AN ABSTRACT OF THE THESIS OF

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Greenhouse and laboratory experiments were conducted to determine the effect that two by-products of Ni refining--a waste material or tailings and a potential slow-release N and P fertilizer-- would have on plant growth and soil properties.

The tailings contained soluble salts (7.6 mmhos/cm), NH_4-N (377 µg/g), Ni (0.28%), Mn (82 µg/g DTPA-extractable), Cr (0.44%), P (2 and 6 µg/g acid fluoride- and $NaHCO_3$- extractable, respectively). Water leaching decreased the NH_4^+ concentration and electroconductivity to levels satisfactory for plant growth by removal of $MgSO_4$ and $(NH_4)_2SO_4$ salts.

Tall fescue (*Festuca arundinacea* Schreb.) was grown on Eightlar soil amended with 0, 223, 446, 669 g tailings/kg soil and on pure, unleached tailings for 32 weeks in the greenhouse. Seedling establishment of plants grown on soil amended at the highest tailings rate and the pure tailings was initially slow, but plants grown on soils amended at lower rates established readily and grew well.

Ammonium-N decreased in all treated soils over the 32 weeks while NO_3-N substantially increased on soils amended with 669 g/kg and pure tailings. The N concentration of tall fescue usually decreased with

decreasing application of tailings, to levels below 2.5% N by the fourth cutting for plants grown on the unamended soil and soil amended with 223 and 446 g tailings/kg. Soil and plant P and Ca remained low throughout the growth period even though $Ca(H_2PO_4)_2$ and gypsum had been added. The Mn, Ni, and Cr concentrations of tall fescue grown on treated soils were within normal ranges although soil analyses for Ni and Cr were higher than commonly found.

The $MeNH_4PO_4$ (the potential fertilizer product) contained 5.0% N, 9.5% P, 6.5% Mg, 0.56% Mn, 0.13% Ni, 22 µg/g Cu, 0.50% S, and trace amounts of K, Ca, Zn, and Fe. Ammonium from $(NH_4)_2SO_4$ comprised 93% of the water soluble NH_4^+ after 24 and 48 hours of shaking. Phosphorus, Mg, Ca, Mn, and Ni in solution were present in approximately the same ratio as in the total analysis.

Tall fescue was grown on Amity, Barron, and Kerby soils amended with 0, 24, 73, and 122 mg N/kg soil from $MeNH_4PO_4$, $MgNH_4PO_4$, or $NH_4H_2PO_4$ (MAP) for 32 weeks in the greenhouse. Inoculated white clover (<u>Trifolium repens</u>) was grown on the same soils amended with 0 or 24 mg N/kg. Magnesium, K, and S were balanced across fertilizer materials by the addition of $MgCl_2 \cdot 6\ H_2O$, KCl, K_2SO_4, or $CaSO_4 \cdot 2\ H_2O$.

Yields and N concentration of tall fescue grown on soils amended with $MeNH_4PO_4$ were higher than for plants grown on soils amended with $MgNH_4PO_4$ or MAP. Yields of white clover were highest for plants grown on soils amended with MAP.

The Mn concentration of tall fescue and white clover grown on amended soils increased in the order: $MgNH_4PO_4 < MeNH_4PO_4 <$ MAP. The pH was lowest for soils amended with MAP and highest for soils amended with $MgNH_4PO_4$. Fertilizer amendments of Cl^-, KCl and $MgCl_2$, were applied to soils amended with MAP and, except for the Barron soil, not at all to soils amended with $MgNH_4PO_4$. Soils amended with $MeNH_4PO_4$ had KCl only applied. The Ni concentration of tall fescue and white clover was below 5 µg/g on amended and unamended soils, although plants amended with $MeNH_4PO_4$ contained the highest Ni concentrations.

It was concluded that the $MeNH_4PO_4$ is a suitable fertilizer material, performing as well as commercial $MgNH_4PO_4$ and MAP; and that the tailings material can support plant growth. However, the tailings should be leached to reduce NH_4-N and soluble salts to levels more conducive to seedling establishment.

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INTRODUCTION

The United States currently imports approximately 90% of the Ni it uses, although domestic Ni resources account for over 12% of the world's total resources (Siemens and Corrick, 1977). A nickel silicate deposit (1.5% Ni), located near Riddle, OR, is the only domestic nickel reserve currently being mined. The largest domestic Ni resource is a NiS deposit (0.21% Ni) located in northeastern Minnesota (Cornwall, 1973). Deposits of nickeliferous iron laterites (0.8-1.3% Ni) located in southwestern Oregon and northern California comprise the second largest domestic Ni resource.

Current refining techniques, pyrometallurgy and H_2SO_4 leaching, are not suitable for the Ni laterites because of the high electrical energy requirements and large amount of acid needed for the extraction. The Bureau of Mines has developed a reduction-ammoniacal leach-electrowinning extraction process to recover Ni, Co, and Cu from the laterites (Siemens and Corrick, 1977). In the extraction process, the ore is dried, crushed, and selectively reduced with CO at 525°C, followed by leaching with NH_4OH and $(NH_4)_2SO_4$. The solid waste, or tailings, is separated from the metal-rich liquid by centrifugation. Magnesium and Mn impurities in the liquid are removed by precipitation using $NH_4H_2PO_4$ followed by solvent extraction and electrowinning which recovers 92.7% of the Ni and 91.4% of the Co (Siemens and Corrick, 1977). The tailings are washed to recover NH_3, dried, ground, and would be returned to the mine site for revegetation. The $MeNH_4PO_4$

(Me = Mg and Mn predominantly) is a potentially-marketable slow-release N and P fertilizer.

The objectives of this study were:

1) To examine the tailings material as a medium for tall fescue (*Festuca arundinacea* Schreb.) establishment; and

2) To assess the suitability of the $MeNH_4PO_4$ as a fertilizer material for tall fescue and New Zealand white clover (*Trifolium repens*).

PLANT AND SOIL REACTIONS TO NICKEL ORE PROCESSED TAILINGS[1]

P. J. Sheets, V. V. Volk, and E. H. Gardner[2]

ABSTRACT

Greenhouse and laboratory experiments were conducted to determine the effect that tailings produced during Ni and Co extraction would have on plant growth and soil properties. The tailings contained soluble salts (7.6 mmhos/cm), NH_4-N (877 µg/g), Ni (0.28%), Mn (82 µg/g DTPA extractable), Cr (0.44%), P (2 and 6 µg/g acid fluoride- and $NaHCO_3$-extractable, respectively), Ca and Mg (1.0 and 20.7 meq/100 g NH_4Ac-extractable, respectively). Water leaching decreased the NH_4-N concentration to 53 µg/g and the EC to 0.4 mmhos/cm by removal of $(NH_4)_2SO_4$ and $MgSO_4$ salts. Tall fescue (<u>Festuca arundinacea</u> Schreb.) was grown on Eightlar soil amended with 0, 223, 446, 669 g tailings/kg soil and pure, unleached tailings for 32 weeks in the greenhouse. Seedling establishment of plants grown on soil amended at the highest tailings rate and the pure tailings was initially slow, but plants grown on soil amended at lower rates established readily and grew well. Plant P was <0.24%, while plant Ca concentrations were <0.45% throughout the growth period even though $Ca(H_2PO_2)_2$ and gypsum had been added. Ammonium acetate-extractable Ca at the end of the growth period was <5.0 meq/100 g on all

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amended soils. The Mn, Ni, and Cr concentrations of plants grown on treated soils were within normal ranges although soil analysis values were higher than commonly found. It is recommended that the tailings be washed to reduce NH_4-N and soluble salts prior to revegetation and that native soil be added to the surface to reduce crusting.

Additional Index Words: tall fescue, ammonium, soluble salts, phosphorus, calcium, serpentine soils.

Nickeliferous iron laterites, formed from serpentinitic weathering, are a potential domestic source of Ni and Co. Deposits of Ni in southwestern Oregon and northern California, estimated at 565,000 tons (Cornwall, 1973), contain 0.5 to 1.2% Ni primarily in the mineral goethite, 0.06 to 0.25% Co in a manganese oxide wad, and 2% Cr as chromite (Siemens and Corrick, 1977).

The only operating Ni smelter in the U.S., located near Riddle, OR extracts Ni from a Ni silicate (1.5% Ni) by pyrometallurgy (Siemens and Corrick, 1977). Commercial processing methods (pyrometallurgy and acid leaching with H_2SO_4) are not feasible for extracting Ni from the lower-grade laterites because of the high electrical energy requirements and the high Mg content of the ore. The Bureau of Mines has developed a reduction-leaching extraction procedure which may allow economic refining of the ore.

To extract the Ni and Co, the ore is dried, crushed, and selectively reduced with CO at 525°C, followed by leaching with NH_4OH and $(NH_4)_2SO_4$. The solid waste, or tailings, is separated from the metal-rich liquid by centrifugation. Magnesium and Mn impurities in the liquid are removed by precipitation using $NH_4H_2PO_4$ followed by solvent extraction and electrowinning which recovers 92.7% of the Ni and 91.4% of the Co (Siemens and Corrick, 1977). The tailings are washed to recover NH_4^+, dried, ground, and would be returned to the mine site for revegetation.

Revegetation of mine spoils can be difficult. Leaching to reduce NH_4^+ and soluble salt concentrations plus the addition of fertilizer P and K were necessary for the successful establishment of salt-tolerant Rhodes grass (Chloris gayana) on alkaline Ni refining wastes in

Australia (Bell and Evans, 1980). The mine wastes initially were saline (EC 6.4 mmhos/cm), low in available P (5 μg/g) and K (0.05 meq/100 g), and contained concentrations of NH_4^+ (167 μg/g) and Ni (13 μg/g DTPA-extractable) that might be toxic to plants.

Ammonia toxicity symptoms, stunted dark-bluish leaves lacking turgidity, were found in sudangrass while cotton plant roots were discolored when the NH_3(aq) concentration exceeded 0.15-0.20 mM (Bennett and Adams, 1970). The concentration of NH_3(aq) in a system is related to pH and NH_4^+ concentration by hydrolysis of the NH_3,

$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$.

Electrical conductivity values between 8 and 16 mmhos/cm have been shown to reduce yields of all but salt tolerant crops (e.g., barley, bermuda grass, tall wheatgrass) (Bernstein, 1964). During the sensitive stages of early seedling growth for grasses, water with an EC value above 4 mmhos/cm can be deleterious to plant growth. Additionally, high concentrations of Mg^{2+} and SO_4^{2-} may cause insufficient uptake of Ca (U.S. Salinity Laboratory Staff, 1954).

Calcium deficiencies of plants grown on serpentine soils is well documented (Martin et al., 1953; Walker et al., 1955; Jones et al., 1977). Acute Ca deficiency of tomato (Lycopersicon esculentum) and sunflower (Helianthus annuus) was found when the Ca level was below 10% of the CEC (Walker et al., 1955). Sunflowers (Helianthus bolanderi A. Grey) native to coastal California serpentine areas, however, tolerated Ca saturation levels as low as 2.8-5.0% of the CEC. Magnesium toxicity was implicated in both soil and solution culture experiments with oats (Avena sativa) and Agrostis stolonifera when the Ca concentration was low (10 µg/g Mg and <0.5 µg/g Ca in solution culture) (Proctor, 1970).

Low levels of extractable P are characteristic of serpentine soils. Phosphorus fertilization at 225 kg P/ha increased plant tissue P in subclover grown on serpentine soils as long as sufficient Ca was supplied (Jones et al., 1977).

Heavy metals, especially Ni and Cr, are often implicated as the cause of poor fertility in serpentine soils. The Ni content of most plants lies between 0.05-5 µg/g (Mishra and Kar, 1974) but oat plants grown on serpentine soils contained 12-44 µg/g Ni (Slingsby and Brown, 1977).

Chromium is present in serpentine soils predominantly as chromite ($FeCr_2O_4$) (Allaway, 1968). Chromite is relatively insoluble and therefore contains little "plant available" Cr. Chromium (VI) is water soluble and considered plant available. Chromium assimilated by plants remains in the roots, with very little translocation to the above-ground portions (Cary et al., 1977). Toxicity symptoms consist of blackened roots and withered tops with the leaves rolling around the shoot (Soane and Saunder, 1959).

The purpose of this study was: 1) to assess the physical and chemical properties of the residual tailings produced during the extraction of Ni and Co, and 2) to study the establishment, growth, and elemental composition of tall fescue grown in tailings-amended soil under greenhouse conditions.

MATERIALS AND METHODS

A bulk sample of the dried and ground tailings material was obtained from the Bureau of Mines, Albany, OR. The material was assayed for particle size (Bouyoucos, 1962); pH; EC; total N, NH_4- and NO_3-N; extractable P; exchangeable Ca, Mg and K; DTPA-extractable Mn and Ni (Berg and Gardner, 1978); and ammonium oxalate-extractable Fe (McKeague and Day, 1966).

Total elemental analysis was accomplished using an HF-HCl-HNO_3 pressure dissolution technique (Farrell et al., 1979). Tailings material (0.5 g air dry) was weighed into 250-ml polycarbonate bottles. Five milliliters of a 7:3 concentrated HF:HCl solution, and two ml of concentrated HNO_3 were added, the bottles capped, and placed in a shaker bath at 50°C. After 24 hours, 43 ml of 1.5% H_3BO_3 was added and the samples returned to the water bath for several hours, cooled, and filtered. Total Ni and Cr were determined on these solutions using a Perkin Elmer Model 306 atomic absorption spectrophotometer.

A leaching experiment was initiated to determine the dominant soluble salts in the tailings and to estimate the water required to reduce the conductivity to levels more amenable to plant growth. Duplicate plexiglass leaching columns, 15 cm long and 7 cm diameter, were constructed and packed with the tailings material (600 g). Distilled water (300 ml) was added to saturate the column, followed by a 50 ml addition daily for 28 days and 100 ml daily for 26 days. The effluent was collected daily and assayed for EC, NH_4-N, SO_4-S (Tabatabai and Bremner, 1970), Mg, Fe, Mn, Ni, Cu, Cr, and Cl^-.

Eightlar soil (clayey-skeletal, serpentinitic, mesic family of Typic Xerochrepts) was collected near one of the potential mine sites on

Eight Dollar Mountain near Cave Junction, OR. The soil was air dried and passed through a 1.2 cm sieve. Tailings and soil were mixed at rates of 0, 223, 446, 669 g tailings/kg soil and a 100% tailings rate. Phosphorus as $Ca(H_2PO_4)_2$ was added at rates of 11, 44 and 178 mg P/kg to all tailings-amended soils, and at 44 mg P/kg to the control soil. Potassium, as KCl, was added to each pot at the rate of 27 mg K/kg. Gypsum was added at rates of 1.4, 2.0, 2.6, 3.4 and 3.8 g/kg to the 0, 223, 446, 669 g/kg and 100% tailings rates, respectively. The gypsum supplied sufficient Ca to theoretically bring the Ca level of each treatment to a minimum of 5.0 meq/100 g of soil (Gardner and Warren, 1970). Ammonium sulfate was added (51 mg N/kg soil) to the control soil.

Treatments were replicated four times and pots arranged in the greenhouse in a randomized complete block design. Tall fescue (*Festuca arundinacea* Schreb.) was seeded at the rate of 25 seeds per pot and thinned to 12 plants/pot 10 days after germination. Plants were watered with distilled water (50-100 ml) according to plant requirements.

The plants were clipped to a height of 1.5 cm four times at eight-week intervals for a total growing period of 32 weeks. After cutting, plant samples were oven dried at 65°C for 2-3 days, dry weights recorded, and the samples ground in a Wiley mill.

Plant material (0.3 g) was weighed into digestion tubes and equal portions (1/4 tsp) of $Na_2S_2O_3$ and catalyst (100 g K_2SO_4, 5 g $CuSO_4$, 1 g Se powder) were added to each tube, followed by 10 ml of a H_2SO_4-salicylic acid mixture (74 g salicylic acid per 9 lb bottle concentrated H_2SO_4) (Bremner, 1965). Nitrogen and P were determined on a Scientific Instruments CFA-200 autoanalyzer.

Additional plant material (1.0 g) was weighed into 125-ml Erlenmeyer flasks and concentrated HNO_3 (12 ml) added, followed by concentrated $HClO_4$ (10 ml). Samples were heated on a hot plate until the solutions were clear, filtered, and brought to 100 ml volume with distilled water. The digests were assayed for Ca, Mg, and Mn by atomic absorption spectrophotometry. An aliquot (50 ml) taken from each $HClO_4$ digest was heated to dryness, 1.0 N HCl added (10 ml), and allowed to sit overnight. Nickel and Cr in the concentrated sample were then determined by atomic absorption spectrophotometry.

Soil samples were collected at the end of the growing period, air dried, passed through a 2 mm sieve, and assayed as described for the tailings material. Ammonium-N, NO_3-N, and P were determined on the autoanalyzer.

Data was arranged into a two-way factorial for the analysis of variance. Control and 100% tailings values were not included in the analysis. No statistical analysis was done for plant composition for the first two cuttings data due to insufficient plant material which necessitated combining replications for chemical analysis.

RESULTS AND DISCUSSION

Physical and Chemical Properties

The tailings received were a dry, fine (predominantly silt-size), black material, which were hydrophilic, yet upon drying formed a hard, cake-like substance. In the initial dry state the powdery tailings could be susceptible to wind erosion. Once wet and re-dried, however, they formed a hard crust which could present a barrier for seedling emergence. Chemical analysis of the tailings revealed potential limitations to plant growth including: high concentrations of soluble salts, NH_4-N, Mg, Ni, Cr, and Mn; and low P and Ca concentrations (Table 1). The high NH_4-N combined with the high pH could release ample NH_3 (aq) (1.42 mM) to cause injury to young plants (Bennett and Adams, 1970). A slight odor of NH_3 was evident in the tailings, even though the extraction process removes 70-80% of the NH_3 (Rhoades et al., 1979). The Ca content of the tailings was low when expressed as exchangeable Ca, percent of CEC, or Ca:Mg ratio (Table 1). Total Ni was high in the tailings compared with most soils, yet within the ranges found in British serpentine soils (1100-9800 μg/g Ni) (Slingsby and Brown, 1977).

Chromium in the tailings occurs in the Cr(III) oxidation state as chromite ($FeCr_2O_4$) both prior to and following Ni extraction (personal communication with Laurel Powers, Bureau of Mines). Chromium (III) is only slightly soluble and not available to plants (Allaway, 1968), however, oxidation of Cr(III) to the more available Cr(VI) has been shown to occur in moist soils if oxidized Mn is present (Bartlett and James, 1979).

Table 1. Physical and chemical properties of tailings and Eightlar soil.

Property	Tailings	Eightlar Soil
Bulk density, g/cm^3	1.04	
Particle size, %		
Sand	38.4	
Silt	60.0	
Clay	1.6	
pH	7.6	6.6
Electrical conductivity, mmhos/cm	8.4	0.2
NH_4-N, μg/g	877	3.0
Extractable P, μg/g (acid fluoride)	2.1	1.0
Extractable P, μg/g ($NaHCO_3$)	6	1
Exchangeable bases, meq/100 g		
K	0.08	0.24
Ca	1.03	4.1
Mg	20.7	2.5
DTPA-extractable metals, μg/g		
Mn	82	77
Ni	17	75
Total Ni, %	0.28	0.53
Total Cr, %	0.44	0.47
Ammonium oxalate-extractable Fe, %	22.7	0.6

Leaching Experiment

Electrical conductivity and the concentration of the major ions in the leachate (Mg^{2+}, NH_4^+, SO_4^{2-}), decreased rapidly as leaching increased, with Mg^{2+} decreasing more rapidly than NH_4^+ (Table 2). This led to the hypothesis that the water soluble salts, $MgSO_4$ and $(NH_4)_2SO_4$, caused the high EC of the tailings. Calculation of the cation-anion balance revealed a close adherence to theoretically anticipated ionic quantities.

Solutions of $MgSO_4$ and $(NH_4)_2SO_4$ at concentrations analogous to the leachate samples yielded similar EC values (Table 2). Recovery of NH_4-N from the column was 58% of that originally present (0.53 g initially present and 0.30 g NH_4-N leached from the tailings), thus about 40% of the NH_4-N (370 µg/g) remained with the tailings at the termination of leaching.

Five pore volumes, equivalent to 56.2 cm of water, were needed to reduce the EC of the tailings to 0.8 mmhos/cm, the level recommended by the U.S. Salinity Laboratory (1954). The average yearly rainfall for Eight Dollar Mountain is 140 cm, thus based only on the leaching column experiment, the conductivity of the tailings would be reduced to acceptable levels during one winter.

Plant Growth and Dry Matter Yield

Tall fescue seed germinated well, 92%, in treated and untreated soils. Seedling survival and plant growth, however, were poor when the tailings were applied at 669 g/kg and 100% rates; however, those plants that did survive (often 2-3 per pot) eventually grew well. The theoretical NH_3(aq) released by the tailings material for the two highest rates (669 g/kg and 100%) was above the 0.15-0.20 mM NH_3 toxicity level for

Table 2. Leachate analysis.

Cumulative Leachate Collected	Electrical Conductivity		$[SO_4^{2-}]$	$[Mg^{2+}]$	$[NH_4^+]$
	Leachate	Solution*			
---ml----	mmhos/cm		-------------meq/l---------		
50	>15.0	>15.0	394	323	78
150	8.6	9.2	166	94	41
350	4.2	5.0	71	56	27
500	3.6		57	26	18
700	2.0	1.9	40	15	12
950	1.4		14	6	8
1200	1.4		10	3	4
1600	0.74	0.8	4.0	1.9	4.6
2200	0.54	0.5	3.0	1.2	2.6
2700	0.37		3.5	1.3	3.8
3100	0.32		3.9	1.4	3.1
3500	0.52		3.8	1.3	3.0

*EC obtained by mixing pure $MgSO_4$ and $(NH_4)_2SO_4$ at the stated concentrations.

wheat seedlings (Table 3) (Bennett and Adams, 1970). Additionally, the initial electrical conductivity of the pure tailings was above 7 mmhos/cm, the value at which yields for tall fescue are reduced (Bernstein, 1964). Thus it was concluded that the poor seedling establishment was the result of NH_3 toxicity and high soluble salt concentration.

Tall fescue yields for the first cutting were low, indicative of slow establishment, compared to subsequent cuttings (Fig. 1). By the eighth week (second cutting), yields had increased but the dry matter weight of tall fescue grown in soil amended with 669 g/kg or grown in pure tailings still yielded the least. By the fourth cutting, tall fescue plants grown on the unamended soil and soil amended at the lowest tailings rate were beginning to yellow and dry matter yields decreased, presumably due to low available soil N levels. The NH_3 toxicity initially observed for seedlings grown on soils amended with 669 g/kg and the pure tailings had been overcome by the fourth cutting and yields continued to increase. The EC, however, remained greater than 7 mmhos/cm (Table 4).

