# NUTRIENT INFLUENCE ON STORAGE QUALITY OF KIWIFRUIT

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## ABSTRACT

Fruit firmness is regarded as an important quality parameter which affects storage life of kiwifruit. Research carried out at the LHRC over the last three years has shown that nitrogen nutrition influences the rate of fruit softening after harvest. Field trials carried out on three properties in 1986-86 on vines having various levels of nitrogen nutrition showed a very strong relationship between both petiole nitrate and fruit N (but not leaf N) and the time to reach 2 kgf and 1.4 kgf flesh firmness. Surveys of 9 orchards in Hawke's Bay carried out in 1984-85 showed that there was a significant relationship between petiole nitrate and time to reach 2 kgf fruit firmness (fruit N was not determined). In 1986-87 a similar survey of 20 orchards in Hastings and 12 orchards in Nelson showed that both petiole nitrate and total N in the fruit were strongly correlated to time to reach 2 kgf, 1 kgf and 0.6 kgf fruit firmness. Generally, fruit from vines having high nitrate stored poorly while fruit from low nitrate vines softened at various rates. It appears therefore that nitrogen status is interacting with other factors (e.g. cultural factors) in determining the rate of softening at low nitrate. At this stage both nitrate and fruit N appear to be useful predictors of fruit softening during storage, however the nitrate test can be performed more easily using test strips.

*Additional Key Words: kiwifruit, nitrogen, storage.*

## INTRODUCTION

Rapid softening in storage can cause some lines of kiwifruit to have an unexpectedly short storage life, resulting in fruit wastage and problems in scheduling fruit through storage and transport.

Overseas importers recognise that lines of kiwifruit vary in their rate of softening, and have noticed in some cases that particular orchards produce fruit which consistently soften rapidly during storage. Factors that have been shown to effect fruit softening include boron toxicity (Smith and Clark, 1984) and shading (Hopkirk, 1987), whereas high calcium levels have been shown to reduce the rate of fruit softening (Harman, 1981) but none of these factors satisfactorily explained the above observation. Preliminary trials in 1983-84 season indicated that nitrogen may be a contributory factor. Subsequently more detailed investigations have been carried out looking at the effect of nitrogen nutrition on storage quality of kiwifruit.

## MATERIALS AND METHODS

**Nutrient Survey 1984-85**

Eight orchards (33 vines providing a range of leaf nitrate values) were selected in Hawke's Bay. Leaf samples were taken on April 16, 1985. Mature fruit (min. 6.2° Brix, 80-100 g) were harvested and stored at 0-1 °C with high ( 95%) humidity. At regular intervals up to 15 weeks, 10 fruit from each vine were selected at random. Fruit firmness was determined on pared opposite sides of fruit using a penetrometer with an 8 mm plunger. Soluble solids content was determined with a refractometer. Time in weeks for the fruit from each vine to reach a mean firmness level of 2 kgf was calculated by interpolation.

**Nutrient Survey 1986-87**

Twenty orchards were selected in Hawke's Bay. Two sites (5 vines per site) were sampled from each orchard providing a total of 40 experimental plots with a range of leaf nitrate values. In the Nelson district, 12 orchards were selected, with each site consisting of 2 complete rows. Leaf samples were taken regularly for analysis. Fruit (count 33, 105-116 g) were harvested, stored for up to 30 weeks, and rate of softening was measured as described above. Dry matter was determined on 5 fruit from each plot.

Sensory evaluation was carried out by 18 judges, using a triangular difference test, with fruit from high and low nitrate orchards at 9 and 12 weeks after harvest. Fruit were ripened to the same firmness (approx. 0.6 kgf) at the time of sampling by holding at 20 °C. Judges were asked to indicate their comments on the flavour of the samples.

**Field Trials 1985-86**

Three orchards were selected in Hawke's Bay for this trial. Twenty eight vines were chosen on each orchard, 14 pairs of approximately equal size. One in each pair received no N, the other received 160 g urea in mid November. Five of the N-supplemented vines received a further 160 g urea in February and 80 g in March in order to achieve a wide range of N levels. Leaf samples were taken regularly for analysis. Fruit from 9 vines from each orchard were selected having a range of nitrate values. Fruit (count 33) were taken from a similar position from each vine, stored and measured for firmness at intervals up to 20 weeks from harvest, as described above.

For all trials, major nutrients (total N, P, K, Ca, Mg) were determined in the leaf after digestion with $H_2SO_4$ and Se. Nitrate was also determined in the petiole after extraction with 2% acetic acid. Fruit analysis was carried out on fresh samples from the Field Trial and one Nutrient Survey (1986-87). Total N, P, K, Ca and Mg were determined after digestion with $H_2SO_4$ and Se.

