7 Milling Economics

This chapter does not contain a rigorous benefit-cost analysis of the substitution of milled minerals for chemical fertilisers. It is provided to place the results the research in a general practical and economic context. A large attritor mill with an effective milling volume of 7L was used to evaluate approximate costs for milling (see Section 3.2.4 for milling details). Microcline was chosen as the test mineral due to:

- Microcline being readily available in commercial quantities;
- Microcline being the most resistant to milling and thus indicative of the upper limit of milling costs;
- The K uptake by plants from microcline being highly responsive to milling with K in unmilled microcline being virtually unavailable for plant growth.

Over a 6 hour period, approximately 0.17kW per hour was required to mill 1 kg of microcline. With current (March 2002) industrial power charges in Western Australia being 17.5 cents per kW hour, it then costs \$A178.50 to mill 1 tonne for 6 hours or \$A29.75 h^{-1}. Microcline is available from several sources in Western Australia and depending on the distance to be transported, the cost of the raw material delivered to a mill in Perth, WA is about \$A60. The cost for an attrition mill with the capacity to process tonnes of minerals is approximately \$A400,000 and an upper range estimate of wear and tear costs is \$A10 t^{-1} h^{-1}. Shipping and spreading costs are estimated at \$30 t^{-1}. Thus the cost of applying 1 tonne of microcline milled for 1 hour is approximately \$130 and the cost of longer periods of milling increases linearly with time (*Figure 7.1*).

The relative effectiveness (RE) of milled microcline to supply K to ryegrass compared with $K_2SO_4.7H_2O$ (*Table 6.4*) does not increase linearly with milling time (*Figure 7.2*), with the greatest increase in RE occurring in the first 1 hour of milling and appears to reach an asymptote of approximately 8% RE. Short milling times are desirable but low RE values mean that high application rates are required to replace water soluble fertilisers such as K_2SO_4. Assuming 50kg ha^{-1} of K is required for adequate plant growth when K is supplied as K_2SO_4 (approximately \$A100 ha^{-1} including shipping and spreading), the corresponding amounts of milled microcline containing 9% K can be calculated from the RE for ryegrass (*Figure 7.3*) and indicates that milling beyond 1 hour increases the cost of application (blue curve in *Figure 7.4*). To estimate whether milling times shorter than 1 hour may produce lower total costs, the data in *Figure 7.2* were fitted to an exponential curve to give:

$$y = 7.2 - 6.6e^{-1.4x} \qquad R^2 = 0.96$$

where y is RE% and x is milling time. RE% for milling times less than 1 hour were interpolated and then used to calculate milling costs for shorter times (hollow blue diamonds in *Figure 7.4*). These data confirm that 1 hour of milling appears to be optimum in that the cost of substituting milled microcline for $K_2SO_4.7H_2O$ is at a minimum.

Thus the combined cost of purchase, milling, transport and spreading of microcline fertiliser on soil is optimal for one hour of milling although cost of K application is approximately 15 times greater than K supplied as K_2SO_4. The RE of ground minerals might reasonably be expected to increase in soils favourable for dissolution such as highly acid soils, and any increases in RE will reduce the application rates and thus the costs of milling, transportation and spreading. Increases of RE by factors of 2 and 3 (red and green curves in *Figure 7.4*) brings the cost of soluble K supplied by milled microcline closer to the cost of applying K_2SO_4. In the final analysis it is probable that in the first year the cost of applying milled microcline K will be much greater than for K_2SO_4.

