Influence of Phosphorus Fertilizer Placement on two Nebraska Sub-irrigated Meadows[1]

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Highlight

On two Nebraska sub-irrigated meadows drilling phosphorus fertilizer at a depth of 3 to 4 inches resulted in lower dry matter yields and lower percentages of phosphorus as compared with surface application. By labelling superphosphate (35 lb P/ac) with ^{32}P it was shown that grasses, which constituted the bulk of the forage, took up less fertilizer phosphorus when the latter was drilled in than when applied on the surface.

In general, the sub-irrigated meadows of the Nebraska Sandhills have shown responses to both phosphorus and nitrogen fertilization (Brouse and Rhoades, 1960; Russell et al., 1965). Since fertilizers have been applied on the sub-irrigated meadows almost exclusively by surface broadcasting, a comparison between surface application and drilling of phosphorus fertilizer was made.

Soils and vegetation at the two sites used in this study have been described by Moore and Rhoades (1966). Both soils were sandy but the soil at site 1 was alkaline throughout the profile (pH 7.3 to 8.0 to 40-inch depth) while that at site 2 was mildly acidic (pH 5.9 to 6.7).

Red clover (*Trifolium pratense*) was present at both sites and alsike clover (*T. hybridium*) at site 2. Grasses at site 1 included redtop (*Agrostis alba*) and Kentucky bluegrass (*Poa pratensis*) but were mainly late-maturing species, viz. prairie cordgrass (*Spartina pectinata*), bluestems (*Andropogon gerardi* and *A. scoparius*), indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*). Prairie cordgrass was present at site 2 also but the grasses were dominated by early-maturing species, viz. redtop, Kentucky bluegrass and timothy (*Phleum pratense*). Both sites carried some rushes, sedges and forbs.

A randomized block design with four replications was used. Ammonium nitrate (0 and 80 lb N/ac) was applied by broadcasting on the surface. Four rates of triple superphosphate (0, 35, 105, 315 lb P/ac) were applied in bands 8 inches apart either on the surface or drilled in at a depth of 3 to 4 inches. It is possible that the drilled bands occupied more restricted volumes than the surface applied bands. Superphosphate labelled with ^{32}P was used for the 35-lb rate. Treatments were applied in April 1955 and forage harvested in July 1955 and 1956. Small samples of forage were also taken from the ^{32}P-labelled plots on five occasions during the growing season of 1955. Only the effect of drilling superphosphate is reported in this note; the responses of the meadows to surface application of nitrogen and phosphorus fertilizers were similar to those reported by Russell et al. (1965).

Botanical Composition

Forage density measurements were made on May 31, 1955, using the point-quadrat method. Over-all density of cover was decreased slightly (7 to 8%) by drilling. On site 1 drilled plots showed a higher percentage of legumes than surface application plots and on site 2 a lower percentage. In both cases the response was associated with red clover. Late-maturing grass percentages were lower on the drilled plots (compared with surface banded plots) at both sites while early-maturing grass percentages were higher on the drilled plots at site 2 and were unchanged at site 1.

Drilling killed much vegetation adjacent to the drill-rows. Site 2 had a high proportion of actively-growing, early-maturing grasses. These grasses tillered and occupied much of the drill-row space and also suppressed legume growth. On site 1, however, the lesser proportion of early-maturing grasses allowed the legumes to occupy space provided by the elimination of late-maturing grasses which were still comparatively inactive.

Dry Matter Yields

In the first season drilling produced lower yields compared with surface application (Table 1) due to killing of some plants by the drill. Drilling

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Table 1. Yields of dry matter (100 lb/acre) from surface application and drilling. Values are means for two nitrogen and four phosphorus fertilizer rates.

Site no.	1955 Surface applic.	1955 Drill[1]	1956 Surface applic.	1956 Drill[1]
1	25	20	18	20
2	34	30	15	15

[1] Drilling resulted in a significantly ($P < 0.01$) lower yield at both sites in 1955 and higher yield at site 1 in 1956, compared with surface application.

Table 2. Phosphorus uptake by meadow vegetation as influenced by rate and placement of phosphorus fertilizer (1955). Values are means for two nitrogen fertilizer rates.