Nitrogen

Nitrogen concentration of tall fescue plants increased as the rate of tailings application increased and usually decreased for each subsequent cutting over the 32 week growth period (Table 5). By the fourth cutting, N concentrations were below 2.5% for plants growing on all tailings-amended soils except when amended with 669 g/kg and 100% tailings. Plants with N concentrations below 2.5% were yellowing and growth was less vigorous. Nitrogen deficiency for tall fescue has been

Table 3. Theoretical NH_3 released by and electrical conductivity of the tailings material.

Tailings Rate	NH_4^+-N	pH	Theoretical NH_3 released	EC
g/kg	µg/g		-----mM-----	mmhos/cm
223	288	6.9	0.09	2.3
446	432	7.1	0.22	4.1
669	721	7.3	0.58	6.6
100%	877	7.6	1.42	8.4

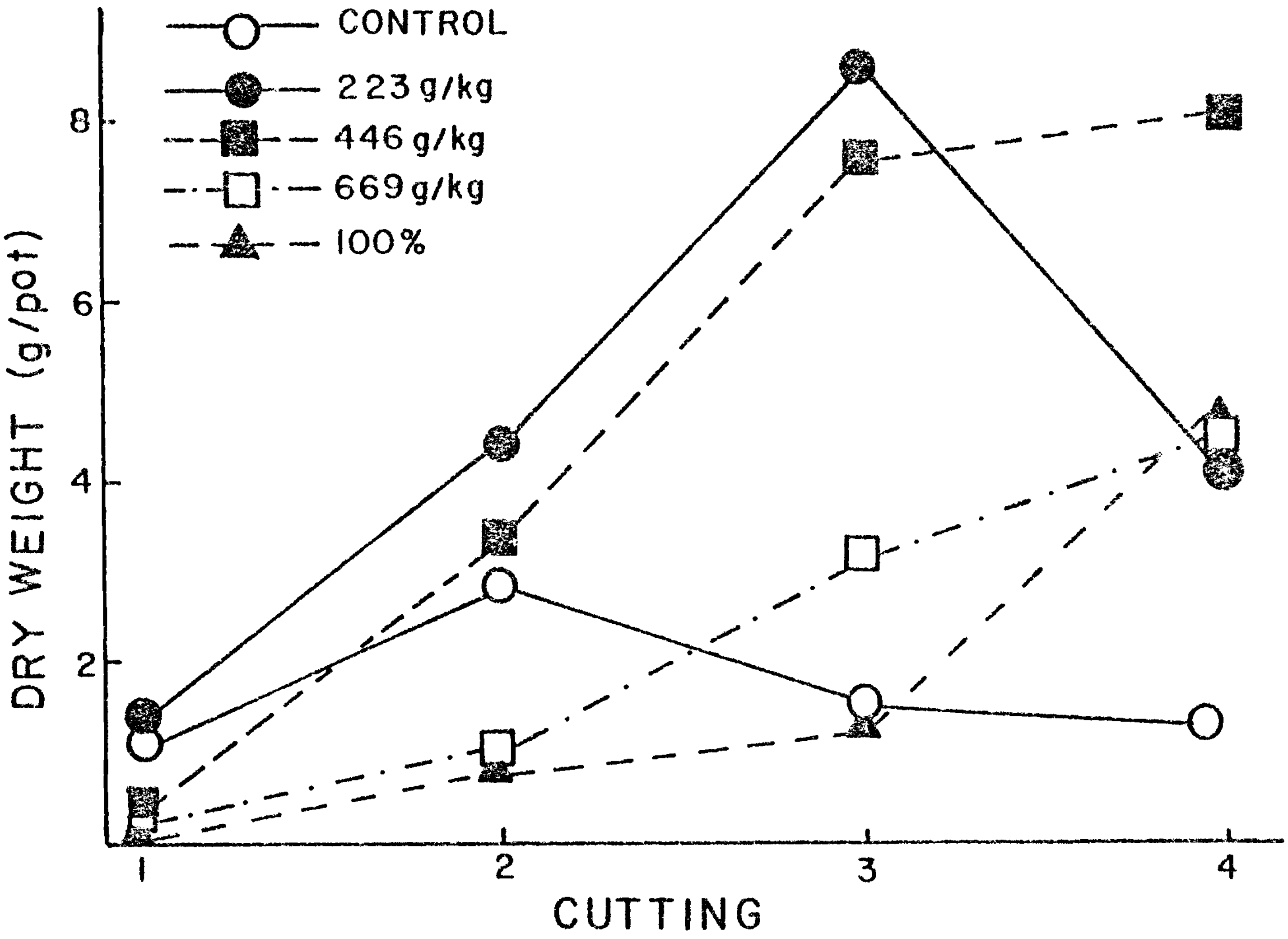

Figure 1. Dry matter yields of tall fescue grown on Eightlar soil amended with tailings material.

Table 4. Analysis of soils amended with tailings material.

	Tailings application									
	Control		223 g/kg		446 g/kg		669 g/kg		100%	
Item	Initial	Final*	Initial	Final	Initial	Final	Initial	Final	Initial	Final
pH	6.6	6.4	6.9	7.2	7.1	7.4	7.3	7.1	7.6	7.5
EC, mmhos/cm	0.2	0.5	2.3	2.0	4.1	3.1	6.6	7.4	8.4	8.7
NH_4-N, μg/g	3.0	4.1	288	3.5	432	3.2	721	4.9	877	6.7
NO_3-N, μg/g	5.4	2.8	6.2	2.2	4.8	6.5	3.1	297	2.2	265
P, μg/g (acid fluoride)	1	<.8	NA	<.8	NA	<.8	NA	<.8	2	<.8
P, μg/g# ($NaHCO_3$)	1	NA	NA	5.0	NA	11	NA	16	6	23
Ca, meq/100 g	4.1	5.5	3.4	4.8	NA	4.8	1.6	2.8	1.0	3.6
Mg, meq/100 g	1.1	1.8	7.1	11.1	11.0	17.0	14.1	20.9	20.7	23.3
Mn, μg/g	77	51	61	29	69	33	82	53	82	59
Ni, μg/g	75	64	50	28	22	24	35	20	17	7

*Except for the control, values post-harvest are means of 4 replications and 3 rates of P.

#$NaHCO_3$-extractable P value at 223 g/kg is for 44 mg P/kg rate only.

NA = not analyzed.

Table 5. Elemental concentration of tall fescue grown on Eightlar soil amended with tailing material.

Tailings Rate	Cutting	Element						
		N	P*	Ca	Mg	Ni	Mn	Cr
g/kg		%				µg/g		
0	1	3.08	.15	.20	.46	22.0	90	1.1
	2	1.99	.14	.30	.43	37.9	88	1.4
	3	1.38	.12	.38	.52	58.7	90	3.3
	4	1.26	.13	.40	.54	61.6	102	2.7
223	1	3.24	.16	.16	.75	8.1	84	2.5
	2	3.48	.18	.15	.80	12.1	84	3.4
	3	1.73	.12	.14	.80	16.6	72	1.6
	4	1.02	.17	.20	.72	18.0	133	1.6
446	1	3.62	.17	.14	.92	5.3	35	1.1
	2	3.85	.20	.15	.88	6.7	102	2.2
	3	2.65	.12	.12	.95	13.2	138	1.6
	4	1.42	.12	.10	.72	12.3	171	3.4
669	1	4.29	.14	.22	.57	4.1	189	3.3
	2	4.04	.18	.17	.80	6.0	253	3.0
	3	3.43	.14	.10	1.09	14.1	243	1.5
	4	2.65	.12	.10	.93	12.6	227	2.9
100%	1	4.11	.15	.43	.41	1.4	128	6.5
	2	4.38	.20	.14	.79	6.8	171	3.7
	3	3.49	.13	.11	.96	8.2	175	1.2
	4	3.09	.12	.10	.90	6.6	155	2.4
$S_{\bar{x}}$	3	0.08	.004	.006	.02	0.49	6.4	NS
	4	0.07	.006	.007	NS	0.60	NS	0.49

NS = not significant.

*Average of 11, 44, 178 mg P/kg rates, except for the control.

observed when plant tissue concentrations are below 2.5% N (Martin and Matocha, 1973).

Initially NH_4-N in amended soils increased with tailings application (Table 4); but after 32 weeks of tall fescue growth the NH_4-N had decreased in all amended soils while the NO_3-N of the soil had substantially increased in soils amended at the highest tailings rate and in the pure tailings. Plant uptake, nitrification of NH_4^+ to NO_3^- with some subsequent leaching loss (leachate was not collected), and NH_3 volatilization presumably accounted for the loss of NH_4-N over time.

Phosphorus

The P content of tall fescue was low compared to concentrations reported by Martin and Matocha (1973) (Table 5). Increased P application did little to alleviate the low tall fescue P levels although a slight increase in P concentration occurred when 178 mg P/kg was applied (Fig. 2).

Acid fluoride-extractable P in the soil was below detectable levels after 32 weeks of tall fescue growth (Table 4). The Fe in the tailings extracted by ammonium oxalate (pH 3.3) was high as compared to the Eightlar soil (Table 1). The total Fe concentration of the tailings was also higher than that of Eightlar soil (32% and 20% respectively), yet the oxalate-extractable Fe was proportionally much higher in the tailings than the soil. Acid ammonium oxalate-extractable Fe and Al, which removes amorphous Fe and Al compounds, has been related to P retention in 50 widely-differing New Zealand soils (Saunders, 1965). Free or amorphous Fe in the tailings could have precipitated the P added to the soil.

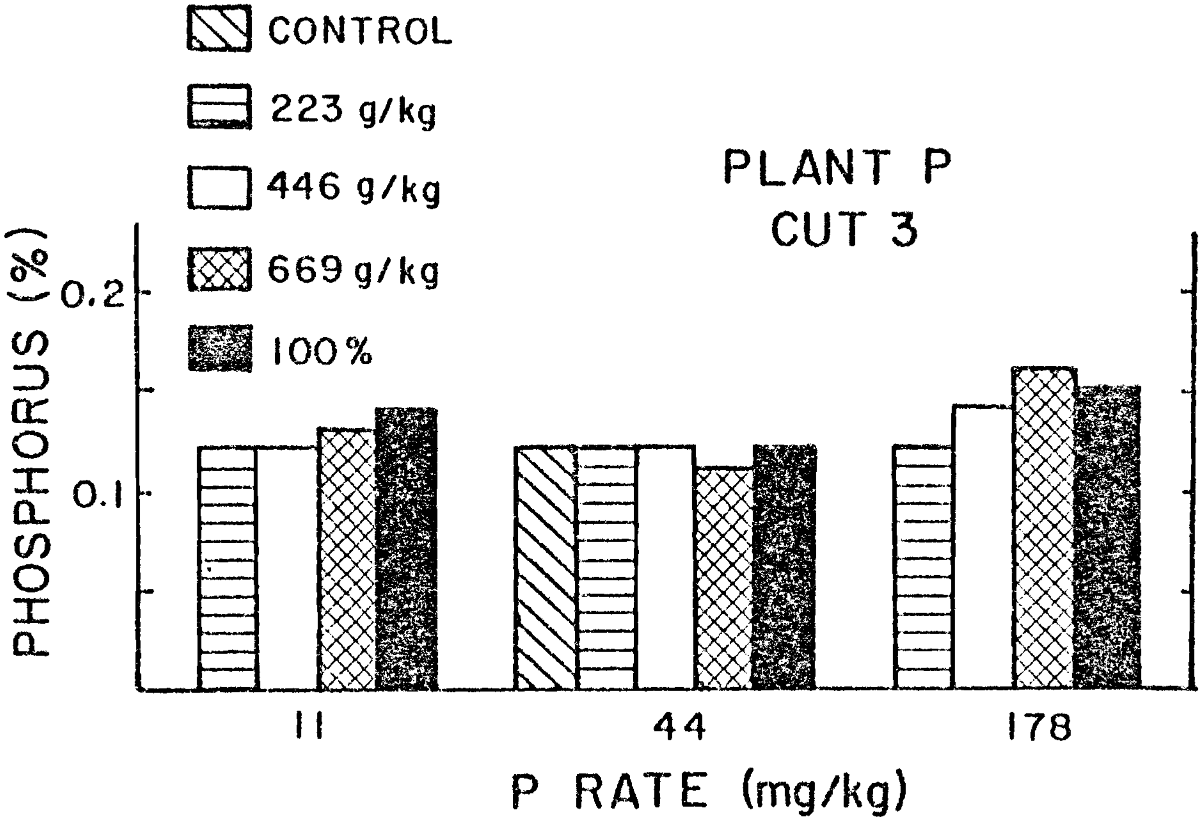

Figure 2. The P concentration of tall fescue grown on Eightlar soil amended with tailings material and fertilized with 11, 44, or 178 mg P/kg.

Sodium bicarbonate-extractable P for tailings-amended soils increased with P application (data not shown, see Appendix IV-2). Available P values ($NaHCO_3$ extractable) for soils amended at the highest tailings rate and the pure tailings would be considered moderate to high for eastern Oregon soils (>10 µg/g) (Table 4). However, plant concentrations did not correlate with $NaHCO_3$-extractable P ($r^2 = 0.12$). Thus it was concluded that $NaHCO_3$ was not a suitable extractant for P in the tailings even though the pH and the Mg concentration of the tailings were high.

Calcium and Magnesium

The Ca concentration of tall fescue in the last two cuttings decreased as the rate of tailings application increased (Table 5) in spite of increased gypsum applications. The Ca concentration of tall fescue grown on the check soil was the highest, reflecting the higher Ca status of the soil as compared to the tailings (Table 1). Although no visual Ca deficiency symptoms were observed, plants grown on all tailings-amended soils contained low concentrations of Ca. The Ca content in tall fescue normally ranges between 0.45-0.60% (Reid et al., 1970). Martin et al. (1953) found that it took one full growing season after gypsum addition to a serpentine soil for Ca in hay to reach normal levels, thus sufficient time for gypsum equilibration with the soil may not have occurred. These results indicate that the Ca availability would be a potential problem on tailings-amended soils.

The Mg concentration increased in plants grown on tailings amended soils as compared to the control soil (Table 5). The Mg concentration in the tall fescue was well above levels of 0.20-0.25% reported by Reid et al. (1970), indicating high availability of Mg in tailings-amended soils and probable reduced Ca uptake resulting from a high Mg:Ca ratio.

Nickel

The Ni concentration of tall fescue decreased with increased rates of tailings application (Table 5). Plants grown on the control soil contained higher concentrations of Ni than plants grown on tailings-amended soil. This is probably related to the higher percentage of Ni in the soil compared to the tailings (Table 1). Nickel concentration increased during the initial 24 weeks of growth for tall fescue grown on treated and untreated soils.

Toxic levels of Ni in tall fescue have not been well established. Levels of 4-9 μg/g have been found in tall fescue grown in soil amended with up to 627 metric tons/ha sewage sludge containing 6.6 μg/g Ni (Stuckey and Newman, 1977). The Ni concentration of plants grown on all treated and untreated soils exceeded these values on all cuttings except the first but were below the levels of 88 μg/g reported to induce Ni toxicity in oats (Anderson et al., 1973). No toxicity symptoms were observed even on plants grown on the native serpentine soil, where tall fescue plants contained up to 62 μg/g Ni. DTPA-extractable Ni decreased in tailings amended soils as tailings application increased (Table 5) and correlated with plant Ni concentration ($r^2 = 0.91$). The Ni extracted from the Eightlar soil did not exceed values observed for Ontario soils (up to 168 μg/g; mean 11.2 μg/g) (Haq et al., 1980).

Manganese and Chromium

The Mn concentration of tall fescue increased as the rate of tailings application increased (Table 5), even though the DTPA-extractable Mn concentration of the Eightlar soil and the tailings was similar (Table 1) and the soil pH increased with tailings application (Table 4). The Mn concentration in plant tissue, however, was within ranges commonly found in tall fescue (50-200 µg/g) (Reid et al., 1970; Stucky and Newman, 1977). DTPA-extractable Mn in all soils at the end of the growing period was within the ranges found in 77 Colorado soils (1.2-60.0 µg/g mean 10.9 µg/g) (Lindsay and Norvell, 1978).

The Cr concentration in tall fescue was not affected by rate of tailings application (Table 5). The Cr concentration in the tailings and the Eightlar soil were similar (Table 1) and Ni processing does not alter the mineral, chromite, in which Cr is most abundant (personal communication with Laurel Powers, Bureau of Mines). The plant Cr concentration was slightly above values commonly found in plants (0.2-1.0 µg/g) but equivalent to concentrations found in corn growing on soil amended with municipal waste containing up to 1.36 µg/g Cr (Allaway, 1968).

SUMMARY

Initial chemical analyses of the tailings revealed potential limitations to plant growth to include: high concentrations of soluble salts, NH_4-N, Ni, Cr, Mn, Mg; and low concentrations of P and Ca. The high conductivity was caused by $MgSO_4$ and $(NH_4)_2SO_4$ salts, requiring leaching with approximately 56.2 cm of water to reduce soluble salts in the pure tailings to 0.8 mmhos/cm.

Tall fescue establishment was slow on soils amended at the highest tailings rate and the pure tailings due to the unfavorable conditions for growth (high soluble salts and NH_3 concentration). Once established, however, growth was fairly good and dry matter yields were comparable to soils treated at lower tailings rates.

Low acid fluoride extractable P and Ca levels were not overcome by fertilizer amendments at the levels used, however no deficiency symptoms were observed on tall fescue plants. Nickel concentration of plants grown on tailings-amended soil was lower than on unamended soil indicating an alleviation of one of the suspected causes of infertility of serpentine soils.

In revegetation studies it must be remembered that the goal is not to optimize yields per se but to establish vegetative growth consistent with undisturbed conditions. Plant growth is sparse on serpentine soils, so optimal yields may not be attainable. It is recommended that the growth of native plants on tailings-amended soil be studied as they are often better adapted to growing under the conditions unique to serpentine soils.

FERTILIZER POTENTIAL OF A METAL AMMONIUM PHOSPHATE BY-PRODUCT OF NICKEL ORE PROCESSING

P. J. Sheets, V. V. Volk, and E. H. Gardner[1]

The fertilizer value of a $MeNH_4PO_4$ by-product of Ni refining was assessed. The $MeNH_4PO_4$ contained 5.0% N, 9.5% P, 6.5% Mg, 0.56% Mn, 0.13% Ni, and 0.50% SO_4-S, with a water solubility of 12.1 mM N, 1.08 mM P, 0.63 mM Mg, 0.17 mM Mn, and 5.62 mM S after 24 hours shaking. Tall fescue (Festuca arundinacea Schreb.) grown for 32 weeks in the greenhouse on Amity, Barron, and Kerby soils amended with 0, 24, 73, or 122 mg N/kg from $MeNH_4PO_4$ yielded greater and contained higher plant N concentrations than plants grown on soils amended with $MgNH_4PO_4$ or $NH_4H_2PO_4$. The Mn and Ni concentrations of tall fescue and white clover (Trifolium repens) grown on soils amended with $MeNH_4PO_4$ were less than 500 and 5 µg Mn and Ni/g, respectively. It was concluded that the $MeNH_4PO_4$ is a suitable N and P fertilizer.

Metal ammonium phosphates, especially $MgNH_4PO_4 \cdot H_2O$, are used as slow-release N and P fertilizers (Lunt et al., 1964; Bridger et al., 1962). The high cost limits fertilizer usage to predominantly specialty, nursery or ornamental plants. Monohydrated magnesium ammonium phosphate ($MgNH_4PO_4 \cdot H_2O$) is most commonly marketed but the hexahydrate form also exists. The monohydrate contains a higher percentage of plant nutrients (9-46-0) than the hexahydrate (6-29-0), and gradually

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hydrates to the hexahydrate when it contacts soil moisture (Bridger et al., 1962).

A metal ammonium phosphate precipitate is produced as a by-product of a procedure developed for solvent extraction of Ni, Co, and Cu from low-grade domestic laterites. The ore is dried, crushed, selectively reduced with CO at 525°C, then leached with NH_4OH and $(NH_4)_2SO_4$ to solubilize the Ni, Co, and Cu (Siemens and Corrick, 1977). Ammoniacal leaching also solubilizes Mg and Mn in the ore which is removed from solution by the addition of $NH_4H_2PO_4$ to form a $MeNH_4PO_4$ precipitate (Me = Mg, Mn).

Magnesium ammonium phosphates have low water solubility (K_{sp} of 1.55×10^{-13}) (Lunt et al., 1964). Nitrification, not solubility, is the primary mechanism for nutrient release (Terman and Taylor, 1965; Lunt et al., 1964; Bridger et al., 1962). More soluble N ($NO_3^- + NH_4^+$) was released from $MgNH_4PO_4$ under nonsterile rather than sterile soil conditions (Lunt et al., 1964), while incorporation of a nitrification inhibitor, 2-chloro-6-(trichloromethyl) pyridine, reduced the release of N to two corn crops (Terman and Taylor, 1965). Incubation studies with $MgNH_4PO_4$ show greater NO_3^- accumulation than could be accounted for by the solubility of the material (Bridger et al., 1962).

Because $MgNH_4PO_4$ does not dissolve congruently, any reaction which removes NH_4^+, Mg^{2+}, or PO_4^{3-}--e.g., nitrification, plant or soil sorption--would enhance the release of nutrients. Conversely, an "excess" of one of the constituents in the soil solution would inhibit the rate of dissolution. In alkaline soils, where greater concentrations of Mg^{2+} and PO_4^{3-} exist, the dissolution of $MgNH_4PO_4$ is reduced (Lunt et al., 1964). Additionally, the pH of alkaline soils (pH > 7.5) is reduced upon fertilization with $MgNH_4PO_4$ because of the acidifying effect of the NH_4^+. In acidic soils (pH < 5.8) an increase in pH was observed due to the release of PO_4^{3-} ($PO_4^{3-} + H^+ \rightleftarrows HPO_4^{2-}$). However, Mattingly et al. (1970) found no change in soil pH when $MgNH_4PO_4$ was applied to two soils at Rothamsted, with a pH of 4.8 and 5.4.

Comparison of $MgNH_4PO_4$ with 10-10-10 fertilizer on five grass species at rates of 2 and 10 lbs N per 1000 square feet, resulted in lower initial yields with $MgNH_4PO_4$ but higher cumulative yields over a five-month period (Bridger et al., 1962). Powdered $MgNH_4PO_4$ was as effective as powdered superphosphate in supplying P to potatoes (Solanum tuberosum) and barley (Hordeum vulgare) followed by ryegrass (Lolium multiflorum) (Mattingly et al., 1970).

The objective of this study was to evaluate the $MeNH_4PO_4$ by-product of Ni refining as a potential fertilizer; specifically the nutrient release rate as measured by plant response and soil reactions as a function of: 1) particle size; 2) method of incorporation (surface or mixed); and 3) fertilizer material ($MeNH_4PO_4$, $MgNH_4PO_4$, $NH_4H_2PO_4$).

