applied by drip irrigation was required for apples on this heavy high pH soil in the Hula valley and that this rate did not affect fruit quality or storage properties.

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