RESPONSES OF ALFALFA AND BARLEY TO FOLIAR APPLICATION OF N AND P ON A COAL MINE SPOIL*

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SUMMARY
To ensure adequate growth of plants on the highly impoverished and erodable surface mined lands, the application of N and P fertilizers by suitable methods is essential. In the present study, five growth chamber experiments were conducted to evaluate the relative efficacy of foliar and spoil application of N and P using alfalfa (Medicago sativa L. var. Erand) and barley (Hordeum vulgare L. var. Manker) as test crops on a freshly exposed coal mine spoil collected from western North Dakota. In general, barley responded to both N and P, but alfalfa mainly to P. Growth responses of barley to foliar or spoil-applied N + P were substantial and similar in magnitude. However, the yields were much higher when the plants received 3-4 sprays of 1.5-2.2% urea, with P supplied through the spoil. Increasing the number of 2.2% urea sprays from 1 to 3 increased the growth response from 40 to 243%. In another study, increasing the concentration of foliar-applied urea from 0 through 1% resulted in further increases in the dry weights of barley at all the levels of spoil-applied (0, 25, 75, 225 µg/g) N.

Foliar sprays of 0.5-1.0% NaH2PO4 increased the dry weights of alfalfa and barley by an average of 366% and 86%, respectively. However, the yield response of alfalfa to spoil-applied P (100 µg/g) was as high as 78% compared to only 11% for barley. Alfalfa responded significantly to increasing concentrations of H3PO4 (0-0.3%) in foliar sprays only in the absence of spoil-applied P. With increasing rates of spoil-applied P, alfalfa yields increased steadily, but additional supply of P sprays caused leaf burning which intensified as the P concentration in sprays increased.

The results of chemical analyses indicated that foliar applications were more effective than soil applications in increasing the concentration of N or P in the plants. Moreover, urea sprays increased the uptake of K, Zn, and Fe in barley, whereas spraying alfalfa with P compounds caused increases in its K and Fe content and decreases in those of Zn and Na. The results of these experiments indicated that the nutritional requirements of plants grown on coal mine spoils can be met through foliar fertilization as effectively as, or better than, through conventional soil fertilization methods.

INTRODUCTION
Deficiencies of N and P are among the important growth limiting factors in the revegetation of coal-mined lands of North Dakota. Although some of the

shale overburden materials have been found to contain appreciable amounts of fixed and exchangeable \(\text{NH}_4^+\), the availability of indigenous as well as fertilizer N to plants grown on western mine spoils or reconstituted mine soils is often low compared to undisturbed soils\(^{13,14}\). Likewise, phosphorus deficiency is also widespread and often severe enough to restrict the seedling establishment and growth of many desirable species on the mined lands of North Dakota. Applications of suitable fertilizers to the spoil material have been found to increase the yield of many grasses and legumes\(^{16}\). However, due to the highly erodable nature of the surface mined lands\(^7\), applications of fertilizers to the spoils can result in appreciable losses of these nutrients in particle bound and soluble forms, and hence increase the risk of environmental contamination\(^5,8,22\).

To face this dual challenge, imposed by the necessity of, and the limitation in fertilizing the spoils, it may be more practical to use foliar fertilization as a means of meeting in part the nutritional requirements of planted species on the mined lands. Foliar application of macro- and micronutrients is already an accepted agricultural practice\(^{23,24}\), but for mined lands it has not as yet received much attention. The usefulness of foliar fertilization to circumvent the problems caused by soil fixation of some nutrients\(^3\), and the importance of late season NPKS sprays in increasing legume yields\(^6,20\) have provided much stimulus for further research.

Thus, in order to assess the feasibility of this approach and to determine the appropriate methods of foliar fertilization relevant to mine spoil revegetation, alfalfa and barley plants were grown on a freshly exposed coal mine spoil in controlled environment chambers. The objectives of this investigation were to study 1) the effects of different frequencies and concentrations of N, P, and N + P sprays on the growth and chemical composition of the two species, and 2) to compare their responses to foliar, spoil, and foliar + spoil methods of nutrient applications.

MATERIALS AND METHODS

Using alfalfa (\textit{Medicago sativa} L. var. Erand) and barley (\textit{Hordeum vulgare} L. var. Manker) as test plants, five pot culture experiments were conducted on a coal mine spoil collected from South Beulah, North Dakota. The spoil was calcareous (\(\text{CaCO}_3\), 5.2%), moderately saline (\(\text{EC}_w\), 5.6; SAR, 11.2) with saturated paste pH of 7.0. Its \(\text{NaHCO}_3\)-extractable P content\(^{12}\) was 2.8 \(\mu\text{g/g}\) and its total N content averaged 0.12%. All the experiments were conducted in growth chambers maintained at 25°C day/15°C night temperature, 12 hour photoperiod, and 50–60% relative humidity. Plants were raised in undrained, polyethylene-lined pots containing 400 g of air-dried and pulverized spoil. Irrespective of species or treatment, 10 plants were allowed to grow in each pot receiving deionized water for irrigation as and when needed. Care was taken to avoid water-logging. All treatments were replicated thrice. The specific details of each experiment are given below: