FERTILIZER PLACEMENT AND ALFALFA PRODUCTION

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Most of the research into the placement of fertilizer for crop production has concentrated upon placement at seeding for annual crops. The limited amount of research into placement of fertilizer for perennial forage crops has also concentrated upon placement at seeding and indicates that responses similar to those of annual crops occur.

There is a considerable body of research into fertilizing established perennial crops such as alfalfa since these crops require a continuing supply of nutrients over a period of years -- the life of the stand. Traditionally, relatively immobile nutrients like phosphorus have been either supplied by a single lifetime application at or prior to seeding, or have been supplied to the established crop every year or so as the need arises by a broadcast application onto the soil surface. More mobile nutrients such as nitrogen are also usually supplied by broadcasting onto the established crop though often at more frequent intervals.

Considerable speculation exists over the effectiveness of surface applications for supplying nutrients such as phosphorus. Previous estimates have ranged from 3% to 15% of applied phosphorus is taken up by the alfalfa crop in the first cut after application with similar small percentages in subsequent years. Ukrainetz (1969) has suggested that this was due to a failure of the surface applied phosphorus to move into the rooting zone, especially under the semiarid conditions of Swift Current. Recovery rates for surface applied nitrogen are usually higher but losses due to volatilization, denitrification and leaching can considerably reduce fertilizer efficiency. Volatilization losses are of especial importance under the semiarid conditions of Swift Current and throughout the Brown soil zone.

With the adoption of wide row spacing for dryland forage crops and larger and better fertilizer placement machinery, the concept of shanking down fertilizer into established stands to moist soil in order to make it more immediately available and less susceptible to losses becomes more attractive.

Very little information is available on subsurface placement of fertilizer for established forage crops. The three experiments discussed herein were designed to investigate what happens to alfalfa yields when fertilizer is applied at various depths.

Experiment I

In the spring of 1975, Drylander alfalfa was seeded into a level and uniform area of Haverhill loam soil at Swift Current in rows 45 cm apart. At seeding the soil contained 7.25 kg bicarbonate extractable P in the top 15 cm and 10 kg nitrate in the top 60 cm.

In the spring of 1976, the uniform alfalfa stand was subdivided into four row plots each 7 m long. Five rates of phosphorus fertilizer (0, 20, 40, 80 and 160 kg P_2O_5/ha) were applied in bands between the rows at three depths (surface, 5 cm and 10 cm) using the Swift Current plot seeder fitted with fertilizer spikes. The treatments were arranged in a four-replicate, split plot design with depth as the main plot and fertilizer rate as the subplot. No further fertilizer applications were made in any subsequent year.

No cut was taken in the establishment year. Two cuts were taken in 1976 and 1977, but only one cut in each subsequent year.

The effects of the two factors, depth of application and phosphorus rate were examined for each cut and the total yield in each year using analysis of variance for split plots (Steel and Torrie 1960). Standard errors of difference were calculated.

The rate of phosphorus fertilizer applied had no effect upon alfalfa yield in any cut in any year (Fig. 1); nor was there any interaction between rate of application and depth of application. There was a tendency for yields to be increased in 1976 and 1977, but the changes in yield were too small to be significant. It is clear, therefore, that the level of available phosphorus already in the soil was sufficient to sustain maximum growth. The variability in yield from year to year reflects the great influence of moisture conditions upon alfalfa yields. The low yields of 1980 reflect the very dry conditions at the start of that crop year.

