University of Idaho
College of Agriculture
Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 763



# The Effects of Phosphorus Rates on Legumes Grown on a Volcanic Ash Soil in Northern Idaho

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Livestock producers face the constant challenge of securing adequate supplies of high quality forages to feed their herds and flocks. The task is especially critical where animals must be fed roughages during long winters. Successful hay and pasture production to meet animal needs throughout the year depends on a combination of the proper inputs. A grower must choose the right crop and variety for his location. Sufficient moisture and plant nutrients to assure highest yields are necessary as is ideal weather for harvesting and curing hay.

In nothern Idaho, conditions for optimum forage production often are less than ideal. Livestock production is the major agricultural industry in much of the area. Alfalfa (*Medicago sativa* L.), the most highly regarded of the forages, grows poorly in many areas. Rainy weather usually leads to inferior quality of the first hay cutting while lack of rain limits second cutting yields. Volcanic soils, which constitute large sections of northern Idaho, restrict the availability of phosphorus (P) for plant growth. These limitations often force ranchers and dairymen to purchase needed roughage rather than produce their own. Increased production costs are the end result.

Since 1913, research conducted at the University of Idaho Research and Extension Center at Sandpoint has addressed forage production problems. A review of annual reports published from 1915 to 1970 reveals that sulfur (S) and boron (B) fertilizers were needed for optimum alfalfa yields, but very little attention was paid to P requirements. Sweet corn (*Zea maize* L.) grown on Mission silt loam has shown a positive relationship between yields, plant and soil P levels and P application rates.

The Mission silt loam soils at the Sandpoint R&E Center are representative of volcanic ash soils that occupy several hundred thousand acres in nothern Idaho. While Mission soils hold moisture well for the benefit of crop growth during drought, they often drain poorly and tend to retard growth in late spring. Phosphorus becomes strongly attached to the volcanic ash, and the availability of P to plants becomes limited. This publication reports research that was conducted to determine the yield and P content of alfalfa, birdsfoot trefoil (*Lotus corniculatus* L.), red clover (*Trifolium pratense* L.) and white clover (*Trifolium repense* L.) and the available soil P when these forages were grown in plots supplied with three rates of P.

## Experimental Procedures

**Phosphorus Rates and Legume Selections** — A field experiment was initiated in 1981 at the Sandpoint R&E Center. The Mission soil at the Center consists of a silt loam volcanic ash material 18 to 30 inches thick overlying lake sediments. The moderately acid (pH 5.9) soil was relatively low in organic matter (3.2 percent) and exchange capacity and lacked only S and P for legume production. The first cuttings of each legume were harvested in 1982 and 1983. Precipitation in 1981, 1982 and 1983 measured 39, 44 and 40 inches, respectively.

Three rates of triple superphosphate (0-44-0) were broadcast in May 1981 on the surface of a field that had been plowed in 1980 and disked several times to destroy weeds and crop residues. All materials were incorporated by disking into the soil to a 6-inch depth. Soil test nitrogen (N) was 35 pounds per acre. The P content of superphosphate is about 20 percent.

Actual phosphorus applied to plots in this study measured 36, 72 and 108 pounds per acre, or 180, 360 and 540 pounds per acre of superphosphate fertilizer. Included also was a topdressing of 20 pounds per acre of S as gypsum. Superphosphate was reapplied at the same rates to the established legumes in April 1982 and 1983.

Alfalfa (Agate), birdsfoot trefoil (Empire), red clover (Florex) and white clover, New Zealand common, seeds were sown in May 1981 on the surface at rates of 9 pounds per acre. A cultipacker was used to lightly cover and firm seeds into the soil. All seeds were inoculated with nitrogen-fixing Rhizobium bacteria before sowing.

The first cuttings of forage were harvested in July in both 1982 and 1983 when plants had reached about 75 percent bloom stage. Harvested forages were weighed and dried with yields expressed on a 13 percent moisture basis.