The economics of using milled microcline can be improved by both increasing the relative effectiveness of the milled minerals as shown in *Figure 7.4* or by considering the residual value of the two fertilisers. We can assume that approximately half of the soluble fertiliser applied in the first year is available in the second year, and half as much again in the third year as shown in *Figure 7.5* which is commonly the case in Western Australia. The slower dissolution of silicate minerals produces a residual value function that declines more slowly than that of soluble fertilisers. For example, in the case of microcline milled for 1 hour applied at the equivalent rate of approximately 10 t ha^{-1}, the decrease of nutrient content of ryegrass with time is shown as the blue curve in *Figure 7.5*. Based on values in *Figure 7.4*, the cost of applying milled microcline K is approximately 15 times as expensive as applying K_2SO_4. Thus \$100 spent on milled microcline is equivalent to \$6.67 value of K_2SO_4 in the first year of application. The residual value of K_2SO_4 is greater than the equivalent application of microcline for up to 6 years but the duration of this advantage and this decreases to less than 4 years if the RE is tripled to approximately 20% (REx3 in *Figures 7.5a* and *b*). For a 6 year period, the extra value of applying \$100 worth of K_2SO_4 compared with \$100 worth of milled microcline is shown in *Figure 7.5c*. Thus despite the slower decline in the residual value of milled microcline relative to K_2SO_4 the much greater relative effectiveness of \$100 spent on K_2SO_4 produces a \$172 greater fertiliser benefit than \$100 spent on ground rock. A full economic analysis would need to assess the plant yield and quality benefits associated with this greater fertiliser benefit. Other factors that require consideration in a full economic analyses include the ability of silicates to provide several nutrients and non-nutritional benefits such as liming, modified surface charge characteristics of soils and consequent enhanced nutrient retention. These benefits may be of considerable value for highly leaching, acid soils. For these soils the relative effectiveness of ground minerals is expected to increase greatly due to greater mineral dissolution and a decrease in the effectiveness of soluble fertiliser due to leaching losses. These views are also shared by other researchers who evaluated ground silicates as fertilisers (Blum et al., 1989b; Coventry et al., 2001; Fragstein et al., 1988).

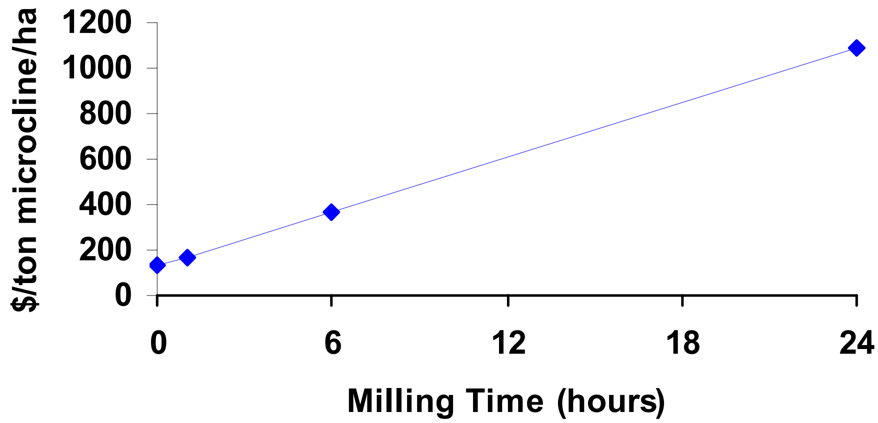

Figure 7.1: Milling costs for microcline for various milling times based on \$60 t^{-1} for microcline, \$30 t^{-1} h^{-1} for milling, \$10 t^{-1} h^{-1} for mill wear costs and \$30 t^{-1} for shipping, spreading costs. Costs are in Australian dollars (\$A).