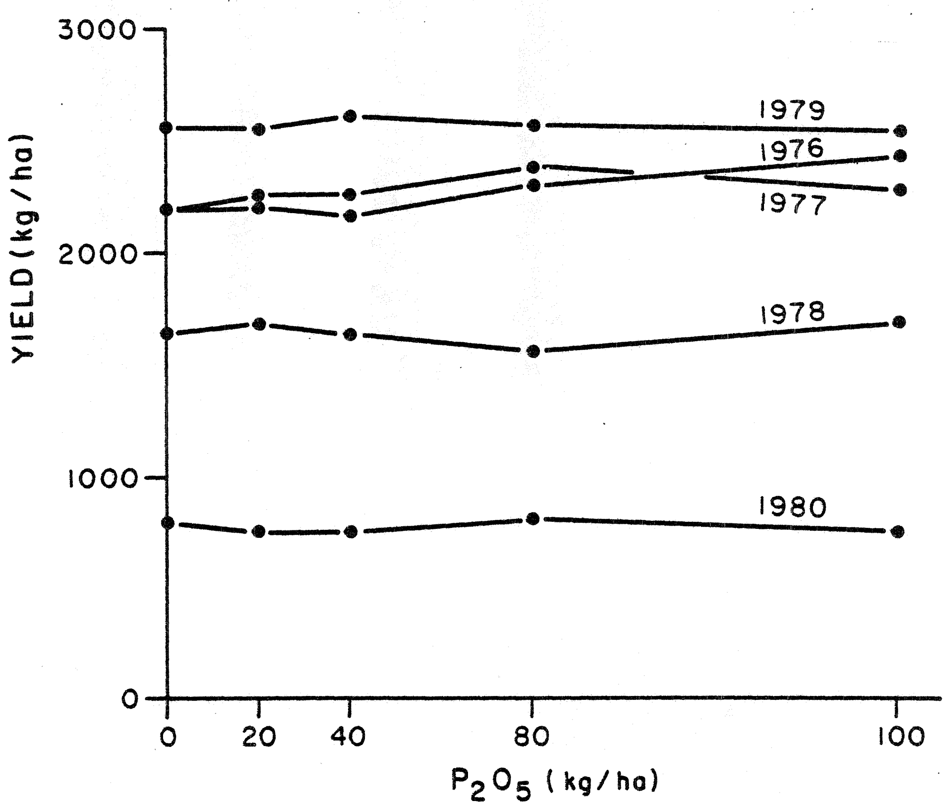

Fig. 1. Effect of a single application of P fertilizer on subsequent yields of alfalfa, 1976-1980 (each point is the mean of 3 depths)

The effect of placing the fertilizer below the soil surface was rather surprising. Instead of yield increases, as were expected, decreases in alfalfa yield of up to 15% due to subsurface placement were observed in 1976 (Fig. 2). The extent of the yield decrease depended upon the depth that fertilizer was placed.

The deleterious effects of subsurface placement continued through 1977 and 1978. During these years, the same yield decrease resulted from both the 5 cm and 10 cm treatments. By 1979 the differences had become too small to be signficant; however, in 1980 yields from surface applications were again significantly higher than when the phosphorus was knifed in. This was probably a result of the lower overall yields in that year.