Phosphorus levels in the tops of the plants were determined through the appropriate methods. Available soil P was determined chemically by collecting and analyzing samples from P treated plots.

## Results

**Forage Yields** — Results of the 1982 tests clearly showed the benefits of P fertilization on all forages (Table 1). Red clover production was stimulated by P fertilization only slightly, but P led to increased growth of other legumes. Birdsfoot trefoil produced the highest yields while alfalfa yields were lowest.

Similar trends continued in 1983 harvests. Yields of alfalfa improved by more than a ton per acre for all treatments. Red clover yields were not affected by P, and birdsfoot trefoil yields increased at only the high rates of P. Yields of white clover increased with increasing rates of P but declined from 1982 levels. The combined production from 2 years clearly showed that birdsfoot trefoil was the leading forage, especially at the two highest P rates.

**Phosphorus Levels in Leaves and Stems** — The level of P in the stems and leaves of the four legumes was lowest on plots that were not fertilized (Table 2). Plants sampled in May 1983 contained nearly twice as much P as plants harvested in July 1982. The differences reflected the contrasting maturity stages of plants at the time of harvest. Mature alfalfa and red clover hay normally contain about 0.25 percent P (dry weight basis). The P levels of birdfoot trefoil and white clover are slightly higher than alfalfa and red clover. The first P increment of 80 pounds P per acre resulted in a rise in the P content from the lower limit of the essential amount for growth to an optimum level. Further P additions increased P levels in birdsfoot trefoil and white clover. This trend was not as apparent in red clover and alfalfa.

**Phosphorus Levels in Soils** — Soil test P levels increased as $P_2O_5$ application rates increased (Table 3). Because the volcanic ash in the Mission silt loam ties up P, plant growth can be restricted. A comparison of soil test P at the 180 pounds per acre shows no appreciable change. When P was reapplied in 1982 and 1983, uptake by plants and tie-up in the soil masked any difference in soil P levels. Residual soil P appeared to be higher under red clover than under alfalfa, birdsfoot trefoil and white clover.

**Relationships Between Variables** — Alfalfa, birdsfoot trefoil and white clover apparently were more responsive to P fertilizer than red clover, although

**Table 1. First cutting forage yields at the University of Idaho Research and Extension Center, Sandpoint.**

| Crop | Phosphorus rate | Yield 1982 | Yield 1983 | 2 year total |
|---|---|---|---|---|
| | (lb/acre) | (lb/acre) | | |
| Alfalfa | 0 | 380c* | 2,900d | 3,280d |
| | 36 | 880b | 3,550c | 4,420c |
| | 72 | 1,420a | 3,980b | 5,400b |
| | 108 | 1,610a | 4,460a | 6,070a |
| Birdsfoot Trefoil | 0 | 1,070c | 4,840b | 5,900c |
| | 36 | 2,860b | 4,620b | 7,480b |
| | 72 | 3,140b | 5,380a | 8,240b |
| | 108 | 4,740a | 5,480a | 10,220a |
| Red Clover | 0 | 1,530b | 4,250a | 5,770a |
| | 36 | 2,370a | 4,620a | 6,990a |
| | 72 | 2,330a | 4,400a | 6,740a |
| | 108 | 2,030a | 4,350a | 6,390a |
| White Clover | 0 | 1,170c | 1,130c | 2,300c |
| | 36 | 2,240b | 1,560b | 3,800b |
| | 72 | 2,370b | 1,510b | 3,870b |
| | 108 | 2,960a | 1,990a | 4,950a |

*Values within column for each legume followed by the same letter are not significantly different at the 0.05 level of probability.