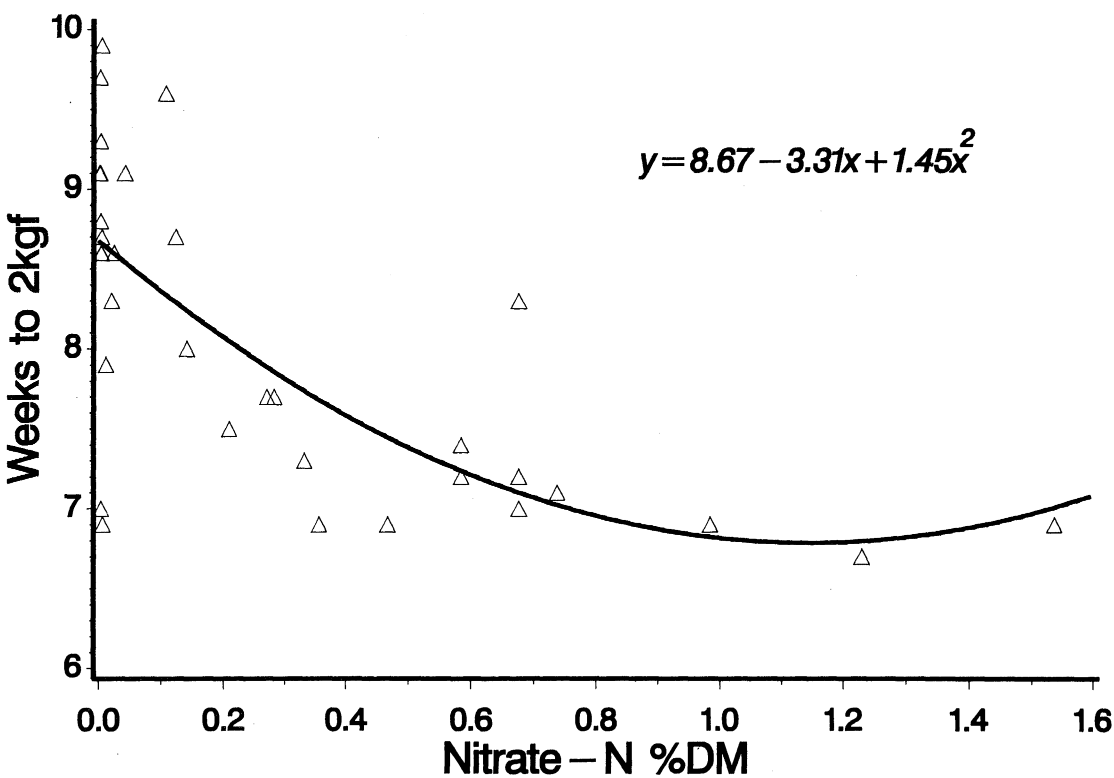


**Figure 1: Relationship between Petiole Nitrate and Time to Reach 2 kgf Firmness in Storage, 1984-85.**

## RESULTS AND DISCUSSION

### Nutrient Surveys

There was a fairly strong relationship between petiole nitrate and the time to reach 2 kgf fruit firmness in the 1984-85 Survey (Fig. 1). Fruit from vines with high levels of nitrate softened quickly, while those with low nitrate softened at varying rates. Fruit having a penetrometer reading of 2 kgf or less is considered unsuitable for grading.

Similar relationships were found when a larger number of orchards were surveyed in two regions in 1986-87. As the storage time was longer, (30 weeks vs 15 weeks in 1984-85), petiole nitrate and fruit N could be compared to the time to reach 2, 1 and 0.6 kgf (Table 1 and Fig. 2). Kiwifruit quality standards state that fruit of less than 1 kgf flesh firmness cannot be exported, while fruit of around 0.6 kgf firmness is considered suitable for eating. Fruit N and petiole nitrate were significantly correlated to these parameters but total leaf N was not (Table 1). An example of the type of relationship which was present can be seen from Fig 2.

### Field Trials

In the 1985-86 Trial the relationships were stronger between both petiole nitrate and fruit N and time to reach 2 kgf and 1 kgf (extrapolated in some cases) fruit firmness (Table 2). An example of the type of relationship is give in

**TABLE 1: Correlation (r) between petiole nitrate, leaf N and fruit N and time to reach 2, 1 and 0.6 kgf flesh firmness, 1986-87 (survey).**

| | Time to reach flesh firmness of | | |
|---|---|---|---|
| | 2 kgf | 1 kgf | 0.6 kgf |
| Petiole $NO_3-N$ | $-0.44^{xxx}$ | $-0.35^{xx}$ | $-0.42^{xx}$ |
| Fruit N | $-0.54^{xxx}$ | $-0.32^{xx}$ | $-0.49^{xxx}$ |
| Leaf N | –.09NS | –.17NS | –0.20NS |

n = 52, $^{x}$, $^{xx}$, $^{xxx}$, significant at 5%, 1% and 0.1% respectively.