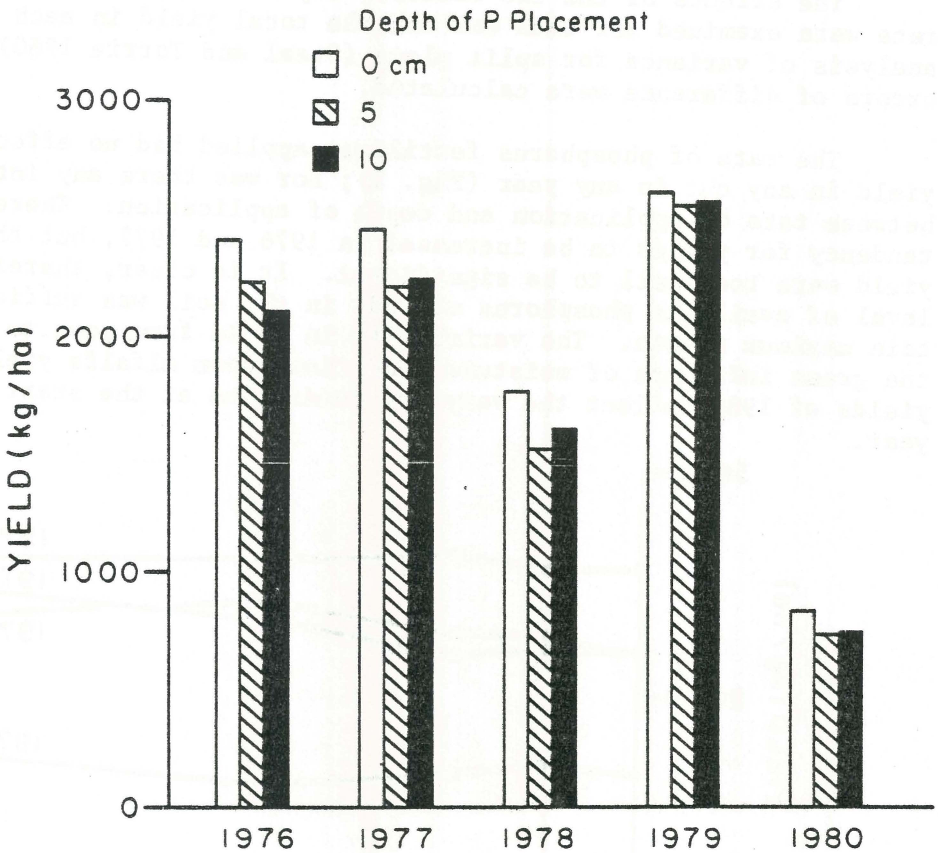

Fig. 2. Effect of P fertilizer applied at three depths on the subsequent yields of alfalfa.

These results left two questions to be answered. Firstly, were these differences due to experimental error and, secondly, if the effect was real, was it caused by the fertilizer used or was it due to the physical effect of placement? The results of a second experiment to study the effects of nitrogen placement on established afalfa were examined with these questions in mind.

Experiment II

The methodology of Experiment II was essentially the same as in

Experiment I, except that the nitrogen fertilizer in the form of ammonium nitrate was applied at rates of 0, 50, 100 and 200 kg/ha. Fertilizer was applied at the same depth as before (0, 5 and 10 cm) in a uniform established alfalfa stand in 45 cm rows.

There was no response to nitrogen at any cut in any of the 3 years the test was cut. This indicated that under dryland conditions alfalfa can fix sufficient nitrogen to sustain maximum growth within the limitations imposed by other factors such as moisture. In addition, at no time was there an interaction between rate of application and depth of placement.

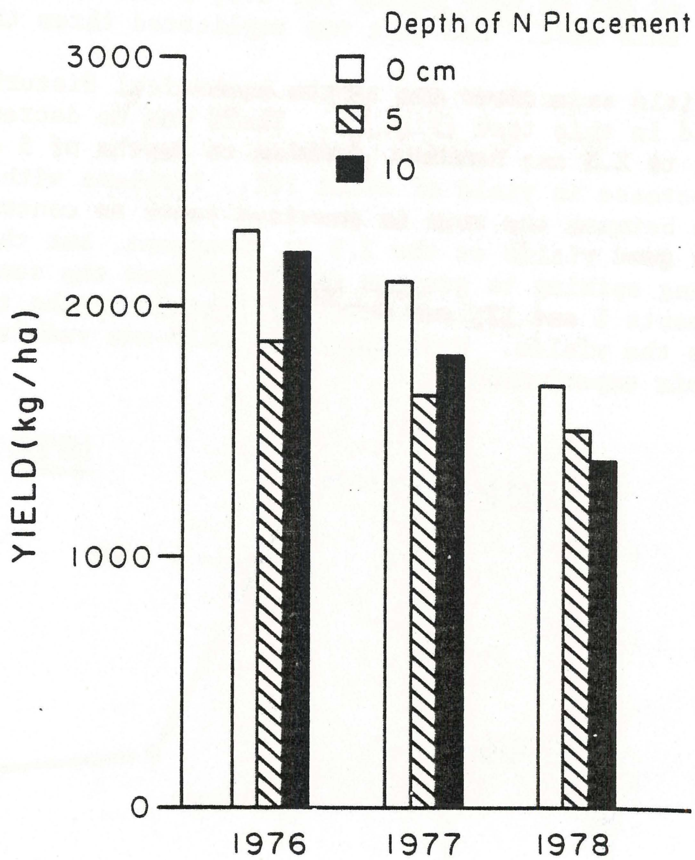

Fig. 3. Effect of N fertilizer applied once at three depths on the subsequent yields of alfalfa

Subsurface placement, on the other hand, was observed to be as deleterious to alfalfa yields as was observed in the first experiment (Fig. 3). Placement to 10 cm was not as deleterious as placement to 5 cm in the first year (1976) but in the two subsequent years the 10-cm treatment was equally as deleterious to yields as the 5-cm treatment. Decreases in yield of up to 20% were observed during the 3 years data were taken. By the third year, there were still no signs of yield recovery following subsurface placement, but no further observations were made.

This second experiment, therefore, confirmed that the yield decreases following subsurface placement of fertilizer were real and probably occurred as a result of the soil disturbance involved in fertilizer placement rather than as a result of the fertilizer itself. To confirm this latter conclusion a third experiment that did not use fertilizer was carried out.