MATERIALS AND METHODS

A $MeNH_4PO_4$ product which had been air-dried and coated with $(NH_4)_2SO_4$ to aid in granulation, was obtained from the Bureau of Mines, Albany, OR. The material was screened to two particle sizes, medium (-8+16 U.S. Standard Sieve) and coarse (-4+8).

The water solubility of the two mesh sizes of $MeNH_4PO_4$ was determined by weighing triplicate samples (1.0 g) of material into bottles containing distilled water (250 ml) and shaking the mixtures for 24 and 48 hours at 23°C. The liquid was assayed for NH_4-N, P, Mg, Mn, Ni, Ca, and pH.

Total N in the $MeNH_4PO_4$ was determined by micro-Kjeldahl procedure (Bremner, 1965). Duplicate fertilizer samples (0.5 g) were weighed into 250-ml polycarbonate bottles and digested in HF-HCl-HNO_3 solution using a pressure dissolution technique (Farrell et al., 1979). Magnesium, Ca, K, Mn, Ni and Cu were determined on a Perkin Elmer Model 306 atomic absorption spectrophotometer. Additional material (1.0 g) was digested in $HClO_4$-HNO_3 and total P determined colorimetrically (Tandon et al., 1968). Sulfate-S was determined turbidimetrically (Tabatabai and Bremner, 1970).

Amity (fine-silty, mixed, mesic family of Argiaquic Xeric Argialbolls), collected from a pasture near Corvallis, OR; Barron (coarse-loamy, mixed, mesic family of Typic Xerochrepts), collected from a field near Grants Pass, OR; and Kerby soils (fine-loamy, mixed, mesic family of Typic Xerochrepts), collected from a pasture near Kerby, OR, were air dried and screened to pass a 1.2 cm sieve. The soils were assayed for pH, total N, NH_4- and NO_3-N, extractable P, and DTPA-extractable Mn (Berg and Gardner, 1978).

Four fertilizer materials, two particle sizes of $MeNH_4PO_4$ (medium and coarse), commercial $MgNH_4PO_4$, and $NH_4H_2PO_4$ (MAP) were applied to each soil at rates of 24, 73, and 122 mg N/kg for tall fescue and 24 mg N/kg for white clover. Supplemental fertilizers (K_2SO_4, KCl, $CaSO_4 \cdot 2H_2O$ and $MgCl_2 \cdot 6H_2O$) were applied to maintain a uniform application of K, S and Mg. Lime, as $CaCO_3$ (1335 mg/kg) was added to the Barron and Kerby soils at recommended levels as the soil pH was below 5.7 (Gardner and Jackson, 1973). Boron, as H_3BO_3 (0.89 mg B/kg) was added to soils where white clover was to be seeded. The fertilizers were either surface applied (top 3 cm) or thoroughly mixed with 3 kg of soil. Treatments were replicated three times and arranged in the greenhouse in a randomized complete block design.

Tall fescue (<u>Festuca arundinacea</u> Schreb.) and inoculated New Zealand white clover (<u>Trifolium repens</u> L.) were seeded at the rate of 25 seeds/pot. Plants were thinned to 12/pot 10 days after germination and clipped to a height of 1.5 cm four times at 8-week intervals for a total growing period of 32 weeks. Plants were watered with distilled water (50-100 ml) 2 to 3 days per week and the leachate recycled back into the pot. After each clipping, the harvested plants were oven-dried at 65°C for 2 to 3 days, dry weights recorded and samples ground in a Wiley mill prior to chemical analysis.

Plant material was digested in a H_2SO_4-$Na_2S_2O_3$-catalyst mixture for N and P determination (Bremner, 1965) on a Scientific Instruments CFA-200 autoanalyzer. Additional plant material (1.0 g) was digested in $HClO_4$-HNO_3 and assayed for Mn by atomic absorption spectrophotometry. An aliquot (50 ml) taken from each $HClO_4$ digest was heated to dryness and 1.0 N HCl (10 ml) added. Nickel in the concentrated sample was determined by atomic absorption spectrophotometry.

Soil samples collected after the 32-week growing period were assayed for pH, extractable P, and DTPA-extractable Mn and Ni.

Data was arranged into a 3 x 4 x 3 x 2 factorial for the analysis of variance. Control values were not included in the analysis.

RESULTS AND DISCUSSION

Properties of the Fertilizer. X-ray diffraction analysis (courtesy of the U.S. Bureau of Mines, Albany, OR) confirmed that the $MeNH_4PO_4$ material was the hexahydrate with an $(NH_4)_2SO_4$ coating. The N, P, and Mg concentrations of the $MeNH_4PO_4$ were lower than commercial $MgNH_4PO_4$, while the Mn, Ni and Cu concentrations were higher than concentrations in either $MgNH_4PO_4$ or MAP (Table 1).

The water solubility of the medium and coarse size $MeNH_4PO_4$ was similar at both 24 and 48 hour time intervals (Table 2). Only the NH_4^+ and SO_4^{2-} concentrations of the medium particle size increased after 48 hours of shaking. Assuming the $(NH_4)_2SO_4$ coating to be soluble and the primary SO_4^{2-} source, the NH_4^+ needed to balance the SO_4^{2-} would account for 93% of the H_2O-soluble NH_4^+ (11.2 of 12.1 mM). The remaining detectable ions in solution (P, Mg, Mn, Ca, Ni) were present in roughly the same proportion as the total fertilizer analysis.

Assuming P (as PO_4^{3-}) to be the major anion of $MeNH_4PO_4$, the solubility of the $MeNH_4PO_4$ was lower than $MgNH_4PO_4$ (1.08 mM P for $MeNH_4PO_4$ and 1.68 mM P for $MgNH_4PO_4$) (Lunt et al., 1964), in accordance with lower water solubilities found for metal ammonium phosphates (Bridger et al., 1962). The $MeNH_4PO_4$ also had less H_2O-soluble Mg and NH_4-N than $MgNH_4PO_4$ (1.71 and 1.41 mM Mg and NH_4-N, respectively, for $MgNH_4PO_4$) presumably because of both the lower solubility and presence of other cations in the $MeNH_4PO_4$.

Dry matter yields and N concentration. Cumulative dry matter yields of tall fescue increased with N application rate for each fertilizer material (Fig. 1) (data not shown for all soils, see Appendix Table V-3) and were highest for plants grown on soils amended with

Table 1. Chemical analysis of fertilizer materials.

Element	$MeNH_4PO_4$ Medium	$MeNH_4PO_4$ Coarse	$MGNH_4PO_4$	$NH_4H_2PO_4$
	%			
N	5.0	5.0	7.0	11.0
P	9.5	9.5	17.5	21.0
Mg	6.5	6.5	12.0	0.6
SO_4-S	0.5	0.5	0.004	0.8
	µg/g			
K	51	62	5000	93
Ca	3620	3565	2630	4270
Mn	5540	5510	31	81
Ni	1300	1470	40	51
Cu	22	24	7	5

Table 2. Water solubility of $MeNH_4PO_4$.

Element	24 hours Medium	24 hours Coarse	48 hours Medium	48 hours Coarse
	mM			
N	12.1	12.2	13.3	11.4
P	1.08	1.07	1.10	1.07
Mg	0.63	0.63	0.64	0.62
Mn	0.17	0.16	0.14	0.14
Ca	0.09	0.10	0.10	0.10
Ni	0.04	0.04	0.03	0.03
SO_4-S	5.62	5.79	6.35	5.45
pH	8.1	8.1	8.1	8.1

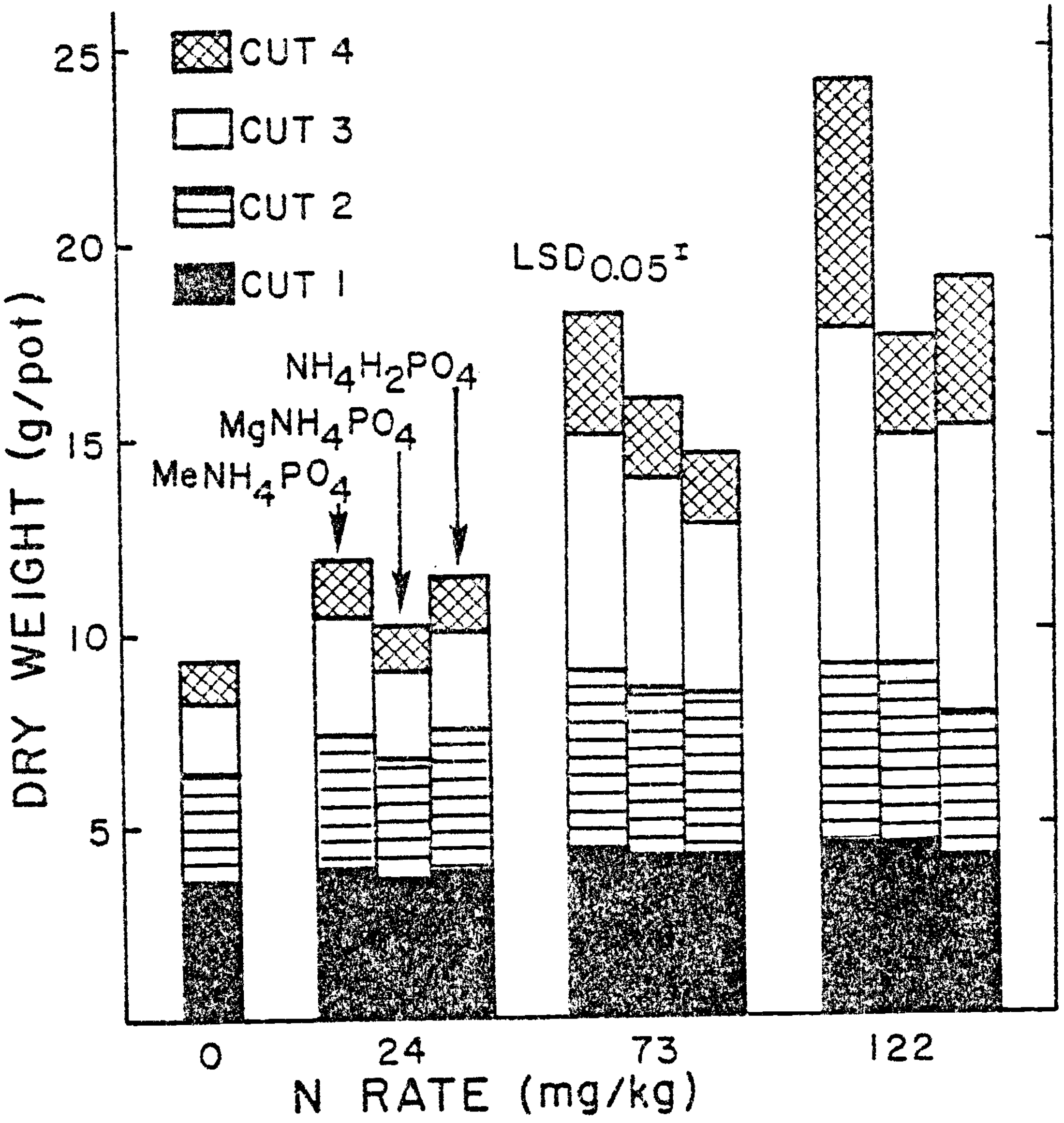

Figure 1. Dry matter yields of tall fescue grown on Amity soil amended with fertilizer materials.

$MeNH_4PO_4$. Assuming the $(NH_4)_2SO_4$ coating of the $MeNH_4PO_4$ to be readily soluble, N would initially be released rapidly from the coating followed by the slow N-release from the $MeNH_4PO_4$. Rapid N release could increase yields over that of $MgNH_4PO_4$, while the slow N-release from the $MeNH_4PO_4$ could provide a residual N source resulting in higher yields than from MAP.

Tall fescue yields and N concentration for the first cutting were similar for plants grown on all amended soils at each N rate, due to the initial fertility status of the soil plus N fertilization (Fig. 1, Tables 3 and 4). Tall fescue grown on unfertilized soils contained adequate but lower N concentrations and yielded the same as treated plants. By the third cutting, tall fescue grown on soils amended with all fertilizer materials at the lowest rate were yellowing and yields had decreased. The N concentration of these plants was below 2.5%, the level where N deficiency has been observed for tall fescue (Martin and Matocha, 1973). Dry matter weights of tall fescue amended at the two highest N rates continued to increase until the fourth cutting, by which time the N concentration was below deficiency levels and plants were visibly yellowing. Tall fescue grown on $MeNH_4PO_4$-amended soils yielded higher than plants grown on soils amended at the two highest N rates with $MgNH_4PO_4$ and MAP the third and fourth cuttings, presumably because of the slow N release by the $MeNH_4PO_4$.

Tall fescue grown on Amity and Barron soils had higher cumulative yields than plants grown on Kerby soil, probably due to the higher fertility status of the Amity and Barron soils (Table 3) (data not shown, see Appendix V-3). In comparison, white clover grown on Amity

Table 3. Analysis of soils prior to fertilization.

Element	Amity soil	Barron soil	Kerby soil
pH	6.0	4.8	5.5
	%		
Total N	.25	.10	.09
	μg/g		
NH_4-N	46	12	22
NO_3-N	7	58	30
Extractable P	44	65	19
DTPA-extractable Mn	39	45	30
DTPA-extractable Ni	1.0	0.6	0.6
	meq/100 g		
Extractable Ca	10.0	4.6	2.4
Extractable Mg	3.0	1.0	1.0
Extractable K	0.30	0.20	0.24
Cation Exchange Capacity	20	9	11

Table 4. Nitrogen and manganese concentrations of tall fescue and white clover grown on Amity soil amended with fertilizer materials.

Fertilizer	N Rate	Nitrogen				Manganese			
		Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
	mg/kg	%				µg/g			
		Tall Fescue							
$MeNH_4PO_4$*	24	4.02	2.86	1.71	1.23	76	104	166	283
	73	4.14	3.14	2.34	0.98	91	186	226	459
	122	4.36	2.98	3.09	1.07	97	202	234	426
$MgNH_4PO_4$	24	4.08	2.89	1.78	1.25	64	96	160	228
	73	4.05	3.03	1.84	1.12	81	124	154	339
	122	4.08	2.97	2.14	1.03	74	124	144	344
$NH_4H_2PO_4$	24	4.12	2.42	1.60	1.22	87	126	198	310
	73	4.06	2.82	1.84	1.05	103	204	238	643
	122	4.15	3.24	2.93	1.00	114	244	284	742
Control	0	3.60	1.97	1.62	1.26	67	99	195	193
$LSD_{0.05}$	--	0.10	0.17	0.18	NS	6	11	14	44
		White Clover							
$MeNH_4PO_4$	24	4.37	3.53	3.96	3.51	67	84	73	76
$MgNH_4PO_4$	24	4.60	3.84	3.96	3.53	64	71	66	72
$NH_4H_2PO_4$	24	4.34	3.82	3.94	3.50	91	108	93	85
Control	0	4.05	3.48	4.11	3.40	60	70	54	69
$LSD_{0.05}$	--	0.24	NS	NS	NS	8	11	11	6

NS=not significant

*Values are means of method of incorporation and particle size.

and Kerby soils yielded higher cumulatively than white clover grown on Barron soil (Fig. 2).

White clover yields increased with each cutting with plants grown on MAP-amended soils yielding slightly higher than plants grown on $MeNH_4PO_4$- or $MgNH_4PO_4$-amended soils. White clover grown on $MgNH_4PO_4$-amended soils contained the highest N concentration although differences were statistically significant ($P \leq 0.05$) the first cutting only (Table 3). The lack of response of white clover to fertilizer N was probably caused by the presence of N-fixing _Rhizobium_ bacteria, the activity of which is suppressed by N fertilization. Thus, fertilizers which slowly release N could suppress rhizobial activity over a longer period by continually releasing N, resulting in lower yields. Visual inspection of white clover roots after the 32-week growth period indicated the presence of _Rhizobium_ as pink nodules on the roots.

No significant differences in yield or N concentration ($P \leq 0.05$) of tall fescue or white clover occurred due to method of $MeNH_4PO_4$ incorporation or particle size (data not shown, see Appendix Tables V-3 and VI-3).

Phosphorus. Phosphorus was not applied in equal amounts for each fertilizer because even at the lowest N rate, P was supplied at more than adequate levels. In western Oregon P is applied at 34-45 kg P/ha on new seedings of tall fescue if the soil test for extractable P is below 45 μg/g (Gardner and Warren, 1970). Fertilizers applied at 24 mg N/kg supplied P at 104, 138 and 120 kg P/ha for $MeNH_4PO_4$, $MgNH_4PO_4$ and MAP, respectively, and only the Kerby soil had P levels below 45 μg/g (Table 3). Nevertheless, tall fescue and white clover plants grown on soils amended with $MgNH_4PO_4$ contained higher P concentrations than

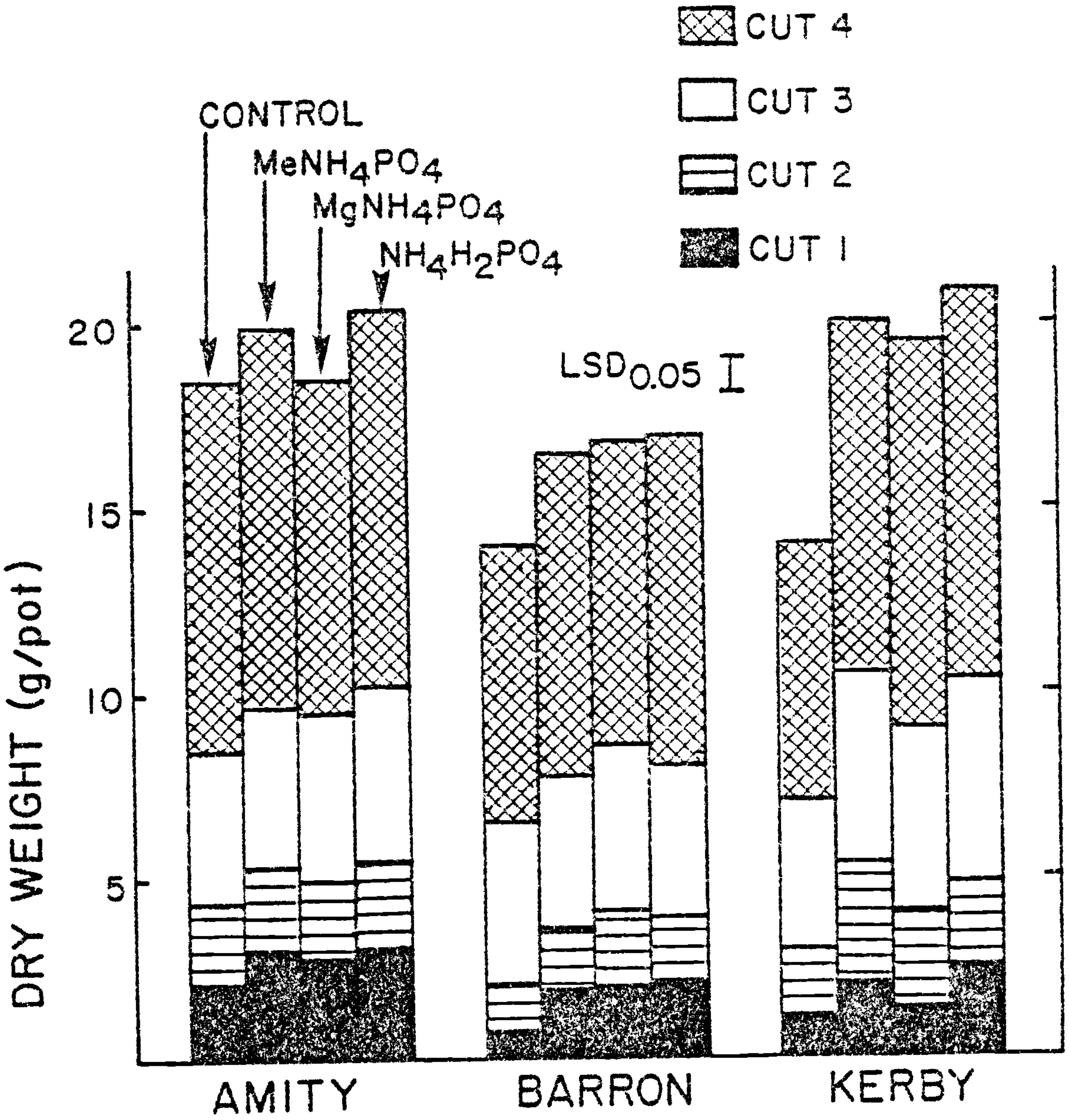

Figure 2. Dry matter yields of white clover grown on soils amended with fertilizer materials.

plants grown on soils amended with $MeNH_4PO_4$ or MAP (Table 5). Phosphorus was not a limiting factor in plant growth, however, and was adequate at each cutting. Plant P concentrations were at or above critical levels for plants grown on amended and unamended soils throughout the growth period (0.26-0.34% for tall fescue, 0.18-0.25% for white clover) (Martin and Matocha, 1977).

Extractable soil P was highest on Amity and Kerby soils amended with $MgNH_4PO_4$, reflecting the higher P applied with $MgNH_4PO_4$ (Table 6). However, Barron soils amended with MAP contained the highest extractable P--a factor not reflected in plant concentrations. Soil test P levels for treated soil after the 32-week growth period were greater than 30 μg/g, the minimum level for established stands of tall fescue and clover in western Oregon. Unamended soils which supported tall fescue growth also contained over 30 μg P/g, indicating adequate P levels in all soils even with no fertilizer amendment.

Tall fescue and white clover plants contained higher P concentrations when the $MeNH_4PO_4$ was surface applied than when it was mixed with the soil (Fig. 3). Soluble P fertilizers are usually banded at planting to reduce the surface exposure between soil and fertilizer thus increasing plant available P. Surface application of $MeNH_4PO_4$ presumably had an effect on P availability similar to banding the material.

Manganese. The Mn concentration of tall fescue increased with each cutting for plants grown on all amended soils and increased with the N application rate for $MeNH_4PO_4$ and MAP (Table 4). The Mn concentration of tall fescue plant tissue increased while the pH decreased on amended soils in the order: $MgNH_4PO_4$ > $MeNH_4PO_4$ > MAP (Tables 4 and 6). The acidifying effect of MAP and the $(NH_4)_2SO_4$ coating of $MeNH_4PO_4$ as NH_4^+

Table 5. Phosphorus and nickel in tall fescue grown on soils amended with 73 mg N/kg and white clover grown on Amity soil.

	P		Ni	
Fertilizer	Fescue	Clover	Fescue	Clover
$MeNH_4PO_4$*	0.34	0.37	4.0	4.8
$MgNH_4PO_4$	0.39	0.39	2.5	3.2
$NH_4H_2PO_4$	0.34	0.33	3.9	4.2
Control	0.31	0.34	2.1	4.1
$LSD_{0.05}$	0.01	0.02	0.4	0.6

*Values are averaged across method of incorporation and particle size.