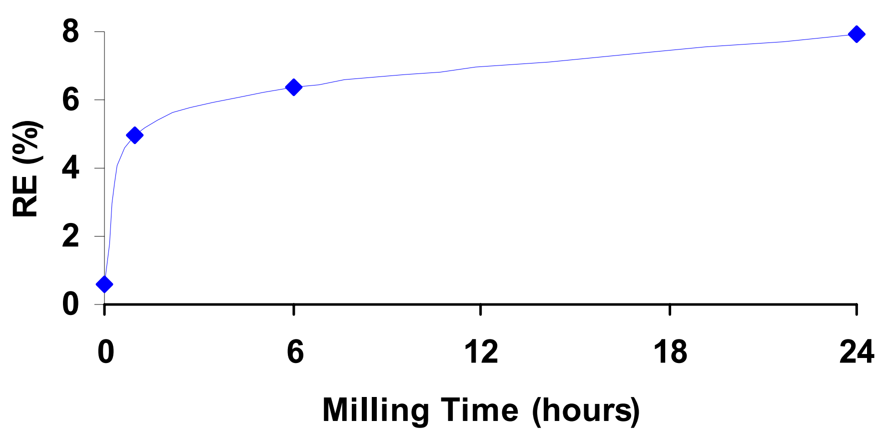

Figure 7.2: The relative effectiveness of milled microcline compared to $K_2SO_4.7H_2O$ for ryegrass K uptake described from Table 6.4.

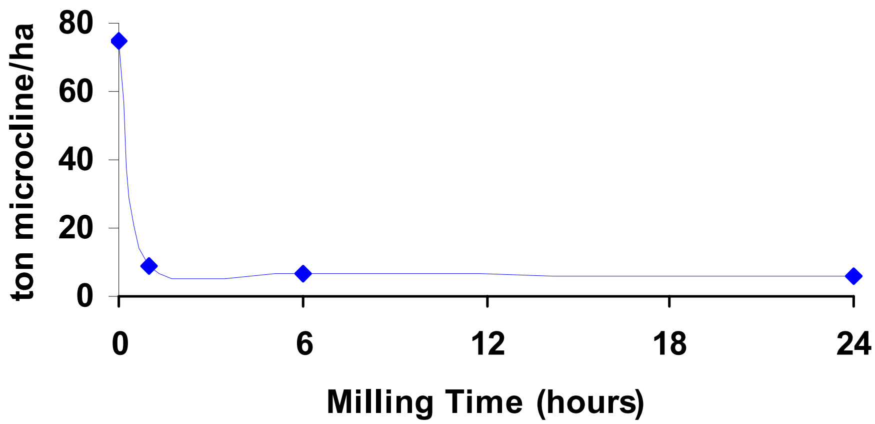

Figure 7.3: Application rates of variously milled microcline that is equivalent to 50 kg K ha^{-1} as $K_2SO_4.7H_2O$, based on the relative effectiveness values in Figure 7.2.

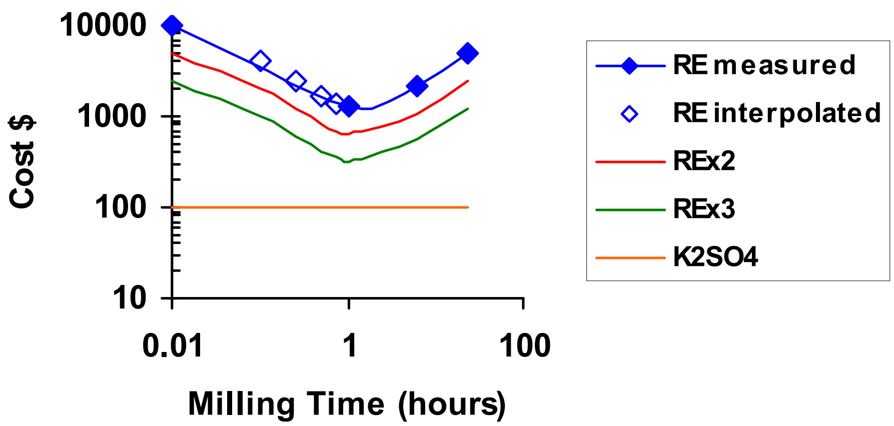

Figure 7.4: The cost of adding 50kg of soluble K to a hectare of soil in the form of $K_2SO_4.7H_2O$ and of applying amounts milled microcline that are as effective as the $K_2SO_4.7H_2O$. RE values used to derive these factors correspond to values based on the relative effectiveness of milled microcline to supply to ryegrass as determined in this research. REx2 and REx3 correspond to values when RE values are increased 2- and 3-fold. All costs are in Australian dollars ($A).