**TABLE 2: Correlation (r) betweeen petiole nitrate, fruit N and leaf N and time to reach 2 and 1 kgf fruit firmness 1985-86 (field trial).**

| | Time to reach 2 kgf fruit firmness | Time to reach 1 kgf fruit firmness |
|---|---|---|
| Petiole $NO_3-N$ | $-0.77^{xxx}$ | $-0.56^{xx}$ |
| Fruit N | $-0.84^{xxx}$ | $-0.73^{xxx}$ |
| Leaf N | NS | NS |

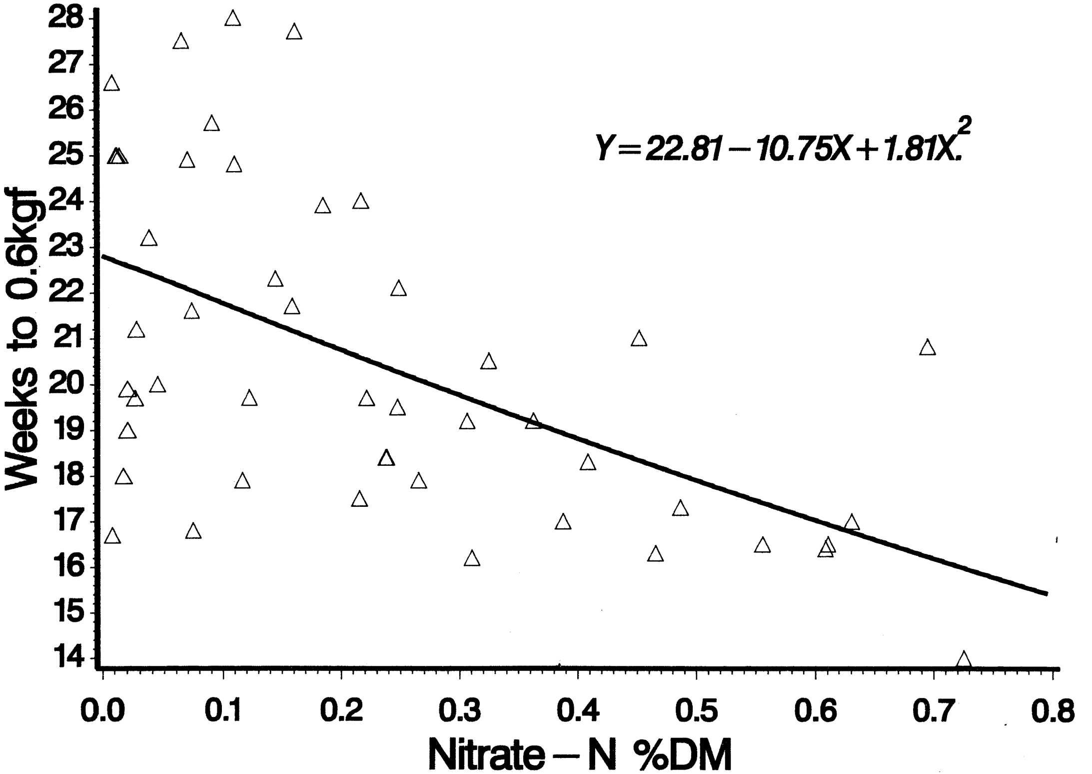


**Figure 2: Relationship between Petiole Nitrate and Time to Reach 0.6 kgf Firmness in Storage, 1986-87.**

Fig. 3. The scatter of points at low nitrate values is less than in the surveys, where the number of different orchards was greater. In multiple orchard studies many other factors besides nitrogen nutrition (e.g. crop loading, irrigation practice, age of vines) may affect fruit softening and may therefore influence the relationship.

Smith and Clark (1984) have shown that fruit from vines suffering from B toxicity soften rapidly during storage. Calcium on the other hand, has been shown to have a beneficial effect on fruit softening (Harman, 1981). In this investigation calcium was positively related to time to reach 1 kgf fruit firmness ($r = 0.33$, $p = 0.05$).

**Nitrogen and Flavour**

Fruit from vines with low nitrate status developed higher soluble solids in both the 1984-85 and 1986-87 Surveys at 15 and 12 weeks ($r = 0.50^{xx}$ and $r = 0.40^{xx}$ respectively). Fruit from low nitrate vines also had a higher dry matter content at harvest ($r = -0.54^{xxx}$) and throughout storage. Recent work in Australia has shown that there is a strong relationship between dry matter content and flavour of the fruit (Scott et al., 1986).

