# Low Level Nitrogen and Phosphorus Fertilization on High Elevation Ranges[1]

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## Highlight

**Low levels of fall applied ammonium sulphate nitrogen and treble superphosphate phosphorus fertilization were effective to increase production, crude protein, and phosphorus content of forage on high elevation native ranges in southwestern Utah. Vegetation was dominated by bistort, western yarrow, bluegrass, tufted hairgrass, spike trisetum, alpine timothy, and letterman needlegrass. The most effective level appeared to be 60 lb. each of available nitrogen and phosphorus in combination. Fertilizers were applied once and the residual effects carried over for two growing seasons for production, three for phosphorus, and one growing season for crude protein and gross energy. Visual differences between treatments were obvious during the first two years.**

In recent years a considerable amount of research has been conducted on the use of commercial fertilizers to improve production and nutrient content of range forages. In the intermountain area only nitrogen and phosphorus appear to be necessary for increasing yields from native perennial ranges. Specific fertilizer responses have varied with rates, geographical location, type of vegetation and precipitation (Cook, 1965). On mountain meadows Cook reported that fertilization increased yield, protein content, and palatability.

Leamer (1963), working on irrigated mountain meadows, reported linear increases in yield with increasing amounts of nitrogen. Smika et al. (1960) reported the response of grasses was due mainly to nitrogen with maximum production of crested wheatgrass and bromegrass obtained from 60 lb./acre of nitrogen. Protein, like yield, generally increases with nitrogen application.

Phosphorus has been reported to have little effect on yield either alone or in combination with nitrogen (Leamer, 1963; Lavin, 1967; and Hull, 1963). However, Cosper and Thomas (1961) did find that maximum production was obtained from nitrogen and phosphorus in combination. They also reported that phosphorus increased the uptake of nitrogen on dry ranges. Smika et al. (1969) indicated that the presence of phosphorus resulted in a more efficient use of fertilizer nitrogen by grass species.

This study was designed to evaluate the effects of low levels of nitrogen and phosphorus fertilizers, alone and in combination, on native vegetation at high elevations.

## Study Area and Methods

The study area is located in southwestern Utah at an elevation of approximately 10,200 feet, adjacent to Cedar Breaks National Monument. The vegetation of this area is characterized by spruce (*Picea engelmannii*) and fir (*Abies lasiocarpa*) interspersed with alpine meadows (Fig. 1). The dominant herbaceous species in these meadows are bistort (*Polygonum bistortoides*), western yarrow (*Achillea lanulosa*), bluegrass (*Poa canbyi*), tufted hairgrass (*Deschampsia caespitosa*), spike trisetum (*Trisetum spicatum*), alpine timothy (*Phleum alpinum*), and letterman needlegrass (*Stipa lettermanii*).

Weather data from the Blowhard Mountain Radar Station, located near the study site, indicate a short frost-free growing season. The 6-year average is 72 days with a maximum of 88 days and a minimum of 53 days. Rainfall for this area was 34.6 inches over a 5-year period with a maximum of 47.2 and a minimum of 21.3 inches. The greatest amount of precipitation falls in December and April and the least in June.

Soils in the area are deep with good horizon differentiation. They may be classified as either Argic Pachic Cryoborollos or Argic Cryoborollos, mixed family. The texture of the $B_2$ horizons varies from a silty clay to a silty loam.

These ranges have a long history of grazing by sheep and are presently grazed from July 1 until early September. Some use is made by mule deer, and these areas support dense populations of pocket gophers and meadow mice.

Six levels of nitrogen and phosphorus were applied in the form of ammonium sulfate and treble super phosphate. The application rates of available nitrogen and available phosphorus in pounds per acre were: N30, N60, P30, P60, N30P30 and N60P60. These treatments, along with a control plot, were arranged in a randomized block design with 4 replications. Each treatment was applied with a cyclone seeder in strips $15 \times 125$ feet, and each replication was fenced to exclude livestock. Fertilizers were applied once in September of 1965.

Plots were harvested in early August after plants had achieved their maximum growth. Treatments were clipped by hand, and weights converted to pounds per acre air dry weight.

