Potassium Fertilization and How It Effects Yield and Quality of Alfalfa

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High producing alfalfa uses large amounts of soil or fertilizer potassium, about 40-50 pounds (K) per ton (48-50 lbs K_2O/ton). In a number of fields, potassium fertilization may be necessary to maintain forage production at its maximum. Fertilization with potassium is known to have a number of effects on the yield and quality of alfalfa. It is the intent of this presentation to give a brief review of past research as well as give preliminary information from a field experiment initiated earlier this year.

The functions of potassium in plant growth are numerous as potassium influences photosynthesis, respiration, translocation and many enzyme systems. Fertilization with potassium when soils are unable to supply sufficient amounts results in large yield responses. Reduced availability of potassium can lead to a reduction in plant growth and occasionally in crop quality. Response from potassium additions is first observed when the rate of regrowth is more rapid following a harvest. The rapid rate of regrowth allows the alfalfa to compete more aggressively against weeds and insects which results in longer stand life. Increased disease resistance may be another factor that can be attributed to potassium fertilization. Potassium is known to improve the level of carbohydrates stored in alfalfa roots. Greater stand persistence is the result of a combination of these factors.

Potassium fertilization increases the potassium content of alfalfa and affects the concentration of other elements. It has been observed in numerous cases that whenever a nutrient addition results in large alfalfa yield increases, many, if not all other element concentrations will be reduced. Research indicates that potassium additions tend to increase protein in only a few cases and a more general result is that protein content is decreased. Potassium additions generally reduce calcium, magnesium, sodium and occasionally some of the micronutrients. Experiments including higher rates of applied potassium show that potassium concentration continues to increase long after any yield increase is observed, clearly indicating "luxury consumption". Maximum yields are usually associated with plant potassium concentrations in midstem samples of 1.25-1.75% and in the top 6 inches of the plant of 2.0-2.5%. Extremely high concentrations, in excess of 3.0 %, may be undesirable in alfalfa because the reduced calcium and other element concentrations effect the animal utilization of the alfalfa forage. Lower rates of applied potassium to maintain alfalfa potassium concentrations in the 1.25-1.75% range in midstem tissue samples or 2.0-2.5% range for top 6 inch samples would reduce fertilizer costs and yet insure adequate potassium is available to produce high yields. Reductions in the concentration of sodium in alfalfa by potassium may be of some benefit in California and other Western States because of the high sodium levels in the soils and in the alfalfa plant. Potassium fertilization reduces the magnesium concentration in the plant but with generally high magnesium levels in the soils and alfalfa of California, this is of minor concern. There are however sandy soils where magnesium as well as potassium levels may be low for the production of high yielding alfalfa. Potassium sources such as potassium chloride (0-0-60) increase the concentration of chloride. This may be of some benefit in suppressing the effect of certain diseases. High rates of potassium chloride in a single application often create a chloride toxicity, particularly where significant soil chloride levels are present. Potassium sulfate (0-0-50) provides a double benefit, supplying a nutrient sulfur which is occasionally deficient as well as potassium, and having an anion ($SO_4^{=}$) which is not toxic even when applied at very high rates.

In response to the fertilizer industry's interest in improving alfalfa forage quality, a field experiment was initiated in the winter of 1995 in Stanislaus County. The site was selected because of the rather low, 40-50 ppm ammonium acetate extractable soil potassium level. The grower was asked to withhold any application of potassium from part of an irrigation check and the following fertilizer treatments were applied in a randomized complete block design with 3 replications. The individual plot size was 15 feet by 25 feet with the experiment consisting of 54 individual plots (3 X 18).

Fertilizer	Rate of Nutrient Application, lbs/A				
	P_2O_5	K_2O	S	Cl	Lime
1. Control	0	0	0	0	0
2. Potassium Chloride	0	50	0	40	0
3. Potassium Chloride	0	100	0	80	0
4. Potassium Chloride	0	200	0	160	0
5. Potassium Chloride	0	400	0	320	0
6. Potassium Chloride	0	800	0	640	0
7. Potassium Sulfate	0	50	18	0	0
8. Potassium Sulfate	0	100	36	0	0
9. Potassium Sulfate	0	200	72	0	0
10. Potassium Sulfate	0	400	144	0	0
11. Potassium Sulfate	0	800	288	0	0
12. Potassium Chloride+Gypsum	0	100	36	80	0
13. Potassium Chloride+Gypsum	0	200	72	160	0
14. Potassium Chloride+Gypsum	0	400	144	320	0
15. Potassium Chloride+Gypsum	120	400	144	320	0
16. Potassium Chloride+Gypsum	240	400	144	320	0
17. Lime	0	0	0	0	2 tons
18. Lime+Potassium Chloride+Gypsum	240	400	144	320	2 tons