Neither the soluble solids nor dry matter content at harvest were related to the rate of softening during storage.

Sensory analyses performed after ripening at both 9 and 12 weeks of storage indicated that judges could detect a significant difference ($p = 0.01$, 9 weeks; $p = 0.001$, 12 weeks) between fruit from high and low nitrate blocks. Judges comments suggested that fruit from high nitrate status vines developed less flavour (descriptions used included "bland" and "tasteless") than fruit from low nitrate vines ("tangy", "nice"). These results are consistent with the above finding on nitrate effect on soluble solids and dry matter.

These results indicate that nitrogen nutrition is an important factor on the rate of fruit softening during storage. Other N trials not reported here (2 in Hawke's Bay) and surveys (2 in Nelson) have shown a significant relationship between petiole nitrate and rate of fruit softening. These results suggest that exporters should sell fruit from high N blocks (as evidenced by high petiole nitrate of fruit N, but not total leaf N) earlier than from low N blocks to reduce losses due to premature softening. This would require that all blocks be tested for nitrogen at harvest. Either fruit N could be analysed in a lab from a packhouse sample, or petiole nitrate could be determined. The lab method could be used, but a rapid field method using test strips which has been shown to give acceptable results (Prasad and Spiers, 1984) may be more convenient. The test could be done at the same time as maturity testing. It is not yet clear which of these methods is best. However

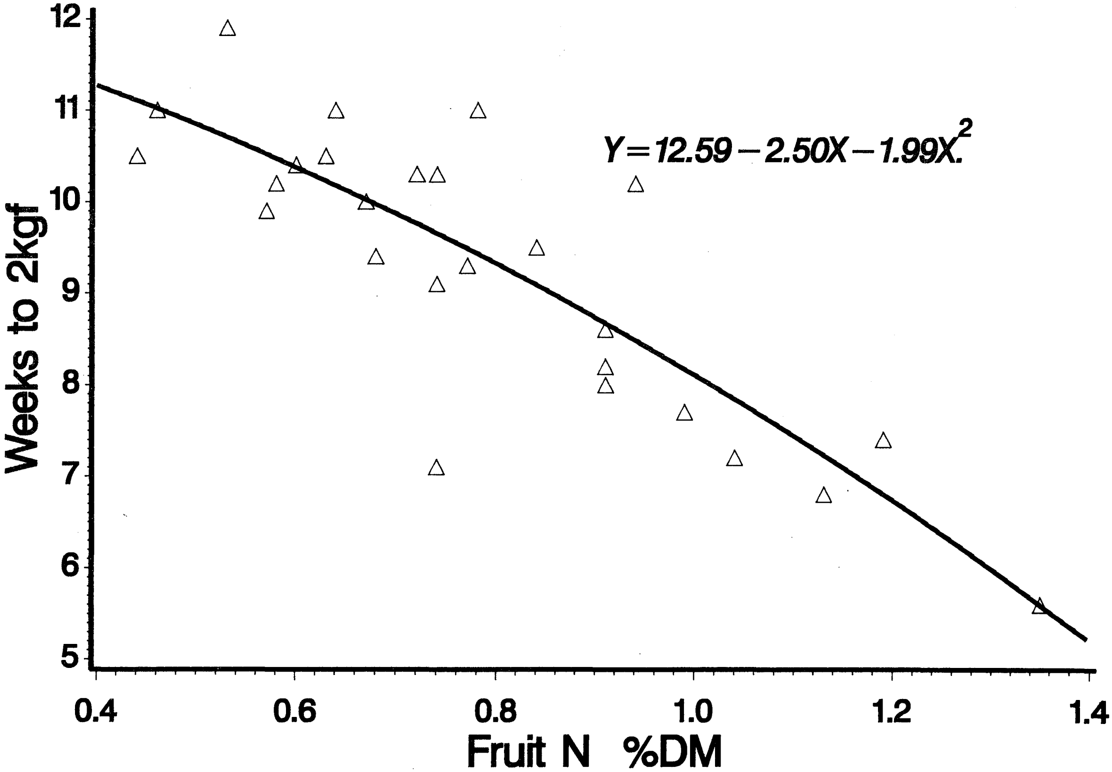


**Figure 3: Relationship between Fruit Nitrogen and Time to Reach 2 kgf Firmness in Storage, 1985-86.**

in order to improve the predictive value of the test, other factors that affect softening need to be identified and integrated into this system of prediction.

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