Material for nutrient analysis was collected during the last week in July. Seven species were collected at the flowering stage. Randomly selected plants of each species were collected and used to form a composite sample. Leaves, stems and flowers were included in the samples. These samples were air dried, ground in a Wiley mill, and analyzed for total nitrogen, percent phosphorus and gross energy.

Data were subjected to an analysis of variance, and separation of significant means at the 5% level was

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FIG. 1. General view of meadows on the study area.

determined by Duncan's (1955) multiple range test.

## Results and Discussion

### Production

The greatest production, for 2 of the 3 years, was obtained from the N60P60 treatment (Table 1). In 1966 and 1967 significant differences were found between treatments. In 1966 the N60P60 (836 lb./acre), N60 (728 lb./acre), N30P30 (697 lb./acre), and P30 (675 lb./acre) treatments were significantly greater than the control (470 lb./acre). In addition, the N60P60 treatment was significantly greater than N30 (537 lb./acre). In 1967 all treatments were significantly greater than the control, but in 1968 no significant differences were found, although fertilization still produced a visual response over the nonfertilized control.

A tremendous increase in production was observed the second year following application for each treatment and the control. This increase was thought to be due, at least in part, to an increase in precipitation (41.9 inches) compared to the previous year (21.3 inches), or the following year (26.0 inches). The increase in summer precipitation was reflected in the higher production during the growing season.

### Phosphorus

The highest levels of plant phosphorus were obtained from the high levels of phosphorus fertilization (Table 2). In 1966 the N60P60 produced the highest level of plant phosphorus (0.24%). The P60 and N60P60 treatments produced equal results in 1967 (0.29%) and for the 3-year average (0.28%), but in 1968 the P60 was the highest (0.34%).

Highly significant differences between treatments were found for each year and for the 3-year period. In 1966 the N60P60 treatment (0.24%) was significantly greater than all other treatments or the control. In addition, all phosphorus treatments were significantly greater than the nitrogen fertilizers alone or the control. In 1967, 1968 and over the 3-year period all phosphorus treatments were significantly greater than the nitrogen alone or the control.

Decrease in phosphorus content was not found when nitrogen was applied as was reported by Smika et al. (1960) and Cosper and Thomas (1961), nor did phosphorus content increase with increasing amounts of nitrogen as reported by Lavin (1967). Table 2 indicates little or no differences between either level of nitrogen and the control nor did the nitrogen in combination with phosphorus significantly increase the phosphorus content over the phosphorus alone, at the same levels of application.

The phosphorus content of the forage plants was never below the requirement for lactating animals (0.21%) as set by Cook and Harris (1968), except the control, N30, and N60 treatments during 1966 (Table 2). It should be noted, however, that the phosphorus content during

**Table 1. Forage production in pounds per acre.**

| Years | Treatment[1] | | | | | | | Significance[2] |
|---|---|---|---|---|---|---|---|---|
| | Control | N30 | N60 | P30 | P60 | N30P30 | N60P60 | |
| 1966 | 470e | 537bcde | 728ab | 675abcd | 628abcde | 697abc | 836a | * |
| 1967 | 1486g | 2151abcdef | 2569abc | 2263abcde | 2496abcd | 2604ab | 2730a | * |
| 1968 | 938 | 1123 | 1154 | 1192 | 1058 | 1170 | 1214 | N.S. |
| Avg | 965g | 1270bcdef | 1484abc | 1377abcde | 1394abcd | 1490ab | 1593a | * |

[1] Values followed by the same letter are not significantly different at the 5% level.
[2] * Significant at 5% level.

**Table 2. Percent phosphorus in forage samples.**

| Years | Treatment[1] | | | | | | | Significance[2] |
|---|---|---|---|---|---|---|---|---|
| | Control | N30 | N60 | P30 | P60 | N30P30 | N60P60 | |
| 1966 | 0.17e | 0.17e | 0.16c | 0.21b | 0.21bcd | 0.21bc | 0.24a | * |
| 1967 | 0.21e | 0.21e | 0.21e | 0.27abcd | 0.29ab | 0.27abc | 0.29ab | * |
| 1968 | 0.25de | 0.25de | 0.25de | 0.30abcd | 0.34a | 0.32abc | 0.33ab | * |
| Avg | 0.21e | 0.21e | 0.20e | 0.26cd | 0.28ab | 0.27abc | 0.28a | * |

[1] Values followed by the same letter are not significantly different at the 5% level.
[2] * Significant at 5% level.