It should be pointed out at the onset that the results being presented are from the first year only and that final conclusions cannot be drawn until the completion of the study. Alfalfa yields were determined for the 7 harvests on a 100% dry matter (DM) basis and the results for the April 11th and August 7th cuttings are given in Figures 1-4. Total yields for the 7 harvests are given in Figures 5-6. Even though the soil tests would indicate a potassium response might be expected, there were no statistically significant yield increases over the control. The August 7th harvest data are presented because a visual increase in alfalfa plant height was observed in one replication from the 800 lbs/A rate of potassium sulfate. This observation was not consistent across all replications, thus no statistically significant yield increase was recorded in the experiment. It is difficult to explain the reduction in the season long yield for the lime treatment. It can be noted in Figure 1 that the potassium chloride reduced the alfalfa yield at the 800 lbs K_2O per acre rate. Visible damage to the alfalfa plants was observed at the initiation of growth in the spring in all of the plots receiving the 800 lbs K_2O/A rate of potassium chloride. There was little or no detrimental effect in the second and later harvests from the high rates of potassium chloride.

Figures 7-12 present the alfalfa total digestible nutrient (TDN) data for the April 11th, June 12th and August 7th harvest dates. There was no statistically significant difference between the TDN values in the alfalfa forage for the first 5 harvests where the two potassium fertilizer sources potassium chloride and potassium sulfate were applied. Both Figure 9 and 11 show the trend for higher rates of potassium additions to reduce the TDN values but this was not observed in the other three harvest where the analyses have been completed. No trends for phosphorus effects on TDN were observed, but it appeared that the lower yielding lime treatments had slightly higher TDN values.

The effect of potassium fertilizer sources, phosphorus and lime on crude protein for the April 11th and August 7th harvests is illustrated in Figures 13-16. The early harvests show no trends or significant differences in crude protein but by the August 7th harvest there was a significantly lower crude protein for the 800 lbs K_2O/A rate of both potassium fertilizer sources, potassium chloride and potassium sulfate.

As mentioned previously, this is very preliminary data from part of the first year's experimental investigation. We look forward to conducting the study for two more years to develop meaningful results and reach final conclusions at this location.

Figure 1. Alfalfa yield response to rates of potassium sulfate and chloride on April 11, 1995 at Foster Farms Ranch.

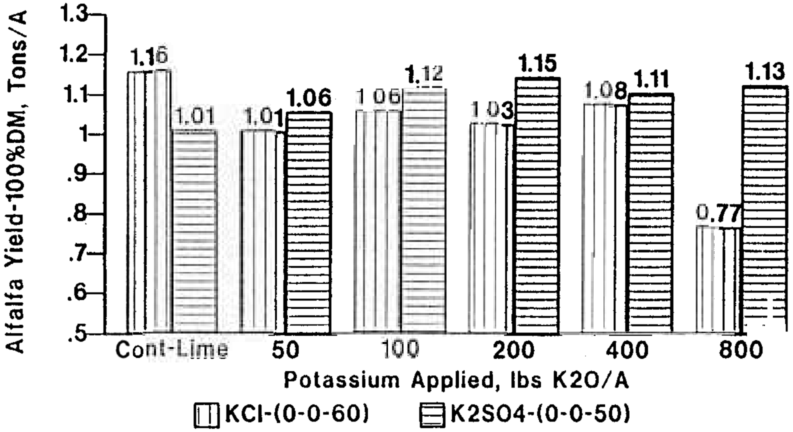


Figure 2. Alfalfa yield response to rates of potassium sulfate, potassium chloride, potassium chloride+gypsum and phosphorus on April 11, 1995 at Foster Farms Ranch.