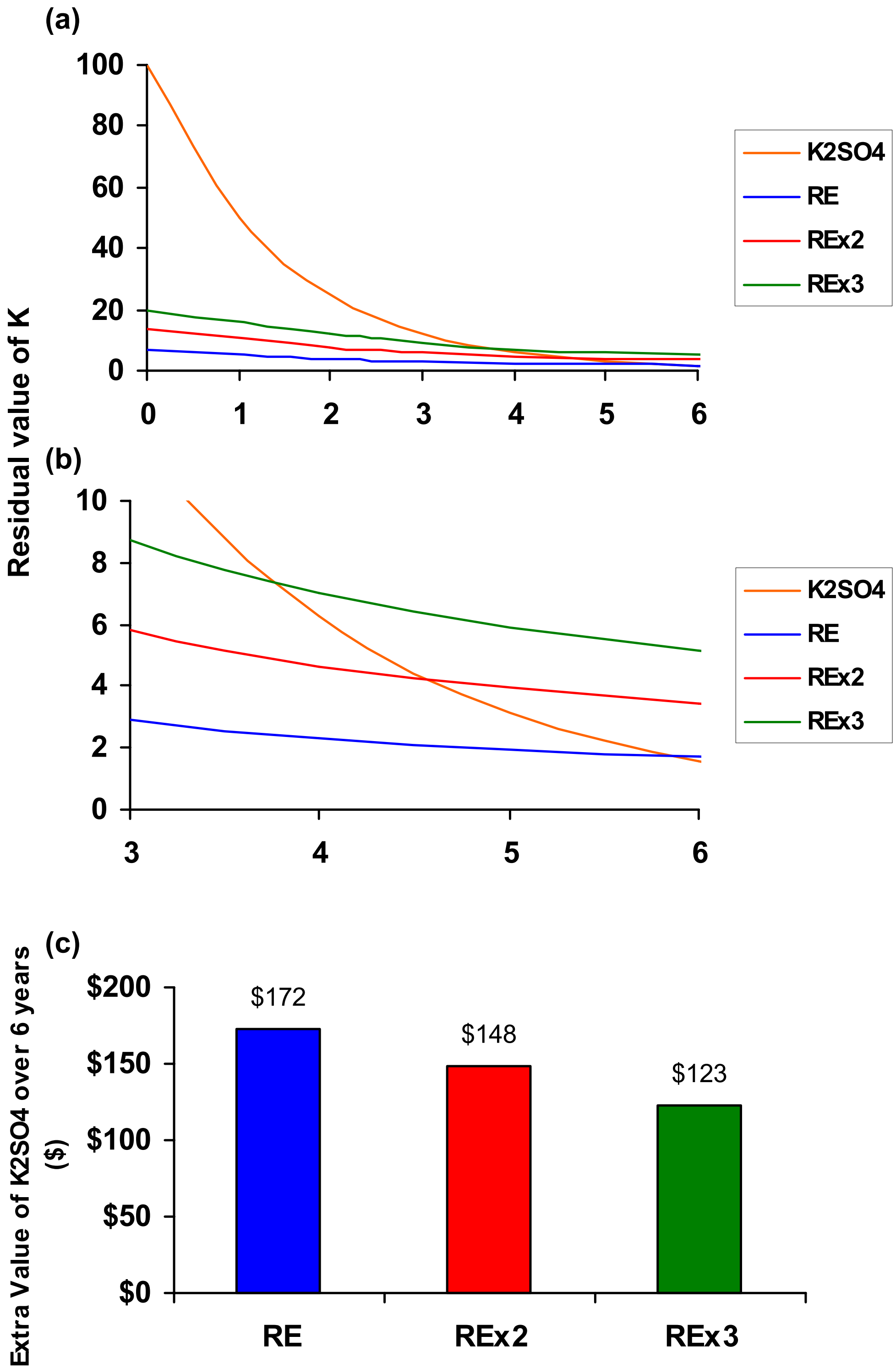

Figure 7.5: Residual value of K_2SO_4 and milled microcline over (a) 0-6 years and (b) 3-6 years and (c) the extra value of K_2SO_4 relative to milled microcline over a period of 6 years.