1966 and 1967 was borderline or deficient for the nonphosphorus fertilized plots. Phosphorus fertilization did provide a margin of safety for lactating animals.

### Crude Protein

Crude protein content of the plants was increased by the application of fertilizers the first year only. In 1966 protein levels in plants from the N60 (11.80%) and N60P60 (11.69%) were significantly greater than those of the N30P30 (11.05%), P60 (10.99%), N30 (11.64%), and control treatments (10.37%). All levels of nitrogen fertilization and the P60 treatments produced significantly greater crude protein levels than the control. Differences approached significance in 1967 but in 1968 no significant differences were found (Table 3).

In nearly all cases, the highest levels of protein were obtained from the high levels of nitrogen either alone or in combination with phosphorus.

Phosphorus in combination with nitrogen did not significantly decrease plant crude protein content when compared with nitrogen alone as reported by Smika et al. (1960). In most years both levels of phosphorus alone produced slightly higher crude protein levels than did the controls.

### Gross Energy

The rates of fertilization used in this study did not produce a marked effect on the gross energy content of the plants (Table 4).

Only during the first year was there a significant difference between treatments. At that time the N60 treatment (4485 kcal/kg) was significantly greater than all treatments except N60P60 (4472 kcal/kg).

No significant differences were found during 1967, 1968 or for the 3-year averages.

## Conclusions

An increase in forage production, phosphorus, crude protein, and gross energy content was obtained by the application of low levels of nitrogen and phosphate fertilizers. The residual effect of the one application carried over for two growing seasons in production, three growing seasons for phosphorus and one growing season for crude protein and gross energy.

A visual difference between treatments was obvious during the first 2 years of the study. These differences were noted in production and color of the plants. Nitrogen fertilized plants were a darker green color.

The greatest average production for the 3-year period was obtained from the N60P60 (1593 lb./acre) followed in order by the N30P30 (1490 lb./acre) and N60 (1484 lb./acre).

The most striking effect of fertilization was the increase in phosphorus content. All phosphorus treatments resulted in considerable increases in phosphorus content over the treatments not receiving phosphorus.

It appears from this study, that the above rates of fertilizer would not produce a marked effect on the gross energy content of the plants.

This study indicates that low rates of fertilization are an effective means of increasing forage production and nutrient content on high elevation native meadows.

**Table 3. Percent crude protein in forage samples.**

| Years | Treatment[1] | | | | | | | Significance[2] |
|---|---|---|---|---|---|---|---|---|
| | Control | N30 | N60 | P30 | P60 | N30P30 | N60P60 | |
| 1966 | 10.37fe | 11.46abc | 11.80a | 10.68dcf | 10.99cde | 11.05cd | 11.69ab | * |
| 1967 | 12.74 | 13.00 | 13.15 | 12.77 | 12.96 | 13.14 | 13.89 | N.S. |
| 1968 | 14.43 | 15.51 | 15.21 | 14.32 | 15.05 | 15.08 | 15.95 | N.S. |
| Avg | 12.51d | 13.32abc | 13.38ab | 12.59bcd | 13.00bcd | 13.09abcd | 13.84a | * |

[1] Values followed by the same letter are not significantly different at the 5% level.
[2] * Significant at 5% level.

**Table 4. Gross energy (kcal/kg) in forage samples.**

| Years | Treatment[1] | | | | | | | Significance[2] |
|---|---|---|---|---|---|---|---|---|
| | Control | N30 | N60 | P30 | P60 | N30P30 | N60P60 | |
| 1966 | 4440bcd | 4448bc | 4485a | 4412d | 4414cd | 4426cd | 4472ab | * |
| 1967 | 4307 | 4389 | 4378 | 4334 | 4339 | 4323 | 4342 | N.S. |
| 1968 | 4478 | 4488 | 4488 | 4485 | 4483 | 4495 | 4467 | N.S. |
| Avg | 4408 | 4442 | 4450 | 4410 | 4395 | 4415 | 4427 | N.S. |

[1] Values followed by the same letter are not significantly different at the 5% level.
[2] * Significant at 5% level.

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