**Table 2. Concentration of P (ppm) in plant tops in fertilizer trials at the UI R&E Center, Sandpoint.**

| Crop | Phosphorus rate | 1982 | 1983 |
|---|---|---|---|
| | (lb/acre) | (ppm) | (ppm) |
| Alfalfa | 0 | 2,250b* | 3,790b |
| | 36 | 2,500ab | 4,110a |
| | 72 | 2,440ab | 4,240a |
| | 108 | 2,550a | 4,020ab |
| Birdsfoot Trefoil | 0 | 2,010d | 4,360b |
| | 36 | 2,310c | 4,170b |
| | 72 | 2,770b | 4,710a |
| | 108 | 3,060a | 4,780a |
| Red Clover | 0 | 1,890c | 3,680c |
| | 36 | 2,220b | 3,970bc |
| | 72 | 2,520a | 4,290ab |
| | 108 | 2,580a | 4,390a |
| White Clover | 0 | 2,260c | 3,680c |
| | 36 | 2,890b | 4,210b |
| | 72 | 3,150ab | 4,390b |
| | 108 | 3,630a | 5,120a |

* Values within column for each legume followed by the same letter are not significantly different at the 0.05 level of probability.

Table 3. Sodium-acetate-available soil P in plots at the UI R&E Center, Sandpoint.

| Crop | Phosphorus rate | 1982 | 1983 |
|---|---|---|---|
| | (lb/acre) | (ppm) | (ppm) |
| Alfalfa | 0 | 2.1c* | 2.1b |
| | 36 | 2.6bc | 2.7b |
| | 72 | 3.4b | 3.1b |
| | 108 | 5.8a | 4.8a |
| Birdsfoot Trefoil | 0 | 2.3c | 2.2b |
| | 36 | 2.6c | 2.7b |
| | 72 | 3.3b | 3.2ab |
| | 108 | 5.0a | 4.4a |
| Red Clover | 0 | 2.8c | 2.9c |
| | 36 | 3.5bc | 4.0bc |
| | 72 | 4.1b | 4.5b |
| | 108 | 6.6a | 6.8a |
| White Clover | 0 | 2.4c | 2.3b |
| | 36 | 2.8bc | 2.5b |
| | 72 | 3.6b | 3.5ab |
| | 108 | 5.0a | 4.6a |

* Values within column for each legume followed by the same letter are not significantly different at the 0.05 level of probability.

red clover yields compared favorably with alfalfa and birdsfoot trefoil. Results of the experiments also indicate that available soil P may be a better guide than foliar P levels of the yield potentials of alfalfa, birdsfoot trefoil and white clover when these crops are grown on volcanic ash soils.

## Conclusions

Phosphorus applications are needed to increase the yields of forage legumes in northern Idaho. Alfalfa, birdsfoot trefoil and white clover production improved with the use of P. Although legume yields improved as P rates increased, the economics of P rates and yield increases are questionable.

Phosphorus should be applied to established legumes to minimize P tie-up by volcanic ash soils. Fall applications are more likely to be unavailable to plants when spring growth resumes.

Red clover is more likely to produce the highest hay yields regardless of P fertilization; however, red clover does not persist more than 2 or 3 years, and hay quality may be moldy in the cool, rainy areas of northern Idaho.

Birdsfoot trefoil may offer growers an alternative to alfalfa and red clover. While most growers traditionally prefer alfalfa, birdsfoot trefoil could become popular. This legume responded favorably to P and seems adapted to the wet, acid soils that grow poor alfalfa crops. Research is needed to further evaluate birdsfoot trefoil in northern Idaho. Alfalfa will probably remain the number one choice of any grower who can secure and sustain good stands; however, a high level of soil fertility must be maintained to obtain good alfalfa performance. Predicting the potential yield of alfalfa and birdsfoot trefoil grown on the Mission soil was more reliable when based on available soil phosphorus as compared with foliar phosphorus.

This study shows that acceptable yields of alfalfa and birdsfoot trefoil can be achieved by intensive phosphorus management of the Mission soil. Predictably similar results may be possible on the tens of thousands of acres of other volcanic ash influenced soils in northern Idaho.

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