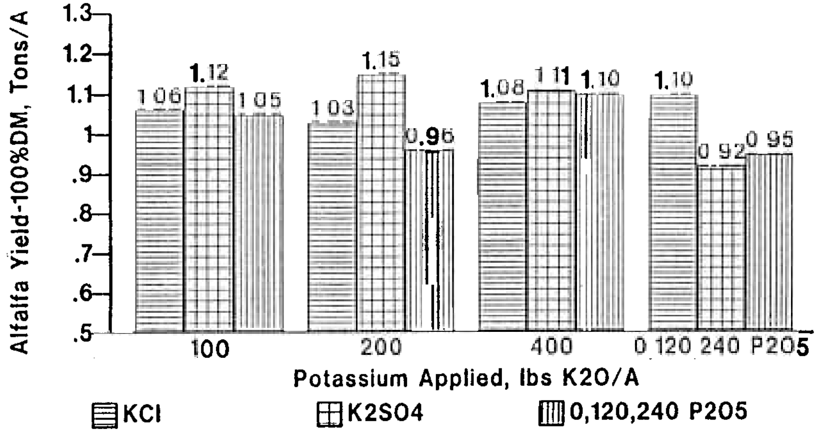


Figure 3. Alfalfa yield response to rates of potassium sulfate and chloride on August 7, 1995 at Foster Farms Ranch.

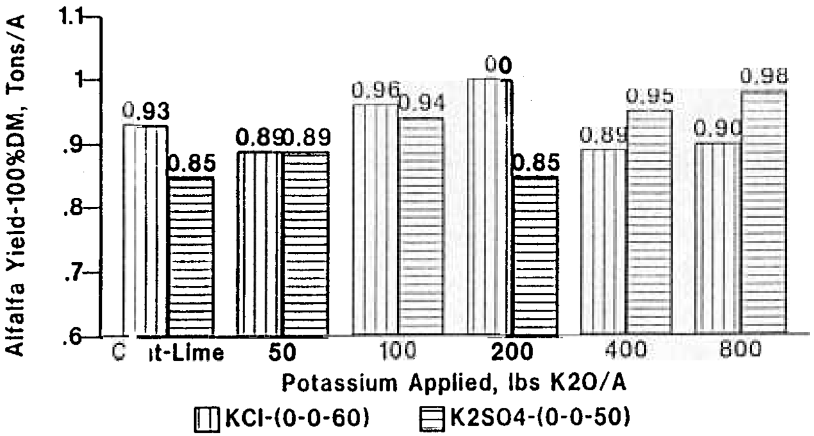


Figure 4. Alfalfa yield response to rates of potassium sulfate, potassium chloride, potassium chloride+gypsum and phosphorus on August 7, 1995 at Foster Farms Ranch.

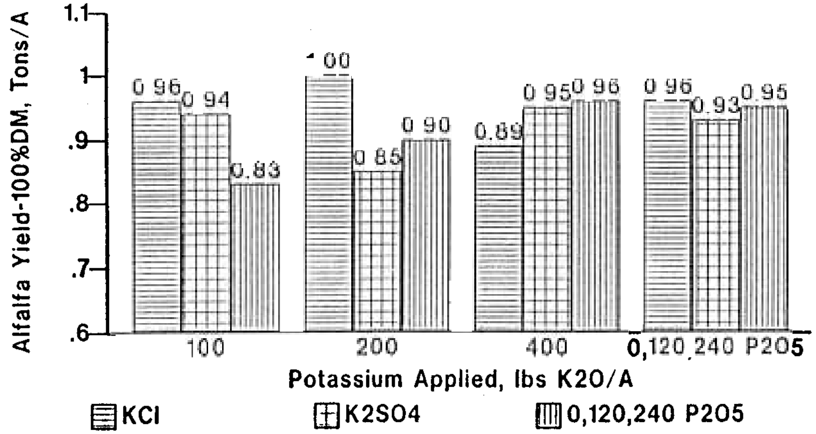


Figure 5. Total 1995 alfalfa yield response to rates of potassium sulfate and chloride on Foster Farms Ranch.