Table 6. Soil pH, phosphorus, manganese, and nickel after cropping with tall fescue fertilized at 73 mg N/kg and white clover.

		pH		Extractable P		DTPA Mn		DTPA Ni	
Soil	Fertilizer	Fescue	Clover	Fescue	Clover	Fescue	Clover	Fescue	Clover
				-----μg/g-----		--------------μg/g--------------			
Amity	$MeNH_4PO_4$*	5.5	5.2	74.2	38.3	10.7	13.8	2.2	1.6
	$MgNH_4PO_4$	5.6	5.2	106.0	52.0	10.6	13.0	1.2	1.2
	$NH_4H_2PO_4$	5.6	5.3	73.6	38.6	10.8	15.3	1.2	1.2
	Control	5.8	5.3	32.7	28.7	10.3	13.9	1.2	1.2
Barron	$MeNH_4PO_4$	6.0	5.7	85.7	44.2	11.6	12.0	1.2	0.8
	$MgNH_4PO_4$	6.3	5.8	116.9	58.2	11.0	12.6	0.6	0.6
	$NH_4H_2PO_4$	5.8	5.8	123.9	62.6	11.2	11.2	0.6	0.6
	Control	6.3	6.0	40.7	31.3	7.0	11.1	0.5	0.5
	$LSD_{0.05}$	0.05	0.10	4.1	3.5	0.9	NS	0.08	0.12

NS = not significant

*Values are averaged across particle size and method of incorporation.

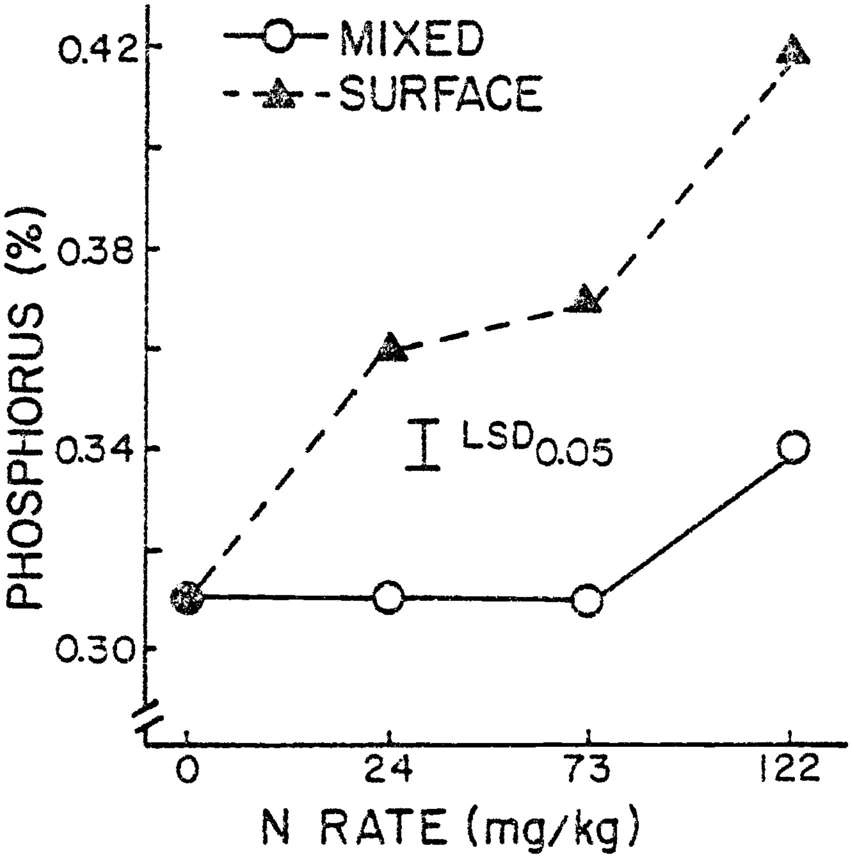

Figure 3. The P concentration of tall fescue grown on Amity soil amended with $MeNH_4PO_4$.

was oxidized to NO_3^- could account for the decrease in pH seen in MAP and $MeNH_4PO_4$-amended soils as compared to the control. Magnesium ammonium phosphate fertilizers have been found to have no effect on soil pH in the ranges of the three soils used (Lunt et al, 1964; Mattingly et al., 1970). Since plant Mn concentration has been found to increase as soil pH decreases, the higher Mn concentration of tall fescue fertilized with MAP and $MeNH_4PO_4$ could have been caused by the decrease in soil pH (Lohnis, 1951; Jackson et al., 1966).

However, for Amity soil pH differences were too small to account for the high Mn concentration of plants grown on $MeNH_4PO_4$- and MAP-amended soils. Chloride, as $MgCl_2$ and KCl, was added in greatest amounts to soils amended with MAP. Chloride, as KCl, was added in smaller amounts to soils amended with $MeNH_4PO_4$ and only to the low N rate Barron soil amended with $MgNH_4PO_4$. Increasing amounts of Cl^- have been found to increase the level of Mn in bush beans (Phaseolus vulgaris), sweet corn (Zea mays var. ragosa), and oats (Avena sativa) (Jackson et al., 1966; Hamilton, 1966), especially in acid soils by functioning in an oxidation-reduction reaction (Westermann, 1969). Thus, Cl^- in addition to soil pH could have caused tall fescue grown in MAP-amended soils to contain higher Mn concentration than plants grown on $MeNH_4PO_4$- and $MgNH_4PO_4$-amended soils.

Except for white clover grown on Amity soil, DTPA-extractable Mn was not consistently higher for soils amended with MAP (Table 6). However, DTPA-extractable Mn for all fertilizer materials was correlated with plant Mn concentration for Amity and Kerby soils ($r^2 = 0.59^{**}$ and 0.74^{**} for Amity and Kerby soils, respectively), but not for Barron soil ($r^2 = 0.19$).

Nickel. Tall fescue and white clover plants grown on $MeNH_4PO_4$-amended soil contained the highest Ni concentrations (Table 5), but concentrations were within levels commonly found in plants (0.5-5.0 µg/g) (Mishra and Kar, 1974). The Ni concentration of tall fescue grown on $MeNH_4PO_4$-amended soils increased between 0.5-1.0 µg/g as fertilizer application rate increased, but plant Ni concentrations were approximately equivalent for each soil.

DTPA-extractable Ni was highest in soils amended with $MeNH_4PO_4$ (Table 6) yet correlated with plant tissue concentration ($r^2 = 0.81^{**}$) only for Amity soil ($r^2 = 0.20$ and 0.28 for Barron and Kerby soils, respectively). DTPA-extractable Ni was within ranges found in most soils for amended and unamended soils (Mitchell, et al, 1978; Haq et al., 1980).

SUMMARY

The water solubility of $MeNH_4PO_4$ was not influenced by particle size or shaking time over a 48-hour period. The solubility was lower for $MeNH_4PO_4$ than $MgNH_4PO_4$ while the Mn and Ni concentrations of the material were higher for $MeNH_4PO_4$. With $MeNH_4PO_4$ most (93%) of the water-soluble NH_4^+ was derived from the $(NH_4)_2SO_4$ coating.

Yields and N concentration of tall fescue grown on $MeNH_4PO_4$-amended soils were higher than yields and N concentration of tall fescue grown on $MgNH_4PO_4$- or MAP-amended soils. The combination of the soluble $(NH_4)_2SO_4$ coating and the slower N release of $MeNH_4PO_4$ was presumably responsible for the higher yields and N concentration.

The P concentration of tall fescue was highest for plants grown on soils amended with $MgNH_4PO_4$, as was extractable soil P; however, plants grown on both amended and unamended soils contained adequate P concentrations. Phosphorus in tall fescue and white clover plants was higher when $MeNH_4PO_4$ was surface applied rather than incorporated into the soil.

The Mn concentration of tall fescue and white clover grown on amended soils decreased in the order: MAP > $MeNH_4PO_4$ > $MgNH_4PO_4$. The pH was lowest for soils amended with $NH_4H_2PO_4$ and highest for soils amended with $MgNH_4PO_4$. Fertilizer supplements containing Cl^-, KCl and $MgCl_2$, were applied to soils amended with $NH_4H_2PO_4$ and, except for the Barron soil, not at all to soils amended with $MgNH_4PO_4$. Soils amended with $MeNH_4PO_4$ had KCl only applied. The Ni concentration of tall fescue and white clover was highest when grown on soils amended with $MeNH_4PO_4$, yet remained within levels commonly found in plants.

Particle size of the $MeNH_4PO_4$ (medium or coarse) had no effect on any of the parameters studied.

CONCLUSIONS

It was concluded that the tailings material can support plant growth. However, several recommendations would enhance plant establishment for revegetation:

1) Addition of native soil to the surface tailings layer to reduce crusting; and
2) Additional washing to reduce the NH_4-N and soluble salt concentrations.

Further study is needed to determine the amount of supplemental P and Ca needed to bring plant concentrations of these elements up to more suitable levels. It is finally recommended that field studies using native plant species be undertaken as they are often better adapted to growing under the conditions unique to serpentine soils.

The $MeNH_4PO_4$ was concluded to be a suitable fertilizer material. Tall fescue and white clover responded as well to the $MeNH_4PO_4$ as to $MgNH_4PO_4$ and $NH_4H_2PO_4$. Particle size of the $MeNH_4PO_4$ (medium or coarse) had no effect on any of the parameters studied. Method of incorporation affected P concentration only--higher plant P concentration was observed when $MeNH_4PO_4$ was surface applied rather than mixed with soil. Further study is needed to determine if the Mn and Ni present in the $MeNH_4PO_4$ is detrimental to plant growth over a longer time period and after repeated applications of $MeNH_4PO_4$.

The limitations of a greenhouse study must be remembered in assessing the results of this experiment. Additional investigation under field conditions is needed to verify the results.

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APPENDICES

APPENDIX I: ANALYSIS OF TAILINGS AND POTENTIAL FERTILIZER MATERIALS

Measurement	Tailings	Fertilizer Medium	Fertilizer Coarse
pH	7.6		
Electroconductivity, mmhos/cm	8.4		
Bulk density, g/cm^3	1.04		
Particle size, %			
Sand	38.4		
Silt	60.0		
Clay	1.6		
NH_4-N, %	0.09	5.0	5.0
NO_3-N, μg/g	2.22		
Total Elemental Concentration			
P, %		9.5	9.5
K, μg/g	480	51	62
Ca, μg/g	533	3620	3565
Mg, %	1.8	6.5	6.5
SO_4-S, %		0.5	0.5
Zn, μg/g	220	34	33
Mn, μg/g	2580	5540	5510
Cu, μg/g	92	22	24
Fe, %	32.2	0.05	0.05
Ni, μg/g	2800	1280	1470
Co, μg/g	394	212	206
Cr, μg/g	4400	12	8
Pb, μg/g	46	10	9
Cd, μg/g	0.25		
Na, μg/g	187		
Mo, μg/g	4.2		
NH_4Ac-extractable, meq/100 g			
Ca	1.03		
Mg	20.7		
K	0.08		
Acid fluoride-extractable P, μg/g	2.1		
$NaHCO_3$-extractable P, μg/g	6		
DTPA-extractable, μg/g			
Mn	82		
Cu	9		
Fe	201		
Zn	14		
Ni	17		
Co	5		
Hot water soluble B, μg/g	1		

APPENDIX II: ANALYSIS OF LEACHATE FROM COLUMNS PACKED WITH TAILINGS

Cumulative Leachate Collected	Replication	Conductivity	NH_4-N	Mg	SO_4-S
---mls----		--mmhos/cm--	----------μg/g----------		
50	1	>15.0	1073	3500	5900
	2	>15.0	1113	4250	6700
100	1	11.0	----	1425	
	2	10.8	778	1175	
150	1	8.5	611	1150	2750
	2	8.8	531	1100	2580
200	1	8.0	543	950	
	2	7.5	372	775	
250	1	7.8	229	775	
	2	6.5	386	680	
300	1	5.7	95	560	
	2	5.4	302	550	
350	1	4.1	374	660	1200
	2	4.2	242	---	1080
400	1	4.8	278	450	
	2	3.4	362	430	
450	1	4.0	223	360	
	2	4.0	241	380	
500	1	3.6	253	290	920
	2	3.5	241	350	900
550	1	3.0	229	260	
	2	3.1	241	250	
600	1	2.6	34	250	
	2	2.9	157	220	
650	1	1.7	96	250	
	2	2.3	181	165	
700	1	2.0	169	165	650
	2	2.0	181	190	620
750	1	2.0	181	140	
	2	1.8	121	150	

Appendix II. Continued.

Cumulative Leachate Collected	Replication	Conductivity	NH_4-N	Mg	SO_4-S
---mls----		--mmhos/cm--	----------	µg/g	----------
800	1	1.8	133	160	
	2	1.9	121	200	
850	1	1.8	36	---	
	2	1.8	109	170	
900	1	1.6	121	78	
	2	1.7	132	98	
950	1	1.3	109	68	222
	2	1.6	121	84	240
1000	1	1.1	12	68	
	2	1.5	48	120	
1050	1	1.2	96	53	
	2	1.2	109	78	
1100	1	1.2	110	45	
	2	1.4	109	74	
1150	1	1.1	48	47	
	2	1.3	60	72	
1200	1	1.6	84	44	142
	2	1.3	36	59	180
1300	1	1.0	84	31	
	2	0.90	84	45	
1400	1	0.81	68	34	
	2	0.98	66	42	
1500	1	0.71	67	23	
	2	0.90	65	36	
1600	1	0.69	58	---	32
	2	0.82	70	31	95
1700	1	0.60	27	20	
	2	0.76	66	28	
1800	1	0.56	34	39	
	2	0.68	58	26	

Appendix II. Continued.

Cumulative Leachate Collected	Replication	Conductivity	NH_4-N	Mg	SO_4-S
---mls----		--mmhos/cm--	--------- µg/g -----------		
1900	1	0.51	44	15	
	2	0.60	56	22	
2000	1	0.51	53	16	
	2	0.64	51	24	
2100	1	0.35	44	15	
	2	0.61	43	22	
2200	1	0.47	35	15	40
	2	0.61	39	22	56
2300	1	0.48	46	13	
	2	0.56	51	23	
2400	1	0.46	41	16	
	2	0.53	48	21	
2500	1	0.47	48	17	
	2	0.66	58	27	
2600	1	0.50	53	21	
	2	0.23	---	29	
2700	1	0.30	46	14	43
	2	0.44	60	28	68
2800	1	0.40	42	15	
	2	0.45	56	35	
2900	1	0.30	94	14	
	2	0.25	59	32	
3000	1	0.30	51	14	
	2	0.35	42	29	
3100	1	0.35	36	15	43
	2	0.30	51	30	80
3200	1	0.33	43	16	
	2	0.31	48	27	
3300	1	0.30	44	21	
	2	0.55	50	28	

Appendix II. Continued.

Cumulative Leachate Collected	Replication	Conductivity	NH_4-N	Mg	SO_4-S
---mls----		--mmhos/cm--	---------	μg/g	----------
3400	1	0.39	48	17	
	2	0.30	48	22	
3500	1	0.52	28	21	60
	2	0.51	57	21	59

APPENDIX III: TREATMENT NUMBERS FOR TALL FESCUE AND WHITE CLOVER GROWN ON SOILS AMENDED WITH FERTILIZER MATERIALS

Fertilizer Material	N Rate	Amity Soil				Barron Soil				Kerby Soil			
		Mixed		Surface		Mixed		Surface		Mixed		Surface	
		Fescue	Clover	Fescue	Clover	Fescue	Clover	Fescue	Clover	Fescue	Clover	Fescue	Clover
	mg/kg												
$MeNH_4PO_4$ Medium	24	1	2	3	4	5	6	7	8	9	10	11	12
	73	13		14		15		16		17		18	
	122	19		20		21		22		23		24	
$MeNH_4PO_4$ Coarse	24	25	26	27	28	29	30	31	32	33	34	35	36
	73	37		38		39		40		41		42	
	122	43		44		45		46		47		48	
$MgNH_4PO_4$	24	49	50	51	52	53	54	55	56	57	58	59	60
	73	61		62		63		64		65		66	
	122	67		68		69		70		71		72	
$NH_4H_2PO_4$	24	73	74	75	76	77	78	79	80	81	82	83	84
	73	85		86		87		88		89		90	
	122	91		92		93		94		95		96	
Control	---	97	98			99	100			101	102		

APPENDIX IV: SOIL ANALYSIS

Table IV-1. Analysis of soils prior to by-product treatment.

Measurement	Amity	Barron	Kerby	Eightlar
pH	6.0	4.8	5.5	6.2
Electrical conductivity, mmhos/cm	0.2	1.0	0.2	0.2
Total N, %	0.25	0.10	0.09	0.16
NH_4-N, μg/g	46	12	22	2
NO_3-N, μg/g	7	58	30	1
Total elemental analysis				
P, μg/g	1350	625	550	107
K, %	1.8	2.0	1.0	0.14
Ca, μg/g	604	1589	158	1047
Mg, %	0.52	1.10	0.40	2.72
SO_4-S, μg/g	300	425	420	540
Zn, μg/g	60	96	96	153
Mn, μg/g	340	520	310	3700
Cu, μg/g	12	26	26	78
Fe, %	2.9	3.1	2.3	20.0
Ni, μg/g	30	104	70	5300
Co, μg/g	32	46	18	460
Cr, μg/g	24	40	20	4700
Pb, μg/g	28	12	24	60
Extractable P, μg/g	44	65	19	1
Extractable bases, meq/100 g				
Ca	10.0	4.6	2.4	4.0
Mg	3.0	1.0	1.0	2.5
K	0.30	0.20	0.24	0.63
Na	0.05	0.04	0.02	0.02
DTPA-extractable metals, μg/g				
Zn	2.0	1.0	0.7	4.8
Mn	39	45	30	77
Cu	2.4	0.5	0.3	2.3
Fe	24	52	37	34
Ni	1.0	0.6	0.6	75
Co	0.3	0.2	0.2	4.0
Hot water soluble B, μg/g	1.04	0.62	0.60	0.72
CEC, meq/100 g	20	9	11	16

Table IV-2. Analysis of soils amended with tailings material after the fourth cutting of tall fescue.

								Bray	$NaHCO_3$	NH_4Ac		DTPA-extractable				
Soil	Tailings Rate	P Rate	Replication	pH	EC	NH_4-N	NO_3-N	P	P	Ca	Mg	Zn	Mn	Cu	Ni	Fe
	- g/kg -	mg/kg			mmhos/cm	µg/g				-meq/100g-		µg/g				
Amity	0	44	1	5.3	0.4	3.8	3.0	35	NA	9.4	2.8	4.5	12	1.9	1.4	391
			2	5.3	0.4	3.8	2.0	39	NA	9.3	2.8	4.8	13	1.4	1.2	384
			3	5.4	0.4	4.9	2.8	43	NA	9.5	2.8	5.3	12	1.3	1.2	383
			4	5.4	0.3	4.5	2.1	36	NA	9.3	2.7	5.2	12	1.4	1.2	391
	223	11	1	6.4	1.4	4.1	1.8	14	NA	6.8	9.3	1.8	13	2.1	9.8	269
			2	6.2	2.9	4.8	2.0	4	NA	6.1	14.1	3.2	11	3.5	17.1	269
			3	6.4	2.5	4.1	6.7	4	NA	5.7	13.5	3.0	12	2.7	10.6	233
			4	6.8	1.0	4.5	3.2	9	NA	6.5	9.8	1.8	11	2.7	10.6	235
		44	1	6.6	0.6	5.0	2.1	12	NA	6.5	8.8	1.6	12	2.2	10.5	263
			2	6.5	1.8	3.7	2.2	11	NA	6.8	9.9	2.0	11	2.2	11.4	231
			3	6.5	1.6	4.2	5.5	11	NA	6.7	10.0	1.8	11	2.2	11.4	231
			4	6.5	1.6	4.1	2.1	12	NA	6.5	10.7	1.7	12	2.2	11.3	293
		178	1	6.6	1.2	4.0	3.7	23	NA	6.8	9.4	1.6	11	2.2	10.3	227
			2	6.6	1.5	4.0	2.0	22	NA	6.9	9.6	1.6	11	2.2	10.5	279
			3	6.5	1.5	4.5	3.0	22	NA	7.1	9.9	1.6	11	2.4	10.7	237
			4	6.5	0.9	3.8	4.8	22	NA	7.2	9.3	1.8	10	2.2	10.6	229
	446	11	1	7.1	3.7	3.9	14.4	3	NA	4.6	12.6	1.9	14	2.1	11.7	192
			2	6.9	2.3	4.4	18.8	6	NA	4.8	14.0	1.7	13	2.0	11.4	174
			3	7.0	2.1	3.9	12.0	3	NA	4.7	13.5	1.6	12	2.0	11.8	178
			4	6.9	1.8	3.5	2.6	6	NA	4.9	12.8	1.7	15	2.1	11.7	183
		44	1	6.9	2.1	4.0	24.8	6	NA	4.7	12.8	2.1	14	2.2	12.0	185
			2	7.2	1.7	3.8	NA	3	NA	4.4	15.2	2.2	12	3.3	13.5	143
			3	7.5	2.7	4.8	12.8	<1	NA	4.5	17.5	3.9	14	7.4	16.4	169
			4	7.0	2.6	3.6	6.5	3	NA	4.9	14.8	1.8	11	2.0	11.2	156

Table IV-2. Continued.

