TECHNICAL NOTES

Growth Response of Two Saltbush Species to Nitrate, Ammonium and Urea Nitrogen Added to Processed Oil Shale

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Abstract

Nitrate nitrogen promoted good growth of cuneate saltbush *(Atriplex cuneata)* and gardner saltbush *(A. gardneri)* on processed oil shale in a glasshouse pot experiment, but ammonium and urea nitrogen were not utilized effectively in growth.

Processed oil shale is virtually devoid of plant available nitrogen (Institute for Land Rehabilitation 1979 and Berg 1973). This deficiency can be corrected by fertilizer application but the chemical form of the nitrogen applied may affect the plant response. For example, tobacco growth in sand culture was much greater when the nitrate form of nitrogen was supplied in the nutrient solution than when ammonium was the nitrogen source (McEvoy 1946). Greater growth response to nitrate than ammonium nitrogen was also observed for tobacco and tomato on fumigated soils in which nitrification activity by soil microorganisms had been retarded (McCants et al. 1959; Morris and Gidden 1963).

Having been mined from underground and retorted at high temperature, processed oil shale is biologically sterile and thus microbial nitrogen transformations would not occur. An experiment was conducted to determine how two salt tolerant subshrubs from northeastern Utah, cuneate saltbush *(Atriplex cuneata)* and gardner saltbush *(Atriplex gardneri),* would respond to nitrate, ammonium and urea nitrogen added to processed oil shale.

Methods

Plastic cottage cheese cartons (24 oz. size) without drain holes were filled with 700 grams of air dry, quarter-inch-screened paraho processed Colorado oil shale. The shale had an ECe of 10.6 mmho/cm and a pH of 9.0. Phosphorus as NaH_2PO_4 was added to each pot at the rate of 46 ppm. Nitrogen was applied at the rate of 40 ppm as either urea, $(NH_4)_2SO_4$, NH_4Cl, $NaNO_3$ or $CA(NO_3)_2$. An additional treatment of 80 ppm N as Ca $(NO_3)_2$ was also included. Rooted cuttings of cuneate saltbush and gardner saltbush were then planted in the fertilized shale. Distilled was added by weight daily to maintain a soil moisture percentage of 23.5. There were 5 replications of each fertilizer treatment per species. Shoots were harvested 60 days after planting, and oven-dry weights were measured.

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Table 1. Dry weights (g) of cuneate saltbush and gardner saltbush shoots[1] grown on processed oil shale treated with various forms of N fertilizers.

Fertilizer	ppm N	A. cuneata	A. gardneri
Urea	40	0.5150 a	0.3732 a
$(NH_4)_2SO_4$	40	0.3260 a	0.2014 a
NH_4Cl	40	0.3402 a	0.2478 a
$NaNO_3$	40	0.9324 b	0.8261 b
$Ca(NO_3)_2$	40	1.1878 c	0.7715b
$Ca(NO_3)_2$	80	1.7834 d	1.5622 c

[1] Means followed by the same letter within each species are not significantly different at the .01 level using Duncan's multiple range test.

Results and Discussion

There was a much greater growth response by both species to the nitrate form of nitrogen than to ammonium or urea nitrogen (Table 1). Apparently, ammonium or urea were either less available than nitrate or were toxic. Ammonia toxicity is a possibility when ammonium salts are applied to alkaline processed oil shale. At a pH of 9 for the processed shale used in this study much of the ammonium (NH_4^+) is converted to ammonia (NH_3) (DuPleiss and Kroontje 1964), and NH_3 at external concentrations of only 0.15 to 0.20 millimoles per liter have been shown to be toxic to seedlings of several crop species (Bennett and Adams 1970). Urea may also be toxic to plant roots (Cook 1962).

Ammonium may have been less available for absorption due to volatilization loss of NH_3 which is enhanced at high pH (Fenn and Kissell 1975). Under field conditions, the high surface temperatures (Striffler et al. 1974) that may develop in the black-colored processed oil shale would tend to increase volatilization of ammonia. Incorporation of ammonium fertilizers into processed shale rather than just applying them to the surface should decrease volatilization loss.

It does not seem likely that the lack of growth by cuneate and gardner saltbushes when processed oil shale was fertilized with ammonium salts was due to an inability to absorb NH_4^+. Two other saltbush species, fourwing saltbush *(Atriplex canescens)* and shadscale *(Atriplex confertifolia),* were both able to absorb NH_4^+ and nitrate (NO_3^-) equally well (Wallace et al. 1978). However, it is not known what metabolic or other effects high internal concentrations of NH_4^+ versus NO_3^- might have on these saltbush species.

Poor utilization of urea by the saltbushes in this study may have been related to the biological sterility of processed oil shale. The lack of ammonifying and nitrifying bacteria may have rendered urea nitrogen unavailable. This problem could be overcome by inoculating processed shale with topsoil containing these microorganisms. Inoculation would eventually occur through wind transport of soil particles, but the process would be speeded by mechanically spreading topsoil or mixing topsoil into the shale. The soil surrounding the roots of container-grown transplants might also serve as a source of inoculum.

The significantly greater growth of cuneate saltbush with calcium nitrate ($Ca(NO_3)_2 \cdot 4H_2O$) than with sodium nitrate ($NaNO_3$) could indicate a high calcium requirement for this species. However, the high calcium content of untreated processed oil shale (Berg 1973) casts some doubt upon this interpretation. The true reason for this result remains to be learned.

In conclusion, nitrogen dynamics in processed oil shale and the mineral nutrient requirements of native plant species are poorly understood. The results of this experiment do suggest that growth of cuneate saltbush and gardner saltbush, and perhaps other species, on unmodified processed oil shale will require fertilization with nitrate nitrogen.

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