Superphosphate added lb P/acre	P, % Surface application	P, % Drilled[1]	P, lb/acre Surface application	P, lb/acre Drilled[1]
Site 1				
0	0.08	0.08	0.9	0.8
35	0.14	0.12	3.7	2.4
105	0.18	0.15	5.4	3.7
315	0.20	0.16	6.1	4.4
mean	0.15	0.13	4.0	2.8
Site 2				
0	0.11	0.14	3.2	3.0
35	0.18	0.17	6.2	5.2
105	0.25	0.20	8.3	6.9
315	0.33	0.29	12.2	9.2
mean	0.22	0.20	7.5	6.1

[1] Drilling resulted in significantly ($P < 0.01$) lower percentages and yields of phosphorus at both sites, compared with surface application.

resulted in a slightly higher yield at site 1 in the second season (1956), possibly because early-maturing grasses became established during the spring in areas where late-maturing grasses had been killed in the previous season. The early maturing grasses set seed before harvest.

The over-all lower yields at site 2 in 1956 paralleled a 30% lower control yield in that year as compared with 1955. A major contributing factor in this lower yield was probably moisture deficiency from the end of June 1956 onwards as the water table was 36 inches below the surface at this time (vide Moore and Rhoades, 1966). On the other hand, at site 1 control yields were similar for the two years (cf. the drilled plots, Table 1) and the marked decrease on the plots receiving surface applications may reflect phosphate fixation in the surface layer.

Phosphorus Uptake

There were lower mean phosphorus percentages in forage from the drilled plots at both sites in 1955 (Table 2). There was a similar residual effect in 1956. Total phosphorus yields were also lower on drilled plots as compared with surface application plots (Table 2). Non-legumes exhibited a lower root activity at drill depth than at or near the surface and, since they constituted the greater part of the vegetation, the percentage of phosphorus in the forage was lower when the phosphorus fertilizer was drilled into the sod. In addition, the drying out of the sod immediately adjacent to the drill-rows could have resulted in positional unavailability of some of the fertilizer phosphorus. At site 2 decreased phosphorus uptake would also have resulted from the decrease in legume stand as a result of drilling.

Utilization of Fertilizer Phosphorus

Non-legumes showed a lower utilization of fertilizer phosphorus at both sites as a result of drilling. On site 1, red clover used a small proportion of fertilizer phosphorus on the drilled plots at the beginning of the season, but by the end of the season the utilization from surface applied and drilled phosphate was about equal (Table 3). For red clover on site 2, except for the first cutting, the drilled plots showed a higher utilization of fertilizer phosphorus throughout (data not shown).

Phosphate fertilizer in the soil shows little movement and hence a differential uptake with different placement depths would be expected, since root activity is not uniform throughout a profile. It appears from the literature (e.g. Lawton et al., 1954) that grasses have a higher root activity near the surface than at lower depths and our data support this, although a wider spread of the surface applied bands may be involved also. Although root weight and nutrient uptake are not necessarily related, in these sub-irrigated meadows the weight of roots in the upper 2 inches (control plots) was 3.7 tons/acre for both sites, 0.7 and 1.1 tons in the 2 to 4 inch layer at sites 1 and 2, and 0.4 and 0.6 ton in the 4 to 6 inch layer respectively (Moore and Rhoades, 1966). Most of these roots were grass.

Generally, legumes absorb more fertilizer phosphorus at depths of 2 to 4 inches than they do from surface applications (Lawton et al., 1954; Lipps and Fox, 1964). Red clover on site 2 followed this pattern throughout the season while that on site 1 showed a tendency towards slightly greater activity at the 3 to 4 inch depth near the end of the season. Both showed lower activity at this depth than at the surface early in the season. This may be attributed to lower temperatures below the surface and to some disruption of roots caused by the drill.

Table 3. Influence of drilling on the utilization of fertilizer phosphorus at site 1 (1955), as shown by percentages of phosphorus in plant material derived from fertilizer.

Sampling date	Red clover S[1]	Red clover D[1]	Non-legumes S	Non-legumes D	Total vegetation S	Total vegetation D
May 15	53	20	32	11	44	12
May 30	56	48	29	15	44	22
June 13	84	76	40	23	58	36
July 1	82	86	38	25	63	59
July 15	89	90	44	28	66	62

[1] S and D refer to surface application and drilling respectively.

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