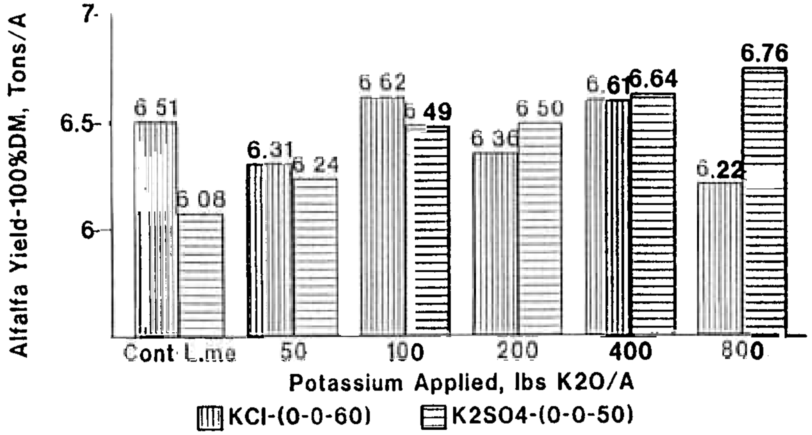
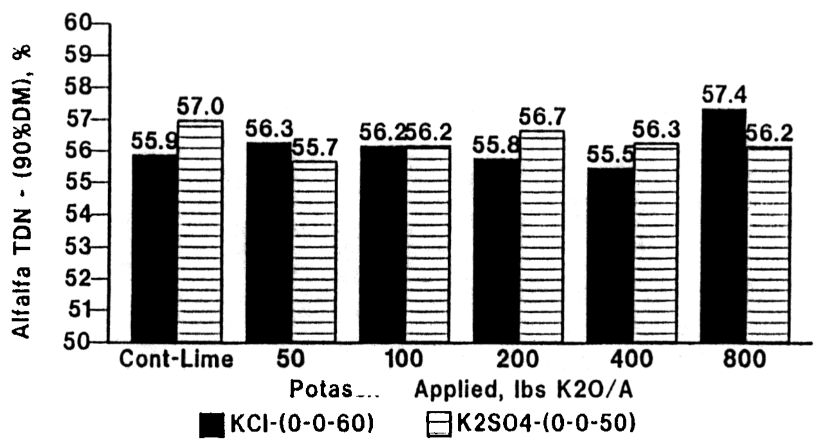


Figure 7. Alfalfa TDN (90%DM) response to rates of potassium sulfate and chloride on April 11, 1995 at Foster Farms Ranch.



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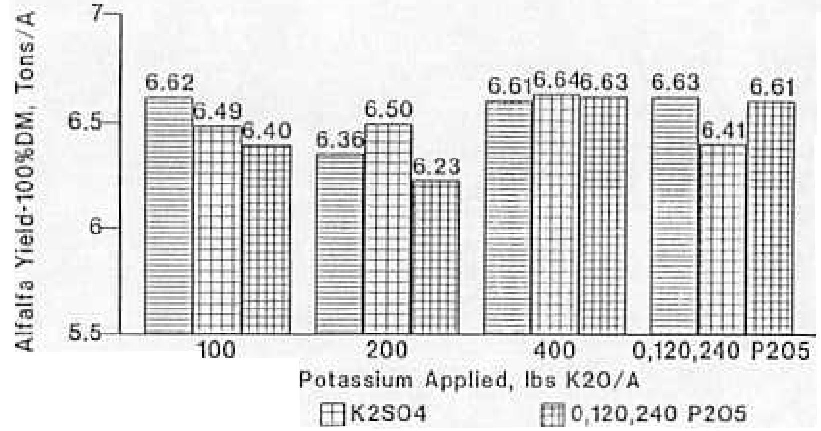

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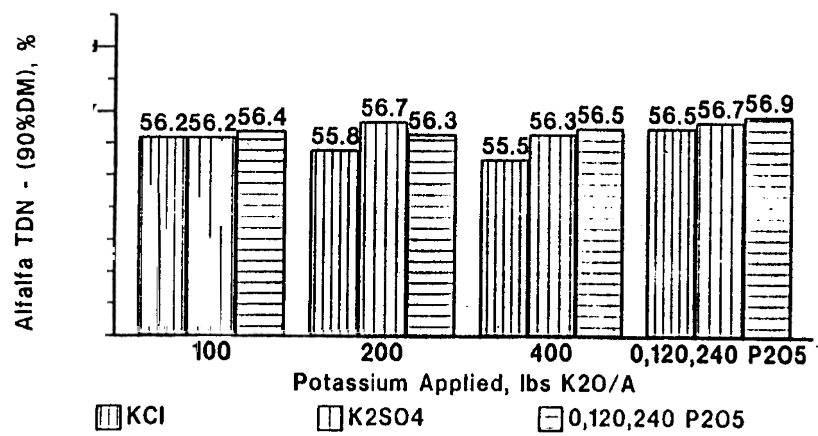