Experiment III

In Experiment III, an old stand of alfalfa seeded in 90-cm rows was used. This stand had been used for seed production since 1971. The stand was divided into four row plots 6.5 m long. Alongside each row, in the spring of 1979, a tractor pulled a spike through the soil about 30 cm from the row at one of four depths (0, 2.5, 5 and 10 cm). No fertilizer was used in this test. The test was replicated three times.

Yield reductions due to the mechanical disturbance of the soil were observed in this test (Fig. 4). There was no decrease in yield following spiking to 2.5 cm; however, spiking to depths of 5 cm and below resulted in a decrease in yield of about 20%. Problems with depth control or tillage between the rows in previous years to control weeds could account for the good yields at the 2.5 cm treatment, but the large drop in yield following spiking to greater depths follows the same pattern as seen in Experiments I and II, and confirms that it is the tillage effect that reduces the yields. Unfortunately, only one year's data is available from this experiment.

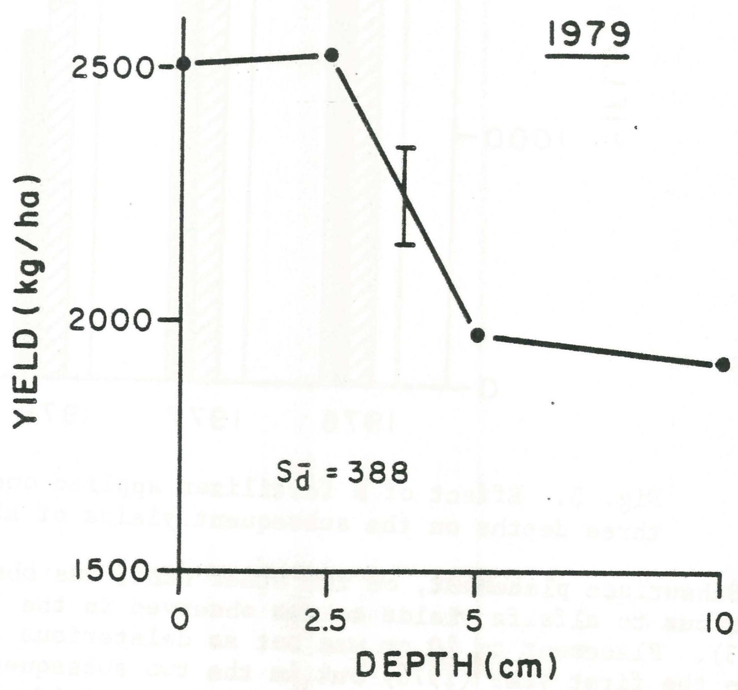

Fig. 4. Effect of spiking to four depths on the subsequent yield of alfalfa

Discussion

It is clear from the above three separate studies that the disturbance of the soil resulting from attempts to band fertilizer at depths under an established alfalfa stand can lead to yield reductions. However, the causes of these reductions is not clear. It seems likely that the cause of the reduction is the root injury to the alfalfa that results from the soil disturbance.

Many workers have shown that the most active roots of alfalfa lie very close to the soil surface. Lambda et al. (1949) showed that more than 50% of the total root growth of alfalfa is in the top 20 cm and Upchurch and Lovvoin (1951) found that approximately 50% of all lateral roots of alfalfa occur in the top 7.5 cm of soil. Stanford et al. in 1949 reported that alfalfa was very efficient at absorbing top dressed phosphorus and suggested it possessed a root system in the top 7.5 cm which absorbed phosphorus quite effectively, although they could not explain why the high rate of utilization continued even under semidrought conditions.

The persistence of the effect of root damage for several years can probably be attributed to poor root regrowth following the damage. The dryness of the top soil under the semiarid climate of Swift Current even after winter is probably not conducive to root repair and regrowth.

The conclusion to be drawn from these results is that disturbance of the soil in established alfalfa will result in reduced yields due to root damage and under dryland conditions will persist for several years. Because the experiments described above did not show any response to fertilizer it has not been established whether on deficient land the benefits to be derived from fertilizer would compensate for any yield depression resulting from application method. Until that point has been investigated thoroughly, it is recommended that for established alfalfa, fertilizer should be surface applied.

References

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