Soil	Tailings Rate	P Rate	Replication	pH	EC	NH_4-N	NO_3-N	Bray P	$NaHCO_3$ P	NH_4Ac Ca	NH_4Ac Mg	DTPA-extractable Zn	Mn	Cu	Ni	Fe
	- g/kg -	mg/kg			mmhos/cm	------ µg/g		----------		-meq/100g-		----------		µg/g	----------	
Eightlar	223	44	1	7.1	2.4	3.5	2.7	<1	NA	4.7	12.9	2.3	27	2.7	26.0	60
			2	7.4	1.8	3.8	1.8	<1	4	4.5	11.8	2.1	32	3.0	30.4	61
			3	7.3	2.5	3.5	2.4	<1	NA	5.3	13.4	2.0	30	2.8	28.0	61
			4	7.4	1.8	3.4	2.0	<1	6	4.1	12.3	2.6	32	3.9	28.7	72
		178	1	7.2	2.2	3.5	1.9	<1	NA	5.3	12.6	3.1	30	3.0	28.8	62
			2	7.2	2.1	3.6	1.8	<1	NA	4.7	12.9	2.5	31	2.9	30.7	63
			3	7.1	2.6	3.3	1.9	<1	NA	5.0	13.2	2.6	29	2.9	28.1	62
			4	7.2	2.6	4.5	2.1	<1	NA	4.6	13.3	2.8	26	2.9	27.7	59
	446	11	1	7.4	4.1	3.5	4.4	<1	6	4.4	19.3	3.7	43	4.7	21.0	72
			2	7.5	3.4	3.6	4.4	<1	9	4.2	18.3	3.8	64	4.7	23.5	79
			3	7.3	3.8	3.4	8.5	<1	7	4.0	20.0	4.3	45	4.7	22.6	74
			4	7.3	2.6	3.2	5.2	<1	6	3.8	17.0	6.0	45	5.0	23.8	86
		44	1	7.4	3.2	3.1	3.9	<1	NA	5.6	16.6	2.8	24	2.9	23.2	68
			2	7.2	2.8	2.8	2.9	<1	6	4.8	17.4	2.5	25	2.8	22.4	66
			3	7.3	2.9	2.9	1.0	<1	NA	4.7	17.6	3.7	23	3.0	24.5	80
			4	7.4	3.0	2.6	4.4	<1	NA	5.1	15.6	2.7	24	2.9	25.8	77
		178	1	7.4	2.3	3.1	1.0	<1	NA	5.1	15.2	3.5	25	3.0	23.6	70
			2	7.4	3.2	3.2	8.4	<1	NA	5.5	16.2	5.7	24	3.6	28.3	82
			3	7.4	3.1	3.3	26.4	<1	20	4.8	16.7	3.8	24	3.2	22.8	81
			4	7.5	2.5	3.3	7.6	<1	19	5.3	16.7	3.3	26	3.0	23.7	71
	669	11	1	7.2	5.0	2.8	38.8	<1	18	4.2	15.8	2.5	53	2.5	14.5	123
			2	7.3	3.0	2.7	6.0	<1	16	4.4	14.0	2.5	43	2.4	16.0	119
			3	7.2	4.7	2.8	5.6	<1	18	4.2	15.3	2.5	52	2.3	15.6	125
			4	7.2	2.8	2.4	8.9	<1	13	4.1	12.9	2.5	44	2.3	17.2	125

Table IV-2. Continued.

								Bray	NaHCO$_3$	NH$_4$Ac			DTPA-extractable			
Soil	Tailings Rate	P Rate	Replication	pH	EC	NH$_4$-N	NO$_3$-N	P	P	Ca	Mg	Zn	Mn	Cu	Ni	Fe
	- g/kg -	mg/kg			mmhos/cm	------	µg/g	----------		-meq/100g-		---------		µg/g	-----------	
Amity	446	178	1	7.4	3.6	2.4	3.8	4	NA	4.2	19.9	3.0	16	4.6	15.9	116
			2	7.4	2.7	5.2	15.2	3	NA	4.2	20.2	3.2	19	4.6	15.6	114
			3	7.3	3.5	5.1	49.2	3	NA	4.4	20.7	2.9	16	4.6	15.3	116
			4	7.2	4.3	6.2	153.2	4	NA	4.8	21.0	3.2	18	4.6	16.2	120
	669	11	1	7.2	4.0	4.2	264.0	<1	NA	4.1	19.5	2.9	30	2.3	12.6	105
			2	7.4	3.4	3.8	56.8	<1	NA	3.7	14.6	3.1	24	2.5	13.2	104
			3	7.2	5.5	3.6	86.8	<1	NA	4.1	18.3	1.8	30	2.5	12.3	129
			4	7.3	7.4	3.6	49.2	2	NA	4.2	17.2	2.0	30	3.4	11.4	136
		44	1	7.2	6.1	3.6	153.2	1	NA	4.1	17.6	2.1	33	2.0	11.2	147
			2	7.3	2.4	3.3	11.0	1	NA	4.3	13.8	2.0	28	2.1	11.6	150
			3	7.2	2.2	4.1	30.0	2	NA	4.5	17.4	1.8	23	2.1	11.4	145
			4	7.1	3.1	3.3	17.2	3	NA	4.0	14.7	2.0	26	1.9	11.4	143
		178	1	7.4	4.8	3.9	87.6	2	NA	4.2	11.1	3.0	30	2.6	13.8	118
			2	7.2	7.3	4.9	246.8	5	NA	5.0	22.8	3.0	26	3.2	13.3	121
			3	7.4	3.0	3.3	19.6	3	NA	4.4	14.9	2.5	22	2.6	12.8	110
			4	7.4	2.2	3.4	2.6	3	NA	4.0	13.8	3.2	22	2.6	11.0	123
Eightlar	0	44	1	6.4	0.6	3.6	2.4	<1	NA	5.4	1.8	3.7	50	3.1	62.9	22
			2	6.4	0.4	4.9	2.4	<1	NA	5.7	2.0	5.9	50	3.1	65.9	23
			3	6.3	0.4	3.7	2.0	<1	NA	6.1	2.0	8.4	49	3.3	65.3	21
			4	6.4	0.4	4.2	4.6	<1	NA	5.0	1.8	3.3	45	3.1	65.3	17
	223	11	1	7.0	1.5	3.2	1.8	<1	NA	4.8	8.3	8.2	32	2.8	30.2	90
			2	6.8	2.4	3.2	2.6	<1	NA	5.3	9.1	4.1	28	2.6	27.9	82
			3	7.0	1.3	3.4	3.5	<1	NA	5.0	8.3	6.8	28	3.8	28.9	80
			4	7.2	1.2	3.2	2.0	<1	NA	4.9	8.2	11.6	27	2.6	26.6	74

Table IV-2. Continued.

Soil	Tailings Rate	P Rate	Replication	pH	EC	NH_4-N	NO_3-N	Bray P	$NaHCO_3$ P	NH_4Ac Ca	NH_4Ac Mg	DTPA-extractable Zn	DTPA-extractable Mn	DTPA-extractable Cu	DTPA-extractable Ni	Fe
	- g/kg -	mg/kg			mmhos/cm	-------- µg/g			--------	-meq/100g-		----------		µg/g		----------
Eightlar	669	44	1	7.5	5.3	4.0	204.4	<1	14	2.1	23.8	3.4	28	2.6	14.9	90
			2	7.4	7.5	4.2	230.0	<1	11	1.9	23.4	3.3	33	2.8	15.7	77
			3	7.4	10.7	4.2	76.4	<1	12	1.8	23.8	2.5	41	2.6	14.7	95
			4	7.4	4.5	3.5	212.8	<1	14	1.8	22.7	3.3	29	2.6	15.5	87
		178	1	6.9	11.0	7.3	698.0	<1	25	2.4	26.1	5.2	56	3.4	23.2	134
			2	6.6	11.0	9.2	570.4	<1	16	2.2	25.0	5.7	84	4.0	31.0	163
			3	6.5	13.8	7.2	936.0	<1	20	2.4	28.6	5.6	87	3.5	31.2	154
			4	6.5	8.8	8.3	527.6	<1	18	2.2	24.0	5.5	83	3.7	29.9	146
---	100%	11	1	7.5	12.0	7.9	408.8	<1	16	4.1	23.8	4.0	59	1.2	7.2	81
			2	7.4	8.2	4.9	221.6	<1	14	3.4	21.9	4.0	61	1.3	8.4	85
			3	7.5	12.0	7.9	442.4	<1	14	3.4	28.7	4.3	63	1.9	8.1	80
			4	7.4	12.0	8.9	493.6	<1	14	3.3	28.7	4.8	73	2.0	8.9	98
		44	1	7.7	8.5	5.0	197.6	<1	28	4.1	23.8	3.5	45	2.2	3.3	73
			2	7.8	4.5	5.9	87.2	<1	19	3.6	18.6	3.7	45	1.1	6.1	81
			3	7.8	7.1	5.7	109.6	<1	18	3.8	20.4	3.5	55	1.0	6.2	79
			4	7.6	8.2	5.7	220.0	<1	15	3.8	19.3	3.5	51	1.1	6.1	67
		178	1	7.6	5.3	5.9	170.4	<1	36	3.6	22.2	4.6	67	1.9	8.2	93
			2	7.4	7.0	8.9	246.8	<1	36	3.2	24.1	5.1	77	2.0	9.6	101
			3	7.6	8.2	8.2	323.2	<1	34	3.3	26.0	4.9	58	2.1	8.3	93
			4	7.5	11.0	5.7	255.2	<1	37	3.5	25.9	4.4	58	1.9	8.2	93

NA = not analyzed

Table IV-3. pH, NH_4- and NO_3-N, extractable P, exchangeable Ca and Mg, and DTPA-extractable Mn, Cu and Ni of soils amended with fertilizer materials after the fourth cutting of tall fescue and white clover.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac		DTPA-extractable		
						Ca	Mg	Mn	Cu	Ni
			------- µg/g		----	-meq/100 g-		-----	µg/g	-------
1	1	5.7	4.0	6.2	50.7	9.4	2.9	8.8	1.6	1.6
	2	5.8	4.6	10.2	46.7	9.0	2.8	9.8	1.5	1.7
	3	5.7	2.7	1.8	46.7	10.5	2.8	11.1	1.8	1.3
2	1	5.3	8.0	16.8	36.7	8.6	2.7	14.3	1.7	1.6
	2	5.3	8.6	20.7	39.3	8.6	2.7	14.9	1.8	1.7
	3	5.3	6.5	17.4	36.0	9.6	2.8	13.8	1.8	1.7
3	1	5.3	4.7	44.8	51.3	8.6	2.9	11.6	1.6	1.5
	2	5.8	8.0	3.3	49.3	9.6	3.0	15.8	1.7	1.7
	3	5.6	3.8	27.0	45.3	8.8	2.7	12.0	1.9	1.8
4	1	4.9	7.2	57.2	42.0	8.6	2.9	13.6	1.2	1.7
	2	5.1	8.0	53.2	29.3	8.3	2.5	13.4	1.3	1.2
	3	5.0	7.8	58.0	36.7	8.7	2.7	15.2	1.5	1.6
5	1	5.8	2.5	10.8	54.7	5.7	1.1	7.8	1.0	0.6
	2	6.0	2.2	9.8	48.7	6.0	0.9	8.4	1.0	0.6
	3	6.3	2.2	1.4	60.0	5.8	1.0	8.5	0.9	0.8
6	1	5.6	4.0	20.2	47.3	5.8	1.0	11.0	0.9	0.8
	2	6.1	3.9	15.3	30.7	5.8	1.0	10.2	0.9	0.6
	3	6.0	4.3	19.3	44.0	5.6	1.0	12.9	1.0	0.8
7	1	6.0	2.4	11.2	52.0	6.3	1.0	11.1	1.0	0.6
	2	6.2	3.8	1.0	58.7	6.6	1.0	10.7	1.0	0.8
	3	6.2	2.5	16.8	88.7	6.4	1.1	10.5	1.0	0.8
8	1	5.7	3.0	24.8	38.7	5.4	0.9	14.4	1.1	0.8
	2	5.6	3.0	29.9	52.7	5.8	1.9	12.6	0.8	1.0
	3	5.5	2.8	33.4	56.0	5.8	0.9	12.7	1.0	0.9
9	1	6.3	3.5	8.4	26.0	4.5	1.2	12.7	0.8	0.7
	2	6.4	3.6	8.2	17.3	5.5	1.3	9.9	0.7	0.5
	3	6.2	2.6	9.9	25.3	5.3	1.3	12.8	0.8	0.7
10	1	5.6	5.1	4.6	16.0	3.2	1.0	20.5	0.7	0.9
	2	5.7	7.2	12.9	12.0	5.7	1.1	19.9	0.8	1.0
	3	5.8	4.8	7.0	14.7	4.4	1.1	20.3	0.8	0.9
11	1	6.0	3.8	15.3	22.7	4.1	1.2	10.8	0.7	0.5
	2	6.3	2.7	6.6	24.0	8.0	1.3	11.4	0.7	0.5
	3	6.0	3.0	2.5	22.7	4.1	1.2	9.9	0.6	0.5

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac Ca	NH_4Ac Mg	DTPA-extractable Mn	DTPA-extractable Cu	DTPA-extractable Ni
			------- µg/g	----		-meq/100 g-		----- µg/g	---------	
12	1	5.5	5.5	10.7	16.0	3.7	1.0	13.2	0.6	0.7
	2	5.7	4.7	13.2	10.7	4.2	1.0	14.0	0.6	0.7
	3	5.3	6.4	11.9	24.7	4.0	1.1	15.8	0.8	1.1
13	1	5.6	3.9	9.8	62.0	8.5	3.0	3.0	1.7	1.8
	2	5.7	2.7	12.2	68.0	8.5	3.0	7.0	1.2	1.8
	3	5.5	3.6	3.7	57.3	8.9	3.1	9.6	1.7	2.1
14	1	5.3	6.4	16.1	76.0	8.7	3.2	11.3	1.5	2.3
	2	5.5	5.0	3.8	107.3	10.1	3.4	14.2	1.5	2.8
	3	5.3	5.4	11.2	88.7	9.4	3.7	12.3	1.5	2.7
15	1	6.0	2.4	2.8	77.3	5.8	1.4	9.7	0.9	1.2
	2	6.0	2.0	2.4	77.3	6.1	1.2	13.1	1.0	1.2
	3	5.8	2.2	2.7	60.0	5.5	1.3	11.1	1.0	1.0
16	1	5.9	2.6	12.6	118.0	6.1	1.4	7.3	0.9	1.0
	2	6.3	2.6	2.1	126.7	7.4	1.5	11.6	1.0	1.4
	3	6.3	3.3	1.6	93.3	6.8	1.3	12.7	1.1	1.3
17	1	5.9	2.6	3.4	62.0	4.4	1.4	10.6	0.6	0.8
	2	6.0	3.8	4.7	37.3	4.4	1.6	14.3	0.7	0.8
	3	5.9	2.2	2.3	50.0	5.0	1.5	14.7	0.7	1.0
18	1	6.0	3.2	10.5	49.3	4.4	1.7	13.9	0.8	1.0
	2	6.1	4.7	6.6	104.7	4.6	1.9	9.4	0.6	1.2
	3	6.2	5.2	1.6	61.3	4.8	1.5	14.2	0.7	0.8
19	1	5.4	2.9	3.0	85.3	8.5	3.6	13.0	1.7	2.7
	2	5.3	3.0	3.3	78.0	8.4	3.4	12.7	1.8	2.5
	3	5.4	2.7	1.3	72.0	8.7	3.7	13.6	1.6	1.5
20	1	5.4	3.9	4.2	104.7	8.7	3.5	11.6	1.6	2.7
	2	5.7	2.6	3.6	129.3	9.2	3.6	6.6	1.9	1.8
	3	5.3	2.6	2.0	28.0	10.4	3.6	12.6	1.7	2.7
21	1	5.7	2.1	1.1	88.7	5.5	1.6	9.4	0.9	1.1
	2	5.8	1.7	1.1	91.3	4.9	1.4	7.4	0.9	1.2
	3	5.6	3.4	2.2	92.0	5.3	1.6	7.3	0.8	1.2
22	1	6.3	2.4	3.2	148.7	5.8	1.5	11.8	0.9	1.4
	2	6.2	2.0	1.8	115.3	6.3	1.6	13.2	1.0	1.7
	3	6.2	3.1	0.7	174.7	5.9	1.8	17.1	1.1	2.5

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac		DTPA-extractable		
						Ca	Mg	Mn	Cu	Ni
			µg/g			meq/100 g		µg/g		
23	1	5.8	3.2	3.0	67.3	4.7	2.0	10.8	0.7	1.1
	2	5.8	3.6	3.9	96.7	4.3	1.9	12.0	0.7	1.2
	3	5.8	2.8	3.9	90.7	4.5	2.0	15.9	0.8	1.5
24	1	5.7	3.7	6.9	89.3	3.7	1.8	10.9	0.7	1.1
	2	6.1	2.5	2.7	96.0	4.8	1.9	8.0	0.7	1.1
	3	6.4	2.6	2.0	132.0	5.3	2.0	13.5	0.8	1.7
25	1	5.5	3.3	13.9	36.0	8.8	2.7	8.5	1.7	1.5
	2	5.7	1.3	26.5	33.3	8.5	2.5	5.6	1.3	1.1
	3	5.6	4.1	13.6	40.7	8.6	2.6	6.9	1.5	1.1
26	1	5.1	11.4	27.9	46.7	8.4	2.7	13.5	1.7	1.7
	2	5.3	11.0	21.2	40.7	8.5	2.7	15.6	1.8	2.3
	3	5.3	7.5	26.6	34.0	8.8	2.7	13.8	1.7	1.3
27	1	5.6	3.4	14.4	42.7	9.2	3.0	8.0	1.8	1.4
	2	5.8	6.2	24.4	42.7	8.7	2.8	12.2	1.8	1.5
	3	5.8	3.7	5.6	39.3	9.1	2.7	8.9	1.6	1.4
28	1	5.1	9.0	29.6	33.3	8.4	2.6	11.8	1.7	1.2
	2	5.1	9.0	36.5	38.0	8.3	2.6	14.0	1.8	1.7
	3	5.2	6.4	33.1	46.7	8.4	2.8	12.1	1.3	1.7
29	1	6.0	2.0	10.9	54.0	7.0	1.1	6.2	0.9	0.6
	2	6.3	4.3	1.5	50.7	6.1	0.9	9.4	1.0	0.5
	3	5.9	2.5	4.5	49.3	5.5	0.9	7.0	0.8	0.6
30	1	5.4	5.9	24.5	48.0	6.1	1.0	15.2	1.1	0.7
	2	5.9	4.8	17.5	37.3	6.0	0.9	11.3	1.0	0.6
	3	5.9	2.7	32.8	44.7	6.1	0.8	9.9	0.8	0.7
31	1	6.0	2.1	14.0	54.7	7.3	1.0	9.7	1.1	0.6
	2	6.1	2.4	3.0	46.0	6.6	1.0	10.2	1.1	0.5
	3	6.4	2.2	2.5	52.7	6.0	0.9	13.9	1.1	0.6
32	1	5.5	3.2	33.7	39.3	5.2	0.9	9.4	0.9	0.7
	2	5.7	7.3	34.6	47.3	6.2	0.9	11.5	1.0	0.8
	3	5.4	4.0	34.2	44.7	5.4	0.9	12.3	1.0	0.7
33	1	6.3	4.0	5.5	24.0	4.4	1.2	7.9	0.6	0.7
	2	6.2	5.0	1.8	15.3	4.3	1.1	11.4	0.6	0.3
	3	6.2	3.0	13.4	22.7	5.3	1.2	13.7	0.8	0.7

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac Ca	Mg	DTPA-extractable Mn	Cu	Ni
			------- µg/g	-----		-meq/100 g-		------	µg/g	-------
34	1	5.2	10.3	3.2	16.0	2.0	1.0	30.4	0.7	1.1
	2	5.7	6.4	7.0	12.0	4.0	1.0	14.7	0.7	0.7
	3	5.5	10.7	11.6	10.0	3.3	1.0	22.6	0.7	0.7
35	1	6.0	2.6	16.3	20.7	4.3	1.3	13.1	0.8	0.7
	2	6.4	3.8	6.4	19.3	4.7	1.1	7.1	0.6	0.4
	3	6.5	2.2	6.4	28.7	6.8	1.4	11.8	0.7	0.8
36	1	5.8	7.0	7.0	11.3	4.5	1.1	13.7	0.7	0.7
	2	5.8	7.4	7.7	20.7	4.1	1.2	13.1	0.6	0.9
	3	5.6	6.7	6.4	10.0	3.8	1.1	15.6	0.7	0.7
37	1	5.6	3.2	5.0	50.7	9.2	2.9	12.1	1.8	1.6
	2	5.5	4.9	2.0	52.7	8.5	3.0	12.1	1.9	1.9
	3	5.4	3.8	2.7	54.0	8.9	3.1	7.9	1.3	1.6
38	1	5.6	6.8	7.5	92.7	9.0	3.4	10.9	1.7	2.6
	2	5.6	6.7	2.2	80.7	8.7	3.1	12.9	2.0	2.4
	3	5.6	6.9	2.1	100.7	9.3	3.7	14.6	1.8	2.9
39	1	5.7	2.3	5.2	88.0	6.6	1.3	13.6	1.1	1.1
	2	6.0	2.3	2.0	58.7	8.2	1.3	12.4	1.0	0.8
	3	6.0	2.0	2.3	62.0	6.8	1.2	11.0	1.0	1.0
40	1	6.0	1.8	16.0	95.3	6.1	1.4	9.0	1.2	1.3
	2	6.2	1.7	7.7	81.3	6.8	1.3	13.4	1.1	1.1
	3	6.1	1.9	4.9	90.7	7.0	1.4	13.8	1.1	1.4
41	1	6.1	2.7	7.6	40.4	4.4	1.6	14.4	0.8	1.2
	2	6.0	2.4	6.0	42.0	4.8	1.5	14.5	0.8	1.0
	3	6.2	2.4	1.9	38.7	4.0	1.4	10.8	0.7	0.8
42	1	6.2	3.2	5.6	68.7	5.0	1.6	11.9	0.7	0.9
	2	6.1	3.1	6.9	82.0	5.0	1.5	10.1	0.7	1.0
	3	6.2	2.8	9.5	60.0	5.2	1.6	11.5	0.6	0.8
43	1	5.4	3.0	1.7	74.7	8.9	3.1	13.5	1.7	2.1
	2	5.4	4.4	5.6	76.0	8.5	3.3	12.0	1.5	2.1
	3	5.7	2.9	1.4	62.0	8.9	3.1	13.0	1.7	2.2
44	1	5.5	3.6	4.3	114.0	9.0	3.7	12.8	1.5	2.5
	2	5.5	5.6	1.7	72.7	9.3	3.4	13.4	1.9	2.0
	3	5.5	4.7	3.3	114.0	9.2	3.7	13.3	1.7	3.0