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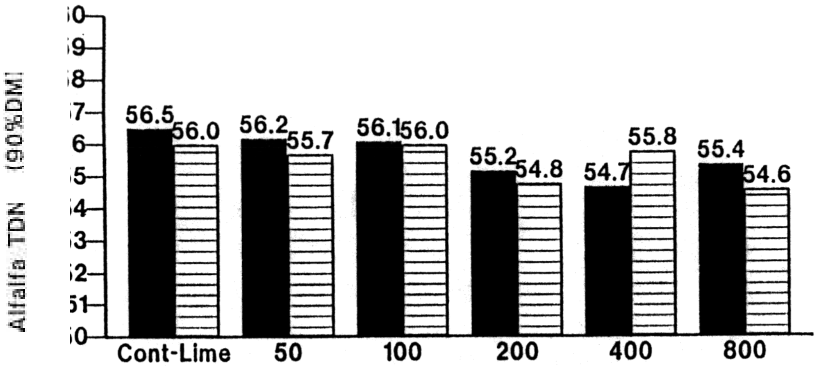

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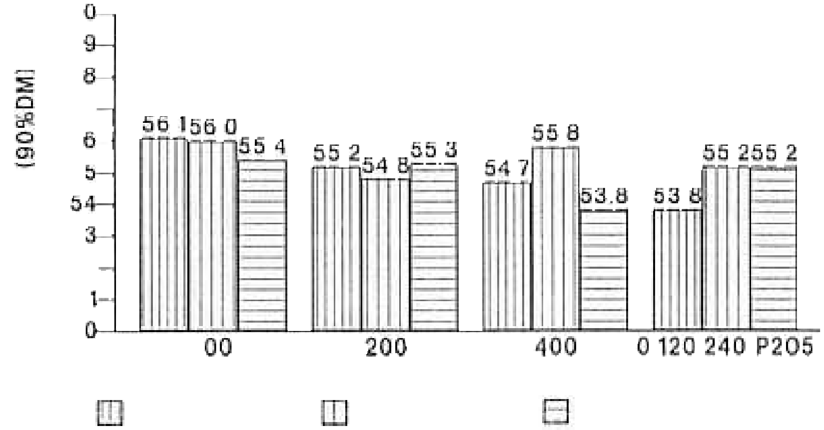

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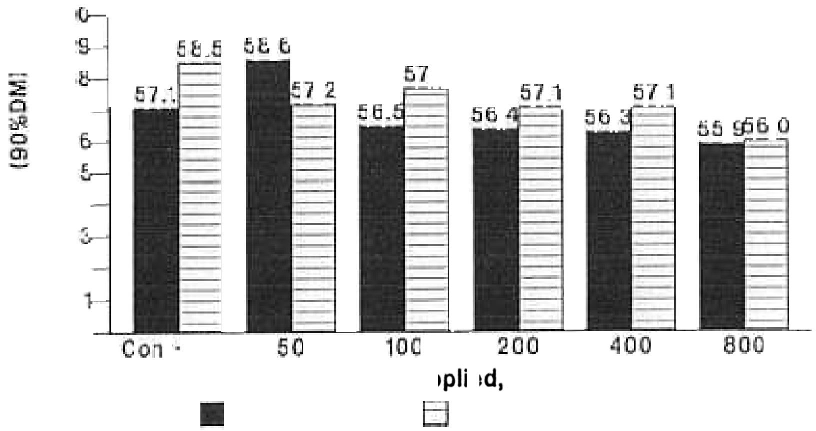