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac		DTPA-extractable		
						Ca	Mg	Mn	Cu	Ni
			------ µg/g -----			-meq/100 g-		------ µg/g ------		
45	1	5.6	2.5	1.8	88.0	6.0	1.8	10.7	0.9	1.0
	2	5.7	2.5	2.3	70.7	5.0	1.4	9.0	0.8	1.0
	3	5.7	1.8	1.7	62.0	5.5	1.5	9.4	0.9	1.0
46	1	5.9	1.6	1.8	126.7	6.1	1.6	12.2	0.8	1.4
	2	5.8	1.6	1.8	124.0	5.6	1.5	12.3	1.0	0.7
	3	5.9	2.1	1.1	137.3	7.0	1.7	13.3	1.0	1.6
47	1	5.7	3.2	1.4	86.7	4.7	2.0	15.5	0.7	1.6
	2	5.9	2.4	1.4	73.3	4.4	2.0	11.7	0.7	1.1
	3	6.1	2.8	1.1	78.7	4.0	1.6	15.9	0.6	1.4
48	1	6.2	3.2	2.4	99.3	5.0	2.0	15.6	0.8	1.8
	2	6.3	4.9	1.8	86.0	5.1	1.8	16.9	0.7	1.1
	3	6.1	2.4	2.2	115.3	5.4	2.2	20.3	0.8	2.2
49	1	5.7	4.2	18.4	52.7	8.8	2.8	6.7	1.4	1.2
	2	5.8	5.0	4.9	55.3	10.2	3.0	8.7	1.7	1.3
	3	5.7	3.7	11.2	49.3	9.0	2.9	7.9	1.5	1.3
50	1	5.3	7.8	25.4	43.3	8.0	2.7	12.2	1.7	1.2
	2	5.2	8.9	34.6	53.3	8.4	2.8	12.7	1.7	1.1
	3	5.4	8.2	34.2	47.3	9.6	2.9	13.9	1.8	1.3
51	1	5.7	3.1	22.4	56.0	8.8	2.9	7.3	1.7	1.2
	2	5.8	5.4	2.6	68.3	9.5	3.1	11.5	1.8	1.3
	3	5.7	1.3	25.4	56.0	8.6	2.9	6.9	1.3	1.2
52	1	5.0	8.5	37.0	69.3	9.1	3.5	13.5	1.5	1.1
	2	5.0	7.7	32.7	54.7	8.6	3.1	13.3	1.5	1.3
	3	5.2	10.7	41.3	44.0	11.2	3.0	12.7	1.3	1.3
53	1	6.1	2.2	19.8	66.0	6.2	1.1	9.5	1.1	0.7
	2	6.4	1.8	4.6	59.3	6.5	1.1	4.7	0.8	0.5
	3	6.2	2.5	11.5	56.0	6.4	1.2	9.2	1.0	0.6
54	1	5.9	3.6	35.9	48.7	6.2	1.0	11.6	1.0	0.6
	2	5.7	4.7	44.8	56.0	6.0	1.1	19.8	1.1	0.7
	3	5.8	6.5	19.4	59.3	6.0	1.0	11.6	0.9	0.6
55	1	6.0	2.4	14.2	70.0	6.2	1.1	11.0	1.1	0.7
	2	6.2	2.1	9.7	64.7	6.2	1.2	7.6	1.0	0.6
	3	6.1	2.0	13.7	87.3	6.8	1.1	6.7	0.9	0.5

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac Ca	Mg	DTPA-extractable Mn	Cu	Ni
			------ µg/g	----		-meq/100	g-	------	µg/g	-------
56	1	5.8	2.7	24.9	48.7	5.8	0.9	11.2	0.9	0.5
	2	5.9	2.9	43.6	54.7	6.3	1.1	8.5	1.4	0.5
	3	5.8	2.9	35.3	82.0	6.1	1.2	12.7	1.1	0.7
57	1	6.3	5.2	16.4	28.0	4.5	1.2	5.0	0.6	0.3
	2	6.5	4.0	3.8	36.7	4.9	1.3	7.0	0.7	0.4
	3	6.8	3.0	3.0	21.3	5.8	1.0	5.6	0.6	0.4
58	1	6.2	6.9	6.5	18.0	4.0	1.1	15.0	0.7	0.5
	2	6.0	5.5	9.8	13.3	4.0	1.0	14.4	0.6	0.7
	3	5.6	13.2	8.2	14.0	3.3	1.1	15.3	0.6	0.6
59	1	6.2	2.8	18.3	30.7	4.8	1.4	12.9	1.2	0.8
	2	6.4	5.4	7.3	44.0	4.6	1.4	9.8	0.7	0.5
	3	6.7	2.5	2.2	38.0	4.9	1.2	8.6	0.6	0.4
60	1	5.8	4.5	7.7	12.7	3.9	1.1	15.0	0.7	0.6
	2	5.8	4.8	39.0	33.3	4.6	1.3	16.6	0.8	0.7
	3	5.5	5.8	23.6	37.3	3.3	1.2	15.3	0.6	0.6
61	1	5.4	5.6	21.2	115.3	9.6	3.8	10.4	1.8	1.2
	2	5.6	4.4	6.6	94.0	10.4	3.9	11.3	1.6	1.1
	3	5.5	2.2	29.3	98.0	9.1	3.7	11.5	1.4	1.3
62	1	5.4	2.6	35.8	86.0	9.0	3.4	9.8	1.5	1.3
	2	5.7	4.2	4.1	135.3	10.0	3.9	12.8	1.6	1.3
	3	6.0	2.8	16.8	107.3	9.3	3.6	7.5	1.5	1.3
63	1	6.0	2.4	12.0	110.0	6.5	1.5	12.1	1.1	0.5
	2	6.4	2.1	2.6	95.3	6.2	1.6	8.4	0.9	0.5
	3	6.2	2.4	4.6	97.3	6.0	1.4	11.5	1.1	0.7
64	1	6.4	2.0	5.7	110.7	6.4	1.3	11.1	1.0	0.7
	2	6.4	3.6	2.0	146.7	6.4	1.6	8.7	0.9	0.5
	3	6.5	2.4	3.8	141.3	6.7	1.6	8.1	0.9	0.6
65	1	6.4	1.6	7.2	94.7	4.2	1.9	13.3	0.8	0.8
	2	6.7	2.8	3.0	98.7	4.7	1.8	6.4	0.6	0.3
	3	6.4	1.8	1.6	85.3	5.0	1.8	11.9	0.7	0.5
66	1	6.3	2.3	19.9	99.3	4.6	1.9	10.9	0.7	0.6
	2	6.6	2.2	7.3	110.7	5.2	2.2	13.7	0.8	0.5
	3	6.6	3.1	8.2	133.3	5.6	2.2	11.6	0.8	0.7

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac		DTPA-extractable		
						Ca	Mg	Mn	Cu	Ni
			-------	µg/g	----	-meq/100	g-	------	µg/g	-------
67	1	5.9	3.0	5.0	142.0	8.7	4.0	8.7	1.6	1.1
	2	6.0	3.0	4.3	118.0	8.1	3.5	7.8	1.6	1.3
	3	5.8	2.6	3.6	93.3	9.1	3.5	10.4	1.9	1.4
68	1	5.8	2.4	5.6	140.7	9.0	4.0	6.9	1.6	1.2
	2	6.0	3.8	4.6	128.0	8.9	3.7	5.1	1.2	1.0
	3	5.8	4.6	7.5	98.7	13.4	3.4	9.8	1.7	1.4
69	1	6.2	2.1	8.0	157.3	5.2	1.8	12.3	1.0	0.8
	2	6.3	1.7	1.4	132.0	6.1	1.9	11.7	1.1	0.8
	3	6.3	1.8	2.0	120.7	7.4	1.7	10.0	1.1	0.7
70	1	6.2	2.6	8.8	229.7	6.3	2.0	12.7	1.1	0.9
	2	6.6	2.4	3.1	208.7	7.4	2.5	8.9	0.9	0.7
	3	6.3	3.1	0.8	250.7	6.2	2.5	10.6	1.0	0.8
71	1	6.4	6.6	17.2	149.3	4.7	2.3	10.6	0.8	0.8
	2	6.5	1.8	1.2	157.3	4.7	2.5	10.4	0.7	0.6
	3	6.7	2.2	1.2	124.7	4.2	1.9	12.0	0.7	0.5
72	1	6.2	4.8	15.0	87.3	4.6	1.6	9.3	0.7	0.5
	2	6.7	3.0	5.3	140.7	4.8	2.4	6.6	0.6	0.5
	3	6.6	2.5	13.0	174.7	5.4	2.8	9.7	0.7	0.8
73	1	5.7	4.0	6.2	44.7	8.7	2.7	8.7	1.7	1.2
	2	5.7	4.4	4.7	39.3	9.1	2.7	6.9	1.4	1.2
	3	5.7	2.8	1.5	42.7	8.8	2.6	11.5	1.8	1.2
74	1	5.2	11.6	45.6	40.0	8.6	2.7	14.6	1.8	1.2
	2	5.4	9.9	9.8	36.7	8.7	2.7	16.8	1.8	1.3
	3	5.3	11.2	22.5	34.7	8.7	2.7	13.6	1.7	1.3
75	1	5.6	3.1	15.3	52.0	8.9	2.6	8.3	1.7	1.2
	2	5.8	3.4	10.8	38.0	8.9	2.5	9.1	1.5	1.1
	3	5.6	1.9	15.3	46.0	8.6	2.5	6.5	1.3	0.9
76	1	5.2	8.8	25.2	36.0	8.3	2.6	16.2	1.8	0.9
	2	5.3	9.1	35.3	41.3	8.2	2.6	14.6	1.9	1.3
	3	5.3	11.0	28.4	42.7	8.6	2.7	16.1	1.7	1.2
77	1	6.0	2.2	4.4	78.7	7.4	1.2	10.4	1.1	0.7
	2	6.1	2.0	3.7	50.7	7.2	1.1	11.3	1.0	0.4
	3	6.2	2.9	1.6	75.3	6.2	0.9	9.5	0.9	0.6

Table IV-3. Continued.

Treat-ment Number	Repli-cation	pH	NH_4-N	NO_3-N	P	NH_4Ac Ca	NH_4Ac Mg	DTPA-extractable Mn	DTPA-extractable Cu	DTPA-extractable Ni
			µg/g	µg/g	µg/g	meq/100 g	meq/100 g	µg/g	µg/g	µg/g
78	1	6.0	2.8	16.3	47.3	5.9	0.8	10.0	0.8	0.7
	2	5.9	3.4	30.0	54.7	6.2	0.9	11.5	0.8	0.5
	3	5.8	2.8	24.4	66.7	7.5	1.1	14.0	1.1	0.8
79	1	6.1	4.4	15.7	50.7	6.8	1.0	8.0	0.9	0.6
	2	6.5	1.6	4.0	70.7	7.4	1.2	11.2	1.1	0.5
	3	6.3	3.2	7.0	68.0	9.1	1.0	9.6	1.0	0.6
80	1	5.6	3.2	40.8	72.7	5.6	0.9	10.4	0.8	0.7
	2	5.7	3.0	27.3	64.0	6.2	1.2	11.2	1.0	0.6
	3	5.6	4.4	43.6	70.0	6.4	1.2	10.4	1.2	0.5
81	1	6.8	3.4	2.8	26.7	7.6	1.2	11.0	0.6	0.6
	2	6.2	2.3	1.7	34.7	6.2	1.5	11.3	0.7	0.5
	3	6.4	2.3	1.1	38.7	6.1	1.2	13.8	0.7	0.6
82	1	5.7	4.5	9.8	16.7	3.7	1.0	13.3	0.5	0.5
	2	5.8	6.9	5.3	21.3	3.6	1.0	20.0	0.6	0.6
	3	5.9	6.4	8.2	10.7	3.9	1.0	16.2	0.6	0.6
83	1	6.2	4.5	12.5	13.3	6.4	1.2	11.3	0.7	0.5
	2	6.2	3.5	15.6	50.0	5.2	1.2	10.9	0.8	0.6
	3	6.3	2.6	4.9	24.0	5.1	1.3	13.4	0.7	0.5
84	1	5.9	7.7	4.7	20.7	3.3	1.0	23.6	0.7	0.8
	2	5.5	9.2	17.0	25.3	3.8	1.1	12.4	0.6	0.8
	3	5.6	5.6	14.7	24.7	3.8	1.1	20.2	0.7	0.6
85	1	5.3	3.0	5.2	95.3	8.9	3.3	12.8	1.6	1.2
	2	5.4	4.7	5.4	77.3	10.3	3.1	12.0	1.7	1.3
	3	5.4	3.0	4.6	58.0	9.1	3.1	9.9	1.5	1.2
86	1	5.7	3.0	8.4	79.3	8.5	2.5	11.5	1.7	1.4
	2	5.7	3.0	10.2	68.0	8.7	2.5	6.9	1.3	1.1
	3	5.7	4.8	10.8	63.3	9.3	2.6	11.3	1.7	1.3
87	1	6.0	2.4	4.0	108.7	7.4	1.5	8.9	0.9	0.5
	2	5.9	1.8	3.0	100.0	7.1	1.5	12.6	1.0	0.7
	3	5.8	2.1	6.6	114.7	7.2	1.5	14.6	1.1	0.8
88	1	5.8	2.2	4.6	126.0	5.9	1.4	8.9	0.9	0.5
	2	5.8	1.9	2.5	157.3	6.1	1.4	7.4	0.7	0.6
	3	5.9	2.0	2.1	136.7	6.9	1.5	14.8	1.1	0.6

Table IV-3. Continued.

Treat- ment	Repli-					NH_4Ac		DTPA-extractable		
Number	cation	pH	NH_4-N	NO_3-N	P	Ca	Mg	Mn	Cu	Ni
89	1	5.9	3.8	2.8	44.7	4.4	1.5	11.4	0.6	0.5
	2	5.9	1.7	1.2	42.7	4.8	1.6	13.6	0.7	0.5
	3	5.6	2.7	2.4	56.0	3.7	1.4	13.5	0.6	0.6
90	1	6.0	2.7	2.0	62.7	4.3	1.5	13.2	0.6	0.5
	2	5.8	2.5	2.0	76.7	5.9	1.6	18.3	0.7	0.7
	3	5.9	2.4	1.6	101.3	4.6	1.7	12.1	0.6	0.6
91	1	5.2	2.9	1.6	86.0	8.6	3.4	30.2	1.6	1.1
	2	5.2	2.8	1.8	79.3	8.9	3.4	25.6	1.6	1.3
	3	5.1	3.0	4.4	69.3	9.4	3.5	28.4	1.7	1.5
92	1	5.3	6.9	5.6	72.0	8.6	3.7	9.4	1.1	1.1
	2	5.3	5.3	3.8	40.7	9.0	3.6	7.8	1.3	1.2
	3	5.4	3.7	3.3	76.7	8.8	3.6	11.9	1.4	1.2
93	1	5.5	1.3	1.3	110.0	5.8	1.6	8.4	0.9	0.6
	2	5.7	1.7	1.4	107.3	6.6	1.9	12.9	1.1	0.8
	3	5.7	2.0	1.8	99.3	6.1	1.8	10.8	1.0	0.6
94	1	5.0	2.2	2.8	86.0	4.5	1.9	15.3	0.8	0.7
	2	5.8	2.6	2.2	106.0	6.7	1.8	12.6	1.0	0.6
	3	5.8	1.4	2.8	138.7	7.1	1.9	7.7	0.8	0.6
95	1	5.6	3.7	2.4	102.0	4.3	2.0	16.1	0.6	0.9
	2	5.8	3.0	1.6	72.0	4.6	1.9	11.2	0.6	0.5
	3	5.4	5.4	1.4	52.0	3.6	2.0	31.6	0.7	0.5
96	1	5.8	2.5	2.6	78.7	4.3	1.9	16.1	0.7	0.5
	2	5.8	2.3	2.3	146.0	4.6	2.0	12.9	0.6	0.8
	3	5.7	2.0	1.6	140.7	4.4	2.1	23.6	0.8	0.8
97	1	5.8	3.0	7.0	32.7	8.6	2.5	10.2	1.7	1.0
	2	5.8	3.8	18.6	30.7	8.9	2.5	10.6	1.8	1.3
	3	5.7	3.4	20.3	34.7	8.5	2.5	10.2	1.7	1.2
98	1	5.3	8.3	19.6	27.3	8.5	2.5	12.9	1.7	1.3
	2	5.4	6.2	16.7	30.0	8.6	2.5	14.9	2.3	1.2
	3	5.3	7.7	25.6	28.7	8.9	2.5	13.8	1.8	1.2
99	1	6.4	3.8	2.8	40.0	5.6	0.8	7.4	0.9	0.4
	2	6.3	2.7	4.7	42.0	6.5	0.9	7.8	0.9	0.5
	3	6.2	2.4	10.2	40.0	5.9	0.8	5.9	0.9	0.5

Table IV-3. Continued.

Treatment Number	Replication	pH	NH_4-N	NO_3-N	P	NH_4Ac		DTPA-extractable		
						Ca	Mg	Mn	Cu	Ni
			-------- µg/g	----		-meq/100 g-		------ µg/g	--------	
100	1	5.8	4.2	12.9	32.7	5.6	0.7	10.6	1.0	0.6
	2	6.2	6.0	11.7	31.3	6.6	0.9	14.3	1.2	0.6
	3	5.9	4.2	23.6	30.0	6.3	0.8	8.3	0.8	0.4
101	1	6.6	3.6	7.1	11.3	5.0	1.0	8.9	0.6	0.4
	2	6.7	3.2	1.4	10.7	4.5	1.0	9.0	0.8	0.4
	3	6.6	3.3	4.3	18.7	2.4	1.1	19.2	0.7	0.6
102	1	5.9	6.6	6.3	3.3	3.5	0.9	15.3	0.6	0.5
	2	5.9	3.3	7.2	9.3	4.1	1.0	10.7	0.6	0.5
	3	6.0	6.0	5.1	7.3	4.1	0.9	13.6	0.6	0.4

APPENDIX V: DRY MATTER WEIGHTS

Table V-1. Dry matter weight of tall fescue grown on soils amended with tailing material.

Tailings Rate	P Rate	Replication	Cut 1		Cut 2		Cut 3		Cut 4	
			Amity	Eightlar	Amity	Eightlar	Amity	Eightlar	Amity	Eightlar
- g/kg -	mg/kg		g/pot							
0	44	1	2.54	1.32	7.20	3.55	5.11	2.01	2.89	1.80
		2	2.57	0.26	8.25	0.80	4.55	Lost	2.67	1.42
		3	3.76	1.14	8.32	2.81	4.01	1.33	3.00	1.09
		4	3.18	1.63	7.73	2.35	4.35	1.37	3.00	1.28
223	11	1	1.74	1.30	6.74	6.44	8.65	7.64	4.93	2.24
		2	1.72	0.91	6.62	5.74	9.50	7.34	11.10	2.62
		3	1.89	1.65	8.21	6.32	12.56	6.23	9.86	2.25
		4	2.13	1.84	5.93	6.23	9.82	6.06	7.43	1.78
	44	1	2.07	1.17	7.62	6.60	10.20	9.20	6.18	4.17
		2	2.46	1.09	8.35	6.45	10.35	9.71	4.74	4.73
		3	1.96	1.19	8.10	5.36	10.10	9.55	3.47	5.76
		4	2.24	1.51	6.39	5.30	12.04	8.58	5.69	5.02
	178	1	2.07	1.49	7.62	7.24	10.09	11.02	5.90	5.54
		2	2.20	1.15	7.33	5.11	10.25	11.19	5.63	6.30
		3	2.72	1.41	7.00	5.89	10.10	8.82	5.03	5.65
		4	2.06	1.64	6.00	6.48	8.77	8.12	7.49	4.92
446	11	1	0.58	0.08	3.75	0.46	11.70	5.22	11.95	13.00
		2	0.89	0.10	3.42	0.49	11.17	4.12	13.36	10.59
		3	0.76	0.09	3.33	0.22	12.67	2.82	11.81	9.65
		4	1.31	0.10	4.71	0.46	11.39	6.27	12.40	10.12

Table V-1. Continued.

Tailings Rate	P Rate	Replication	Cut 1		Cut 2		Cut 3		Cut 4	
			Amity	Eightlar	Amity	Eightlar	Amity	Eightlar	Amity	Eightlar
- g/kg -	mg/kg		g/pot							
446	44	1	0.50	0.40	2.43	4.63	9.42	12.06	9.56	6.34
		2	1.62	0.49	5.70	4.72	13.21	9.76	12.66	6.50
		3	1.42	0.53	5.33	3.64	11.60	7.66	12.39	8.04
		4	1.87	1.00	5.27	5.53	9.39	8.97	9.72	7.41
	178	1	0.85	0.54	4.90	5.31	13.15	11.97	11.27	5.60
		2	0.91	0.32	5.24	3.89	12.29	9.91	7.40	6.33
		3	1.06	0.69	4.65	2.46	12.14	4.57	11.53	6.34
		4	0.69	0.78	2.41	5.71	7.03	8.12	15.08	7.40
669	11	1	0.21	0.23	0.45	2.82	2.79	8.78	11.89	10.07
		2	1.36	0.31	3.34	2.41	6.01	9.04	6.42	10.63
		3	1.00	0.58	3.83	3.31	13.01	9.30	12.16	11.84
		4	1.13	0.60	3.72	3.30	7.59	6.73	10.65	9.27
	44	1	0.63	0.05	2.11	0.10	5.50	0.77	13.96	2.70
		2	0.69	0.09	2.16	0.10	6.87	0.36	12.72	1.50
		3	1.40	0.07	5.77	----	7.81	----	9.57	----
		4	0.76	0.06	2.91	----	6.62	0.02	9.60	0.24
	178	1	0.82	0.13	3.34	0.31	12.37	0.35	15.00	0.57
		2	0.61	0.18	3.09	0.27	9.11	0.33	14.34	0.46
		3	1.13	0.20	4.69	0.42	10.11	0.94	10.00	1.29
		4	1.31	0.27	3.41	0.45	6.63	2.06	9.51	4.31
100%	11	1	0.03		0.10		1.00		3.22	
		2	0.13		----		0.74		5.93	
		3	0.06		----		0.13		0.44	
		4	0.03		----		----		0.06	

Table V-1. Continued.

Tailings Rate	P Rate	Replication	Cut 1		Cut 2		Cut 3		Cut 4	
			Amity	Eightlar	Amity	Eightlar	Amity	Eightlar	Amity	Eightlar
- g/kg -	mg/kg		g/pot							
100%	44	1		0.23		1.75		5.59		13.58
		2		0.17		0.44		2.55		4.32
		3		0.22		0.67		2.49		8.32
		4		0.11		0.58		2.70		12.43
	178	1		0.04		----		0.18		2.05
		2		0.04		----		----		0.01
		3		0.15		0.24		1.07		3.87
		4		0.01		----		0.04		1.45

Table V-2. Dry matter weight of sickle-keeled lupine grown on soils amended with tailing material.

Tailings Rate	Replication	Amity soil		Eightlar soil	
		Number of Plants	Dry Weight	Number of Plants	Dry Weight
- g/kg -			-- g/pot --		-- g/pot --
0	1	7	7.92	7	5.24
	2	7	8.34	7	3.85
	3	7	8.94	7	4.91
	4	7	6.71	7	5.42
223	1	3	0.38	7	0.60
	2	7	2.25	7	1.28
	3	2	0.32	7	0.94
	4	5	1.11	7	1.09
446	1	2	1.54	3	0.24
	2	7	5.39	0	----
	3	3	1.81	0	----
	4	0	----	2	----
669	1	5	1.54	5	0.70
	2	7	1.59	4	0.80
	3	6	2.08	1	----
	4	5	2.03	0	----
100%	1	0	----		
	2	1	0.12		
	3	0	----		
	4	0	----		

Table V-3. Dry matter weights of tall fescue grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
1	1	4.42	3.79	2.68	1.38	12.27
	2	3.18	3.33	3.40	1.66	11.57
	3	3.56	3.97	2.30	0.97	10.80
3	1	4.04	3.79	3.42	1.85	13.10
	2	4.34	4.00	4.39	2.06	14.79
	3	5.90	3.22	2.49	1.43	13.04
5	1	4.04	3.44	3.35	1.41	12.24
	2	2.92	3.20	4.61	1.95	12.68
	3	2.52	2.09	4.55	2.06	11.22
7	1	3.45	4.03	3.00	1.38	11.86
	2	3.00	2.52	3.36	1.86	10.74
	3	3.61	3.00	3.82	1.68	12.11
9	1	3.06	1.24	0.90	0.41	5.61
	2	3.17	1.98	0.90	0.62	6.67
	3	2.53	1.74	1.00	0.61	5.88
11	1	3.66	1.65	0.80	0.59	6.70
	2	3.42	2.24	1.00	0.66	7.32
	3	3.36	1.44	1.02	0.40	6.22
13	1	5.64	4.92	5.70	2.35	18.61
	2	4.01	4.30	6.74	2.66	17.71
	3	3.85	3.86	5.87	3.54	17.12
14	1	6.09	5.54	6.00	2.64	20.27
	2	4.34	4.61	8.00	3.19	20.14
	3	4.87	6.57	6.07	1.79	19.30
15	1	3.77	3.32	4.62	5.32	17.03
	2	3.23	4.35	6.84	3.32	17.74
	3	2.04	2.16	5.59	6.77	16.56
16	1	5.54	4.16	5.34	2.84	17.88
	2	3.66	3.85	6.41	4.41	18.33
	3	2.81	3.00	7.03	3.84	16.68
17	1	4.24	3.65	4.00	1.50	13.39
	2	3.45	2.50	5.86	1.60	13.41
	3	5.30	3.26	3.68	0.93	13.17

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
18	1	5.20	4.80	2.63	0.91	13.54
	2	4.83	3.94	2.38	0.92	12.07
	3	6.51	3.59	2.60	1.01	13.74
19	1	6.25	5.50	8.18	3.67	18.35
	2	4.05	3.30	8.18	9.18	24.71
	3	3.91	4.30	10.12	5.70	24.03
20	1	5.00	5.61	9.55	4.35	24.51
	2	3.47	4.60	9.08	5.04	22.19
	3	4.62	3.73	8.00	5.49	21.84
21	1	3.80	3.40	7.72	11.69	26.61
	2	3.77	3.74	6.15	8.93	22.59
	3	2.62	2.32	7.74	11.60	24.28
22	1	4.33	4.21	7.51	6.49	22.54
	2	3.61	3.41	8.16	11.89	27.07
	3	3.62	3.40	6.73	9.82	23.57
23	1	4.42	4.97	5.08	2.35	16.82
	2	3.65	3.82	7.66	2.78	17.91
	3	4.20	3.42	8.05	3.10	18.77
24	1	4.14	4.59	6.14	1.80	16.67
	2	5.78	6.14	5.07	2.00	18.99
	3	4.22	2.74	7.00	4.45	18.41
25	1	3.47	3.53	2.78	1.38	11.16
	2	4.33	3.46	2.35	1.29	11.43
	3	3.74	3.00	2.53	1.18	10.45
27	1	3.95	3.70	3.21	1.55	12.41
	2	2.79	3.36	2.80	1.85	10.80
	3	3.00	2.74	3.67	1.86	11.27
29	1	4.16	3.77	2.28	1.40	11.61
	2	3.00	3.10	3.89	1.97	11.96
	3	2.70	3.16	3.54	1.83	11.23
31	1	3.92	3.38	2.40	1.54	11.24
	2	3.88	3.29	2.85	1.75	11.77
	3	2.50	2.16	4.44	1.84	10.94
33	1	3.10	1.59	1.00	0.93	6.62
	2	2.42	2.57	1.30	0.60	7.04
	3	2.33	2.14	1.70	0.87	7.04

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
35	1	2.73	1.80	1.30	0.79	6.62
	2	2.62	2.56	1.54	0.93	7.65
	3	2.43	1.30	1.12	0.65	5.50
37	1	4.69	5.17	4.90	3.51	18.27
	2	2.91	3.95	7.53	3.35	17.74
	3	3.11	2.94	5.59	4.26	15.90
38	1	5.18	5.08	4.71	2.85	17.82
	2	3.00	4.60	6.45	3.57	17.62
	3	4.81	4.70	6.40	3.66	19.57
39	1	3.91	3.76	5.00	5.45	18.12
	2	3.69	3.51	7.73	3.68	18.61
	3	2.82	2.75	7.66	4.45	17.68
40	1	4.00	4.38	6.37	3.28	18.03
	2	4.38	4.52	6.20	2.60	17.70
	3	3.34	3.00	6.57	4.51	17.99
41	1	3.57	4.01	3.64	1.68	12.90
	2	2.84	3.00	5.63	1.96	13.43
	3	3.19	2.33	5.28	1.48	12.08
42	1	4.56	3.37	3.40	2.23	13.56
	2	3.70	5.00	2.69	1.28	12.67
	3	3.54	3.33	3.70	1.16	11.73
43	1	4.88	4.32	8.39	6.03	23.62
	2	3.14	4.22	7.62	11.07	26.05
	3	3.29	3.11	8.69	8.75	23.84
44	1	5.33	5.66	6.88	4.71	22.58
	2	4.63	5.93	9.61	6.18	26.35
	3	5.37	5.59	9.97	6.24	27.17
45	1	4.24	3.71	7.54	8.10	23.54
	2	3.29	3.03	5.38	11.16	22.86
	3	3.27	3.60	8.00	10.57	25.44
46	1	4.10	3.60	7.68	5.72	21.10
	2	4.09	4.75	8.48	7.00	24.32
	3	3.45	3.95	8.45	8.58	24.43
47	1	3.34	3.94	5.57	3.48	17.35
	2	2.49	4.07	4.22	6.22	17.00
	3	3.38	2.56	4.39	8.07	18.40

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
48	1	5.74	4.57	4.45	3.33	18.09
	2	4.22	4.42	6.00	3.29	17.88
	3	4.84	4.38	5.33	3.34	17.89
49	1	4.51	2.75	1.93	1.23	10.42
	2	4.10	3.09	2.09	1.35	10.63
	3	3.56	2.79	2.66	1.26	10.27
51	1	3.73	3.00	1.75	1.03	9.51
	2	3.64	3.50	2.11	1.10	10.35
	3	2.71	2.71	3.37	1.44	10.23
53	1	4.19	3.00	2.46	1.31	10.96
	2	3.60	2.61	2.89	1.63	10.73
	3	1.56	2.49	4.29	2.01	10.35
55	1	3.87	2.87	2.32	1.31	10.37
	2	3.41	3.60	2.66	1.27	10.94
	3	2.38	2.36	3.56	2.12	10.42
57	1	2.80	1.54	1.15	0.60	6.09
	2	2.43	1.64	1.20	0.85	6.12
	3	2.45	1.27	1.07	0.57	5.36
59	1	2.63	1.48	0.94	0.65	6.03
	2	2.59	1.58	1.18	0.77	6.12
	3	2.70	1.35	1.00	0.73	5.78
61	1	4.23	4.64	4.63	1.62	15.12
	2	3.96	4.18	5.84	2.03	16.01
	3	3.93	3.95	6.95	2.31	17.14
62	1	4.57	5.14	4.06	2.44	16.21
	2	4.64	5.10	6.08	2.69	18.51
	3	4.30	3.21	3.81	1.60	12.92
63	1	4.70	4.53	2.92	1.78	13.93
	2	2.08	3.06	4.61	1.99	11.74
	3	2.87	2.94	4.23	2.89	12.93
64	1	3.09	3.98	4.70	2.36	15.21
	2	4.25	3.49	4.31	2.20	14.25
	3	4.12	2.91	4.13	2.03	13.19
65	1	3.29	2.87	1.41	0.87	8.44
	2	3.34	2.47	1.49	1.10	8.40
	3	3.19	2.15	1.54	0.52	7.40

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		----------	----------	g/pot	----------	----------
66	1	4.71	2.13	1.49	0.86	9.19
	2	4.50	2.36	1.90	1.12	9.88
	3	4.49	1.72	1.88	1.04	9.13
67	1	3.54	5.43	4.73	2.28	15.98
	2	3.86	4.75	6.53	2.21	17.35
	3	4.61	3.52	7.23	2.83	18.19
68	1	4.71	4.41	5.91	2.69	17.72
	2	4.64	5.00	5.39	2.48	17.51
	3	5.54	4.75	5.50	2.76	18.55
69	1	4.67	4.20	5.10	2.87	16.84
	2	3.79	2.85	4.73	5.54	16.91
	3	2.84	2.36	5.67	6.56	17.43
70	1	4.48	3.86	5.69	2.98	17.01
	2	4.41	3.92	5.34	3.15	16.82
	3	4.15	3.14	5.34	3.49	16.12
71	1	4.11	3.80	1.92	0.95	10.78
	2	3.73	3.40	2.14	1.05	10.32
	3	3.78	2.16	4.64	1.20	11.78
72	1	4.67	3.33	2.53	1.30	11.83
	2	3.07	3.57	2.47	1.14	10.25
	3	5.25	2.74	2.73	1.02	11.74
73	1	3.00	4.75	2.22	1.15	11.12
	2	3.81	3.74	2.24	1.09	10.88
	3	3.74	2.54	3.70	1.51	11.49
75	1	4.47	3.34	2.29	1.38	11.48
	2	4.09	4.05	2.31	1.40	11.85
	3	4.39	2.97	2.81	1.28	11.45
77	1	2.31	3.66	3.28	1.23	10.48
	2	2.47	2.30	3.39	1.10	9.26
	3	2.73	2.11	3.61	1.05	9.50
79	1	2.91	3.21	2.93	1.23	10.28
	2	3.16	3.19	2.24	1.14	9.73
	3	4.40	2.69	2.42	0.83	10.34
81	1	2.58	1.89	1.00	0.45	5.92
	2	2.43	2.00	1.00	0.54	5.97
	3	3.09	1.30	0.81	0.16	5.36

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
83	1	3.00	1.36	1.09	0.67	6.12
	2	3.34	1.71	1.00	0.53	6.58
	3	3.42	1.20	1.03	0.56	6.21
85	1	4.98	4.63	4.16	1.60	15.37
	2	4.52	4.16	4.80	1.73	15.21
	3	3.00	3.45	5.89	2.36	14.70
86	1	4.53	4.73	3.17	1.65	14.08
	2	3.81	3.36	4.71	1.88	13.76
	3	4.95	4.54	3.71	1.45	14.65
87	1	3.55	3.42	4.64	1.73	13.62
	2	3.44	5.14	4.40	1.67	14.65
	3	3.57	2.19	5.71	2.08	13.55
88	1	3.08	3.27	4.00	1.74	12.09
	2	4.20	3.52	3.95	1.74	13.41
	3	3.29	2.63	6.14	1.93	13.99
89	1	4.06	3.00	1.13	0.54	8.73
	2	3.88	2.44	1.29	0.63	8.24
	3	2.58	2.27	2.08	0.64	7.57
90	1	3.71	2.70	1.22	0.83	8.46
	2	4.26	2.00	1.40	0.65	8.31
	3	3.07	2.73	1.68	0.70	8.18
91	1	3.54	3.87	7.50	3.76	18.67
	2	3.25	3.67	6.71	5.10	18.73
	3	4.18	2.62	7.19	4.47	18.46
92	1	4.04	4.68	8.29	3.19	20.20
	2	3.59	5.32	7.57	2.65	19.13
	3	3.35	4.71	7.47	3.08	18.61
93	1	3.40	3.49	7.18	3.29	17.36
	2	4.19	3.48	6.08	2.48	16.23
	3	2.64	1.68	4.07	7.52	15.91
94	1	3.88	3.58	5.85	2.66	15.97
	2	3.26	3.42	5.00	6.61	18.29
	3	3.19	2.59	7.52	3.55	16.85
95	1	3.26	3.00	4.08	1.19	11.53
	2	2.26	3.34	4.27	0.94	10.81
	3	3.69	2.47	3.23	0.64	10.03

Table V-3. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		----------	----------	g/pot	----------	----------
96	1	4.50	3.68	2.30	0.95	11.43
	2	4.06	3.39	1.72	0.55	9.72
	3	3.91	2.63	2.28	0.67	9.49
97	1	3.49	3.25	1.93	1.14	9.81
	2	3.36	2.52	2.22	1.14	9.24
	3	3.81	2.70	1.59	1.12	9.22
99	1	3.96	2.49	1.56	1.17	9.18
	2	2.88	3.19	2.65	1.31	10.03
	3	2.78	2.42	3.31	1.34	9.85
101	1	1.60	1.13	0.79	0.52	4.04
	2	1.22	1.38	0.82	0.59	4.01
	3	1.09	1.13	1.00	0.39	3.61

Table V-4. Dry matter weights of white clover grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
2	1	2.21	2.52	5.43	10.89	21.05
	2	3.65	2.47	4.76	10.68	21.56
	3	2.26	1.89	4.62	10.15	18.92
4	1	3.81	2.97	3.91	8.01	18.70
	2	3.23	2.69	4.71	8.10	18.73
	3	3.85	1.67	4.87	7.76	18.15
6	1	2.70	1.95	4.38	8.67	17.70
	2	1.80	1.95	4.31	8.83	16.89
	3	1.20	1.63	4.77	7.84	15.44
8	1	2.38	2.00	3.96	9.26	17.60
	2	1.41	1.28	3.03	8.95	14.67
	3	3.76	1.07	3.62	8.42	16.87
10	1	2.53	2.66	5.50	10.15	20.84
	2	2.90	2.31	5.02	10.96	21.19
	3	1.31	1.89	5.48	10.28	18.96
12	1	3.20	2.47	5.36	11.18	22.21
	2	2.73	2.50	5.94	10.07	21.24
	3	2.20	1.93	4.94	12.08	21.15
26	1	2.30	3.48	5.28	10.17	21.23
	2	3.43	1.90	4.45	9.68	19.46
	3	2.26	2.15	5.02	9.87	19.30
28	1	3.18	2.29	4.37	11.38	21.22
	2	2.76	2.59	5.41	9.71	20.47
	3	2.62	2.20	4.67	10.87	20.36
30	1	1.77	2.00	3.48	9.65	16.90
	2	1.22	1.75	4.25	8.23	15.45
	3	1.20	1.87	4.62	8.70	16.39
32	1	1.53	2.14	3.94	9.19	16.80
	2	2.10	2.35	4.60	9.11	18.16
	3	1.16	1.63	4.66	7.44	14.89
34	1	2.00	2.31	5.80	10.06	20.17
	2	2.19	2.26	4.87	9.51	18.83
	3	1.54	2.10	5.17	10.24	19.05

Table V-4. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
36	1	1.29	2.13	4.55	10.56	18.53
	2	2.42	1.93	4.26	10.59	19.20
	3	1.81	1.63	5.11	9.39	17.94
50	1	2.20	2.16	4.89	9.96	19.21
	2	3.25	1.88	4.77	9.55	19.45
	3	2.11	2.18	4.33	8.22	16.73
52	1	3.07	2.09	4.42	9.60	19.18
	2	3.41	1.94	4.73	7.90	17.98
	3	2.90	2.21	4.36	9.05	18.39
54	1	2.52	2.65	4.05	8.72	17.94
	2	1.56	2.04	4.80	9.35	17.75
	3	1.41	1.79	5.30	8.41	16.91
56	1	2.40	1.85	3.88	8.16	16.29
	2	2.20	2.23	4.05	7.96	16.44
	3	2.24	1.73	4.69	7.49	16.15
58	1	1.31	1.89	4.61	12.36	20.17
	2	2.02	2.31	5.34	10.78	20.45
	3	1.51	1.41	5.08	10.42	18.42
60	1	2.45	2.11	4.43	10.13	19.12
	2	2.72	2.19	5.40	9.72	20.03
	3	3.00	2.00	4.40	9.69	19.09
74	1	3.74	2.66	4.68	10.41	21.49
	2	2.82	2.16	4.94	10.62	20.54
	3	2.18	2.00	4.62	11.22	20.02
76	1	2.59	3.19	4.33	9.64	19.75
	2	4.22	2.15	5.19	8.96	20.52
	3	2.86	2.25	5.36	9.37	19.84
78	1	1.95	2.16	4.45	10.55	19.11
	2	1.80	2.12	4.52	9.05	17.49
	3	1.77	1.43	3.34	8.14	14.68
80	1	2.50	1.91	4.61	9.34	18.36
	2	2.50	1.44	4.22	9.31	17.47
	3	2.27	1.66	3.55	7.72	15.20
82	1	1.94	2.57	5.18	11.22	20.91
	2	2.90	3.06	5.51	10.26	21.73
	3	1.73	2.15	5.44	9.30	16.63

Table V-4. Continued.

Treatment Number	Replication	Cut 1	Cut 2	Cut 3	Cut 4	Total
		g/pot				
84	1	2.33	2.40	5.89	11.41	22.03
	2	3.17	2.12	5.36	9.95	20.60
	3	3.14	1.82	5.45	11.16	21.57
98	1	2.02	2.11	4.12	10.69	18.94
	2	1.82	2.54	4.43	9.83	18.62
	3	2.84	1.72	4.01	9.26	17.83
100	1	0.64	1.10	3.93	8.48	14.15
	2	0.99	1.80	4.80	6.77	14.36
	3	0.89	1.30	4.12	7.33	13.64
102	1	1.29	1.78	4.14	7.59	14.80
	2	1.30	1.75	4.46	6.62	14.13
	3	1.13	1.81	4.00	6.71	13.65

APPENDIX VI: PLANT ANALYSIS

Table VI-1. Nitrogen, phosphorus, potassium, calcium, and magnesium concentrations of tall fescue grown on soils amended with tailings material.

Soil	Tailings Rate	P Rate	Replication	Cutting 1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		% N				% P				% K				% Ca				% Mg			
Amity	0	44	1	3.61	3.11	1.11	1.31	0.23	0.22	0.20	0.41	5.4	2.7	1.5	2.1	0.21	0.35	0.41	0.40	0.46	0.50	0.43	0.58
			2	3.36	3.06	1.11	1.24	0.23	0.21	0.20	0.38	5.5	3.4	1.8	2.4	0.32	0.37	0.47	0.49	0.39	0.42	0.42	0.56
			3	3.22	2.72	1.28	1.61	0.21	0.21	0.38	0.56	4.9	2.9	2.5	2.9	0.28	0.39	0.42	0.44	0.40	0.45	0.43	0.46
			4	3.64	2.67	1.09	1.42	0.20	0.19	0.28	0.48	5.6	3.0	2.1	2.7	0.17	0.40	0.43	0.42	0.44	0.45	0.43	0.53
	223	11	1	3.33	3.64	1.76	1.28	0.20	0.19	0.13	0.19	4.5	3.4	0.9	1.3	0.35	0.34	0.28	0.32	0.50	0.70	0.71	0.73
			2	3.61	3.67	2.87	3.57	0.18	0.19	0.15	0.16	5.0	3.2	0.8	0.9	0.22	0.27	0.21	0.23	0.74	0.88	0.92	0.97
			3	3.39	3.75	2.37	1.53	0.18	0.21	0.13	0.20	4.6	3.6	0.7	1.3	0.10	0.27	0.21	0.23	0.70	0.82	0.87	0.84
			4	3.36	3.28	1.64	1.34	0.20	0.20	0.16	0.32	5.6	3.3	1.0	2.6	0.18	0.26	0.22	0.27	0.66	0.76	0.68	0.65
		44	1	3.55	3.31	1.28	1.12	0.20	0.20	0.16	0.20	4.9	2.7	0.9	1.7	0.22	0.30	0.25	0.26	0.64	0.70	0.67	0.63
			2	3.22	2.50	1.40	1.00	0.18	0.16	0.14	0.22	4.4	3.1	0.8	1.6	0.23	0.26	0.21	0.26	0.64	0.70	0.66	0.63
			3	3.47	3.64	1.17	1.24	0.21	0.23	0.14	0.34	4.8	3.0	0.7	2.3	0.23	0.32	0.21	0.29	0.62	0.72	0.61	0.67
			4	3.11	3.28	1.51	1.15	0.18	0.21	0.16	0.26	4.7	3.5	1.0	1.9	0.20	0.23	0.23	0.33	0.70	0.72	0.70	0.72
		178	1	3.44	3.61	1.51	1.15	0.26	0.26	0.19	0.21	4.8	3.4	1.0	1.4	0.13	0.28	0.23	0.32	0.78	0.70	0.67	0.70
			2	3.39	3.28	1.34	0.98	0.26	0.22	0.19	0.21	4.4	3.3	0.9	1.5	0.30	0.27	0.27	0.30	0.66	0.74	0.70	0.68
			3	3.08	3.53	1.40	1.04	0.23	0.22	0.19	0.29	4.3	2.9	0.8	1.8	0.27	0.30	0.24	0.26	0.72	0.76	0.69	0.61
			4	3.33	3.45	1.89	1.00	0.24	0.24	0.20	0.24	5.4	3.7	0.9	1.3	0.16	0.24	0.23	0.22	0.64	0.68	0.68	0.55
	446	11	1	3.47*	3.67	2.72	1.89	0.20	0.21	0.14	0.12	5.6	4.3	1.3	0.6	0.14	0.22	0.18	0.17	0.70	0.72	0.84	0.75
			2		3.94	2.67	2.14		0.22	0.15	0.16		3.8	1.2	0.7		0.12	0.13	0.15		0.66	0.76	0.73
			3	3.50	3.06	2.98	2.20	0.19	0.22	0.17	0.15	5.0	5.2	1.6	0.7	0.14	0.19	0.15	0.15	0.72	0.82	0.84	0.80
			4		3.83	2.67	1.75		0.22	0.14	0.14		4.1	1.0	0.7		0.18	0.15	0.16		0.76	0.79	0.80
		44	1	I	4.17	3.11	1.78	I	0.24	0.16	0.12	I	4.9	1.5	0.7	I	0.21	0.17	0.19	I	0.78	0.86	0.73
			2	2.05	4.17	2.56	1.41	0.11	0.25	0.14	0.22	4.6	4.5	1.0	1.1	0.13	0.16	0.11	0.14	0.76	0.80	0.73	0.72
			3	3.55	3.94	3.17	2.54	0.22	0.23	0.15	0.14	5.3	3.1	1.3	0.7	0.21	0.11	0.11	0.10	0.60	0.88	0.96	1.00
			4	3.39	3.78	2.98	2.14	0.19	0.20	0.17	0.17	4.7	3.6	1.0	0.6	0.14	0.17	0.16	0.16	0.76	0.86	0.91	0.89
		178	1	3.39	3.89	3.47	2.54	0.22	0.24	0.16	0.14	3.7	3.7	1.2	0.6	0.13	0.10	0.11	0.11	0.88	0.98	1.14	1.27
			2		3.94	3.00	2.47		0.27	0.15	0.14		3.8	1.0	0.7		0.12	0.11	0.14		0.96	1.10	1.24
			3	3.50	4.11	3.25	2.74	0.24	0.26	0.17	0.14	3.8	4.0	1.3	0.7	0.15	0.14	0.12	0.12	0.96	0.96	1.06	1.32
			4		4.06	3.42	2.63		0.28	0.20	0.16		3.9	1.8	1.0		0.14	0.13	0.13		0.86	0.94	0.96
	669	11	1	3.67	3.50	3.64	2.86	0.17	0.16	0.20	0.16	4.7	3.3	3.2	0.7	0.44	0.10	0.12	0.11	0.78	0.72	0.85	0.81
			2			3.09	2.44			0.12	0.14			1.4	0.6			0.10	0.13			0.92	1.04
			3	2.17	3.83	2.84	2.74	0.10	0.25	0.13	0.13	5.3	4.8	1.5	0.8	0.23	0.13	0.13	0.14	0.76	0.86	0.99	1.07
			4		3.86	3.39	2.62		0.22	0.16	0.13		4.4	2.1	0.8		0.09	0.14	0.14		0.64	0.88	0.99
		44	1	2.89	3.89	3.56	2.86	0.17	0.22	0.19	0.15	5.3	4.6	2.7	0.8	0.32	0.14	0.12	0.12	0.92	0.80	0.90	0.90
			2		2.84	3.50	2.03		0.16	0.18	0.14		4.0	2.4	0.8		0.09	0.11	0.11		0.80	0.92	0.83
			3	4.11	3.39	3.11	2.48	0.22	0.22	0.14	0.14	5.1	3.8	1.2	0.7	0.28	0.12	0.14	0.16	0.86	0.90	1.09	1.11
			4		3.89	3.17	3.60		0.24	0.16	0.14		4.4	1.8	0.8		0.13	0.13	0.14		0.80	1.03	1.02

Table VI-1. Continued.