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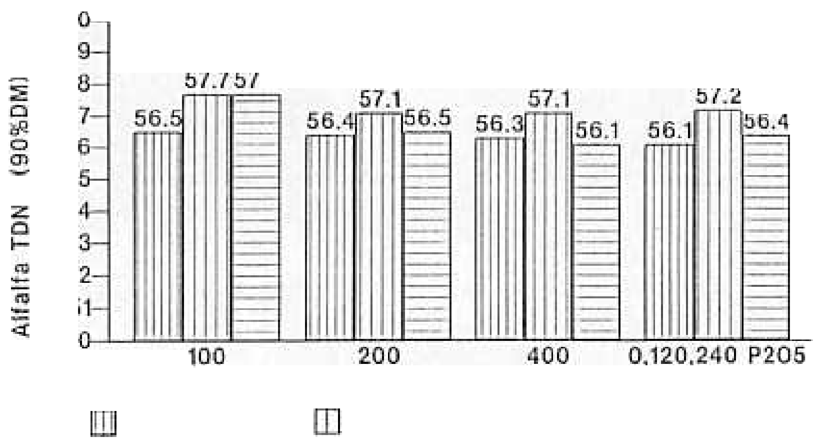

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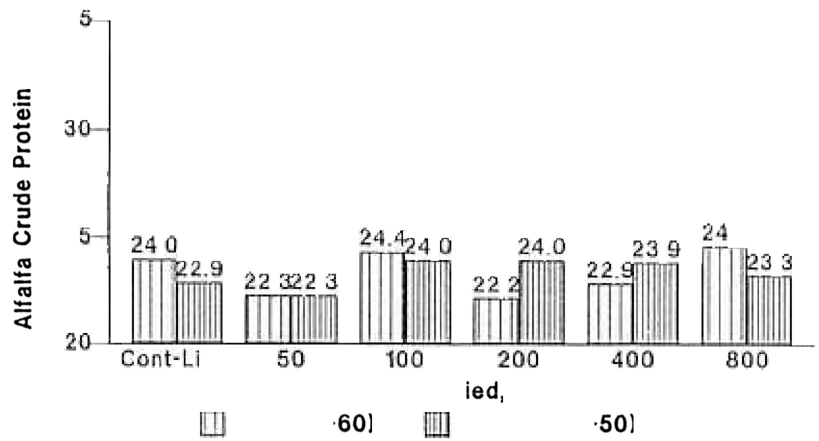

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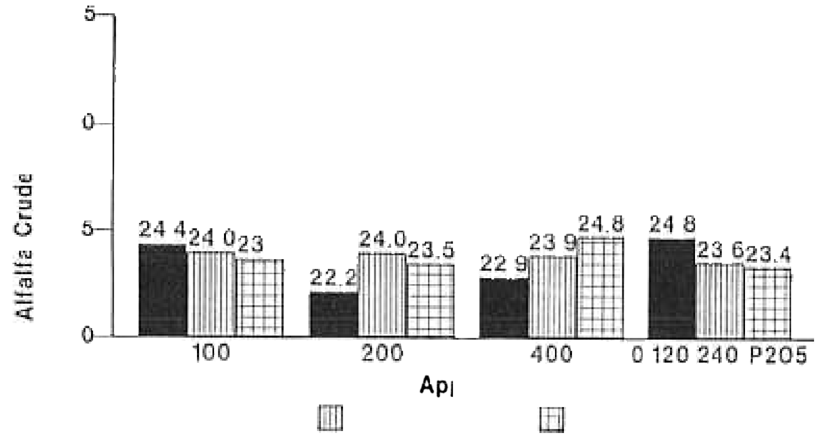

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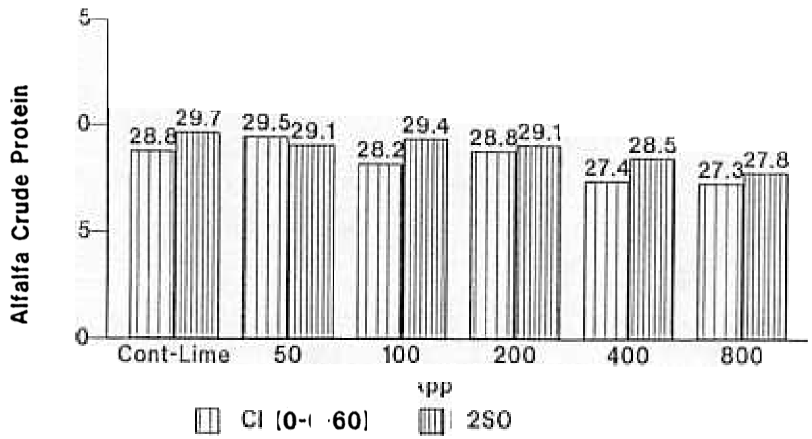

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