													Cutting										
Soil	Tailings Rate	P Rate	Replication	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		% N				% P				% K				% Ca				% Mg			
Amity	669	178	1	3.39	3.94	3.67	2.17	0.20	0.25	0.20	0.12	4.4	4.1	1.8	0.7	0.19	0.22	0.15	0.12	0.82	0.88	1.00	0.95
			2		4.14	3.56	2.54		0.28	0.19	0.12		4.4	1.7	0.7		0.13	0.14	0.15		0.84	1.05	1.05
			3		3.94	2.89	1.90		0.24	0.15	0.18		3.7	1.3	0.8		0.13	0.10	0.11		0.92	0.86	0.80
			4	3.61	3.67	3.37	2.09	0.24	0.22	0.17	0.16	4.2	4.2	2.0	1.0	0.17	0.12	0.12	0.12	0.90	0.82	0.96	0.83
Eightlar	0	44	1	3.08	1.51	1.03	1.04	0.15	0.15	0.13	0.14	5.6	4.2	2.3	2.3	0.23	0.33	0.39	0.41	0.47	0.42	0.50	0.52
			2		2.89	2.20	1.62		0.10	0.07	0.06		NA	2.6	2.8		NA	0.32	0.32		NA	0.55	0.55
			3	3.08	1.70	1.17	1.15	0.15	0.14	0.15	0.17	5.2	4.5	2.4	2.2	0.17	0.29	0.41	0.49	0.44	0.40	0.49	0.56
			4		1.87	1.11	1.21		0.15	0.15	0.16		4.0	2.4	2.3		0.28	0.42	0.40		0.46	0.54	0.51
	223	11	1	3.61	3.39	0.98	1.01	0.14	0.19	0.11	0.20	5.8	3.4	1.1	2.1	0.15	0.17	0.16	0.27	0.70	0.80	0.66	0.75
			2		3.72	1.11	0.96		0.19	0.11	0.16		3.9	1.1	1.8		0.18	0.16	0.24		0.78	0.67	0.73
			3	3.17	3.09	0.98	1.03	0.13	0.18	0.13	0.22	5.6	2.9	1.1	2.3	0.10	0.20	0.18	0.29	0.70	0.76	0.65	0.78
			4	3.17	2.95	1.00	1.04	0.15	0.16	0.11	0.21	5.7	2.9	1.1	2.0	0.10	0.14	0.15	0.31	0.80	0.76	0.65	0.88
		44	1	3.17	3.47	1.89	0.98	0.15	0.18	0.10	0.17	5.7	3.2	0.8	1.3	0.18	0.16	0.12	0.18	0.68	0.80	0.85	0.70
			2		3.14	2.17	1.05		0.18	0.13	0.16		3.4	0.9	1.6		0.10	0.12	0.15		0.78	0.92	0.66
			3	3.22	3.89	2.40	1.15	0.14	0.20	0.12	0.13	5.0	4.6	0.9	1.2	0.15	0.12	0.13	0.15	0.62	0.80	0.93	0.70
			4		3.56	2.00	1.03		0.18	0.11	0.15		2.8	0.8	1.5		0.11	0.11	0.15		0.76	0.75	0.68
		178	1	3.53	3.67	1.64	0.92	0.21	0.18	0.12	0.14	4.8	3.5	0.9	1.4	0.22	0.17	0.15	0.21	0.82	0.80	0.85	0.72
			2	2.55	3.72	2.40	1.03	0.18	0.20	0.13	0.15	4.5	4.1	1.0	1.3	0.19	0.17	0.14	0.14	0.88	0.86	0.94	0.62
			3		3.72	2.06	1.04		0.19	0.13	0.16		3.6	0.8	1.3		0.15	0.14	0.22		0.82	0.82	0.77
			4	3.53	3.45	2.17	1.01	0.18	0.18	0.12	0.19	4.7	3.8	0.8	1.4	0.17	0.15	0.13	0.15	0.80	0.86	0.88	0.63
	446	11	1	3.72	4.50	3.22	1.62	0.07	0.19	0.13	0.08	I	5.7	2.8	1.4	I	0.14	0.11	0.09	I	1.00	1.10	0.81
			2			3.17	1.84			0.12	0.08	I		2.9	1.6	I		0.13	0.09	I		1.16	0.80
			3			3.56	2.36			0.13	0.10	I		3.2	2.1	I		0.11	0.10	I		1.07	0.86
			4			3.06	1.56			0.11	0.08	I		2.5	1.4	I		0.10	0.08	I		1.01	0.78
		44	1	3.53	3.78	1.95	1.07	0.18	0.18	0.12	0.12	4.6	3.0	1.4	1.7	0.13	0.14	0.20	0.11	0.88	0.78	0.77	0.58
			2		3.72	2.45	1.31		0.19	0.12	0.13		4.7	1.0	1.4		0.15	0.11	0.12		0.84	0.90	0.72
			3		3.92	2.67	1.27		0.19	0.12	0.11		4.9	1.6	1.3		0.11	0.11	0.10		0.72	0.80	0.73
			4		4.11	2.45	1.01		0.20	0.12	0.10		4.0	0.8	1.2		0.16	0.12	0.12		0.96	1.06	0.73
		178	1	3.61	3.94	2.17	1.09	0.25	0.22	0.14	0.15	4.6	3.5	1.0	1.4	0.16	0.10	0.11	0.12	0.96	0.86	0.87	0.68
			2		3.81	2.12	0.99		0.23	0.14	0.14		3.6	1.2	1.6		0.16	0.11	0.13		0.90	0.81	0.64
			3		3.45	2.78	1.55		0.19	0.13	0.15		4.0	1.2	1.2		0.17	0.11	0.11		0.96	0.95	0.74
			4		3.42	2.23	1.34		0.22	0.13	0.16		3.5	1.0	1.6		0.21	0.11	0.10		0.88	0.86	0.60
	669	11	1	3.64	4.14	3.22	2.37	0.21	0.19	0.13	0.11	4.8	5.1	2.2	0.8	0.12	0.13	0.11	0.11	0.70	0.80	0.96	0.94
			2		4.39	3.34	1.80		0.22	0.14	0.14		4.9	1.4	1.3		0.18	0.15	0.12		0.96	1.02	0.88
			3		3.81	3.20	2.12		0.18	0.13	0.12		4.5	2.1	0.9		0.10	0.11	0.18		0.70	0.84	0.84
			4		3.34	3.28	1.24		0.13	0.12	0.12		4.6	2.0	1.4		0.13	0.11	0.09		0.80	0.96	0.63

Table VI-1. Continued.

Soil	Tailings Rate	P Rate	Replication	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		% N				% P				% K				% Ca				% Mg			
Eight-Tar	669	44	1	4.21	3.93	3.25	2.83	0.06	0.15	0.11	0.10	I	I	2.9	2.8	I	I	0.06	0.07	I	I	1.24	1.01
			2				3.00				0.10	I	I			I	I			I	I		
			3			3.11	I			0.11	I	I	I			I	I			I	I		
			4				3.14				0.11	I	I			I	I			I	I		
		178	1	5.02	4.61	3.56	3.35	0.15	0.22	0.17	0.18	2.2	3.6	I	I	0.33	0.05	I	I	0.44	0.76	I	I
			2			3.89	3.16			0.18	0.12			I	I			I	I			I	I
			3			3.11	3.10			0.13	0.12			2.2	2.8			0.07	0.08			1.26	1.14
			4			4.30	3.02			0.17	0.11			2.0	2.6			0.09	0.08			1.33	1.08
----	100%	11	1	5.86	4.63	3.56	3.32	0.08	0.17	0.13	0.12	I	I	3.1	3.1	I	I	0.13	0.11	I	I	0.87	0.85
			2			4.28	3.39			0.14	0.11	I	I	I	2.8	I	I	I	0.08	I	I	I	1.01
			3			3.94	2.85			0.14	0.10	I	I	I	I	I	I	I	I	I	I	I	I
			4			I	3.62			I	0.19	I	I	I	I	I	I	I	I	I	I	I	I
		44	1	1.40	4.17	2.78	2.44	0.26	0.23	0.10	0.09	3.7	4.5	1.7	1.4	0.43	0.17	0.10	0.10	0.41	0.88	0.74	0.69
			2			3.14	2.88			0.12	0.09			2.4	2.1			0.14	0.12			1.25	0.86
			3		4.08	2.84	2.85		0.19	0.13	0.10		4.5	3.0	2.8		0.12	0.11	0.12		0.70	0.96	0.60
			4			3.67	2.72			0.15	0.09			3.1	2.3			0.12	0.11			0.77	0.66
		178	1	5.08	4.63	4.04	3.30	0.10	0.21	0.17	0.15	I	I	I	1.3	I	I	I	0.10	I	I	I	1.07
			2				I				I	I	I	I	3.0	I	I	I	0.06	I	I	I	1.16
			3			3.17	2.94			0.13	0.11	I	I	2.1	1.8	I	I	0.08	0.07	I	I	1.17	1.06
			4			I	3.71			I	0.18	I	I	I	2.3	I	I	I	0.10	I	I	I	1.06

*Plant tissue replications combined to provide adequate sample for analysis.
NA = not analyzed
I = insufficient plant material for chemical analysis.

Table VI-2. Manganese, iron, copper, zinc, nickel, and chromium concentrations of tall fescue grown on Eightlar soil amended with tailings material.

Soil	Tailings Rate	P Rate	Replication	Cutting																							
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		μg Mn/g				μg Fe/g				μg Cu/g				μg Zn/g				μg Ni/g				μg Cr/g			
Amity	0	44	1	133	235	534	791	132	152	65	53	2.3	3.8	3.2	6.8	37	33	20	21	0.8	0.0	7.0	3.0	1.8	1.6	0.1	1.9
			2	105	176	449	675	119	147	74	64	1.7	4.2	3.2	5.0	37	40	30	26	3.7	1.2	1.8	3.6	3.6	2.4	1.2	2.1
			3	92	170	395	330	117	128	127	72	1.7	3.8	5.8	7.4	27	37	18	17	4.1	0.8	4.4	3.8	4.0	2.4	1.7	1.4
			4	131	221	426	417	161	140	81	77	2.5	4.0	4.8	10.2	35	40	17	21	1.0	1.4	4.6	2.6	2.2	1.2	1.8	2.3
	223	11	1	140	120	127	242	133	157	109	77	2.3	4.4	4.8	7.8	20	28	16	14	5.7	6.8	6.0	8.0	4.9	3.0	1.9	2.8
			2	199	224	126	73	115	163	106	463	2.7	5.6	6.6	5.6	19	34	16	15	4.1	8.4	10.6	10.2	2.7	2.2	1.6	2.0
			3	161	159	129	127	124	174	181	748	3.2	5.6	7.2	5.2	23	24	13	13	1.9	5.2	8.8	16.2	2.2	1.8	1.2	5.3
			4	72	104	127	147	133	143	153	98	2.5	4.4	3.2	11.0	18	26	12	14	1.9	3.4	8.2	6.8	1.8	1.8	0.2	1.0
		44	1	89	99	116	200	120	140	73	56	1.8	3.8	3.2	3.6	17	17	14	13	3.9	2.4	9.0	6.2	2.2	4.2	0.4	1.5
			2	96	108	105	196	122	172	74	57	2.5	4.4	3.2	2.2	22	29	14	12	1.0	5.2	8.0	6.2	1.8	7.2	0.0	0.7
			3	75	90	82	170	132	112	74	69	1.8	4.6	3.2	3.2	22	26	11	14	3.9	5.0	4.8	7.6	1.3	2.4	0.6	2.4
			4	61	89	78	179	102	126	76	45	2.0	4.0	4.0	6.8	19	22	11	14	4.1	1.4	6.0	7.6	3.6	1.2	1.5	1.5
		178	1	84	99	97	239	116	124	78	52	2.2	4.2	3.2	2.7	20	45	11	26	1.0	7.2	2.4	6.6	3.1	5.4	0.5	1.0
			2	90	112	133	271	131	140	74	65	0.7	2.8	3.2	3.0	20	19	16	13	2.3	4.0	7.2	9.4	2.2	2.2	4.0	2.9
			3	77	116	98	198	129	179	79	74	1.3	4.2	3.2	2.8	18	22	9	10	4.1	7.0	6.2	7.6	1.3	2.4	1.3	1.0
			4	79	113	103	159	129	113	83	64	2.2	3.6	4.8	2.2	21	22	18	17	1.9	6.0	8.4	8.2	1.3	2.4	1.5	3.2
	446	11	1	190*	185	145	177	171	122	151	66	2.2	5.4	3.2	3.0	20	26	13	12	4.9	9.4	8.4	10.2	1.3	6.8	5.3	2.0
			2		200	117	143		140	106	85		3.6	4.0	3.4		20	12	16		7.2	6.0	7.2		1.2	0.1	1.4
			3	171	176	107	125	157	108	88	100	2.2	3.8	4.0	3.2	20	20	17	18	4.9	4.8	9.6	9.4	2.2	5.0	1.5	2.9
			4		190	140	184		111	162	84		4.8	4.0	3.4		26	17	15		8.0	7.8	13.2		2.8	1.3	2.6
		44	1	I	195	136	163	I	140	109	65	I	4.0	4.0	3.0	I	29	15	12	I	8.8	7.4	9.0	I	9.4	1.2	10.6
			2	170	178	107	184	120	146	112	69	1.8	4.4	4.8	5.0	21	19	16	12	25.3	6.2	8.6	10.2	3.6	5.2	1.4	1.4
			3	109	121	91	91	130	116	142	199	1.7	5.4	4.0	5.0	22	29	17	15	17.1	8.2	8.2	9.2	3.1	2.0	0.4	3.6
			4	127	180	110	121	217	123	91	103	1.7	3.4	4.8	5.8	16	33	15	13	4.1	4.0	7.0	7.2	1.8	1.6	1.7	5.3
		178	1	156	146	135	169	174	124	130	204	2.3	5.2	4.8	9.6	18	21	16	15	17.1	6.4	8.0	8.4	0.4	2.2	1.9	16.1
			2		167	136	170		147	85	129		4.2	4.8	7.6		24	15	14		4.6	10.2	9.2		1.4	0.6	2.7
			3	152	153	121	147	144	124	86	125	3.0	4.6	5.8	5.4	33	33	13	14	2.4	8.0	8.0	9.8	2.2	2.4	0.3	1.0
			4		194	147	117		109	122	79		5.4	5.8	5.8		24	16	17		5.0	8.4	8.8		2.6	1.9	0.8
	669	44	1	133	172	203	163	148	118	159	211	2.9	3.4	3.5	3.4	21	19	22	22	1.9	4.6	9.4	7.2	3.1	6.2	2.2	1.0
			2			93	85			82	104			3.2	8.0			17	19			8.8	6.8			0.6	1.1
			3	182	229	191	186	146	125	191	121	2.7	4.8	4.8	5.2	16	21	13	18	4.1	5.8	9.4	7.2	2.2	5.2	0.8	1.7
			4		201	155	132		118	131	267		4.8	4.0	4.0		21	15	11		7.2	6.4	7.8		5.8	1.6	5.8
		178	1	168	255	216	140	121	114	135	162	2.9	5.0	6.6	9.0	18	20	15	15	2.9	6.2	9.6	6.6	4.0	6.6	9.3	1.6
			2		215	151	111		129	133	111		8.4	4.0	8.6		23	18	12		10.8	6.2	8.6		1.8	1.7	4.2
			3	184	172	185	119	167	118	128	73	2.9	4.0	4.0	5.2	18	14	12	9	2.9	7.2	6.6	4.6	4.0	2.6	1.7	2.0
			4		180	156	118		105	141	98		4.4	5.8	10.6		28	16	17		5.8	8.8	6.0		0.8	1.8	1.9

Table VI-2. Continued.

Soil	Tailings Rate	P Rate	Replication	Cutting 1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		μg Mn/g				μg Fe/g				μg Cu/g				μg Zn/g				μg Ni/g				μg Cr/g			
Amity	669	178	1	136	208	145	166	102	114	134	185	2.2	3.8	5.8	9.6	18	18	18	10	1.0	7.0	10.8	8.8	4.0	2.6	2.3	1.6
			2		181	158	142		102	102	94		4.8	4.0	4.2		28	21	14		7.2	10.4	8.4		2.0	1.2	0.7
			3	148	138	97	101	168	191	177	276	2.0	3.8	5.2	4.2	22	21	15	16	8.2	3.4	8.4	8.0	2.2	2.6	2.3	3.2
			4		168	115	79		111	163	195		2.6	4.0	17.6		27	18	10		5.0	10.4	8.0		1.8	3.2	5.0
Eight-lar	0	44	1	83	72	73	93	149	131	82	44	3.6	4.4	4.0	3.6	36	19	24	33	19.4	36.6	54.0	57.8	0.4	1.4	2.0	3.4
			2		88	61	64		114	90	66		4.5	7.0	9.4		29	52	40		37.9	54.8	60.8		1.4	1.2	2.5
			3	96	90	95	118	139	126	85	84	3.3	4.6	4.8	6.8	36	39	38	30	24.5	35.8	66.0	64.8	1.8	1.6	8.2	3.7
			4		103	130	133		86	84	69		4.4	4.0	7.2		28	25	23		41.4	60.1	63.2		1.2	1.7	1.2
	223	11	1	93	79	64	115	132	160	87	44	2.7	5.8	4.0	19.8	24	26	14	20	10.6	11.8	12.2	20.2	1.8	1.8	1.9	0.8
			2		78	74	154		125	88	50		6.8	3.2	4.0		29	15	21		11.8	14.6	19.0		2.8	0.6	0.7
			3	93	87	85	159	110	158	78	40	3.2	4.4	4.0	4.6	29	27	14	21	9.7	9.2	13.2	20.1	0.9	1.6	0.9	0.9
			4	95	91	85	233	150	129	108	45	3.2	6.0	4.8	15.8	34	27	16	31	7.8	13.0	11.6	19.0	4.4	7.4	2.0	4.3
		44	1	87	71	70	149	114	137	85	53	3.2	6.4	4.8	4.0	24	28	13	11	5.8	15.0	18.8	19.0	0.9	6.0	1.5	2.2
			2		82	69	121		158	134	58		5.8	7.2	6.0		22	14	12		14.8	19.8	16.4		5.4	0.2	2.4
			3	95	103	78	119	125	135	156	69	2.9	4.8	6.6	4.0	18	25	16	14	7.8	10.6	16.8	17.0	3.2	2.8	2.0	0.8
			4		84	57	102		93	110	51		5.6	5.8	3.4		24	11	19		12.0	15.2	15.4		2.0	0.2	1.1
		178	1	67	80	76	144	110	156	87	64	3.0	4.4	3.2	2.6	22	24	12	11	8.2	14.4	22.2	18.8	1.3	2.8	1.7	0.6
			2	84	83	69	129	162	118	128	66	2.5	5.4	5.8	2.6	20	22	15	13	5.8	5.0	20.2	18.8	3.6	5.4	2.1	2.7
			3		83	76	171		111	149	59		5.6	3.2	3.4		17	15	9		16.8	20.1	19.2		1.6	1.4	0.7
			4	56	86	61	100	170	115	179	49	3.2	4.2	5.8	6.2	21	22	13	20	8.8	10.8	15.2	12.6	3.6	1.6	5.0	2.6
	446	11	1	1	281	344	375	1	98	92	131	1	7.8	7.2	5.6	1	50	43	14	1	11.8	13.4	13.4	1	1.6	3.7	3.7
			2	1		275	341	1		111	73	1		6.6	6.2	1		24	14	1		11.6	9.2	1		1.4	1.7
			3	1		246	219	1		88	384	1		6.6	5.6	1		28	20	1		14.2	15.4	1		1.2	6.4
			4	1		239	237	1		159	416	1		6.6	11.4	1		29	16	1		11.8	15.4	1		2.2	2.3
		44	1	98	85	63	127	126	106	100	88	2.0	5.4	4.8	3.6	44	26	15	11	6.5	7.4	14.2	13.6	0.9	1.4	2.0	5.9
			2		93	74	104		124	148	66		3.8	5.8	4.2		34	16	15		6.4	12.2	11.6		1.8	0.7	2.0
			3		95	86	108		130	141	132		5.6	4.0	6.2		35	17	15		9.4	13.0	12.2		6.4	0.2	3.1
			4		92	88	121		117	109	66		5.8	6.6	5.0		22	15	14		11.0	11.8	10.2		2.4	1.1	3.8
		178	1	72	69	67	147	189	106	176	70	2.7	5.0	5.8	13.0	24	32	15	9	4.1	10.4	17.8	13.2	1.3	3.2	3.0	3.4
			2		60	56	114		115	119	63		6.6	4.8	8.0		37	14	8		8.4	15.2	14.4		2.2	1.3	1.6
			3		80	59	74		188	100	71		4.0	4.8	5.0		18	23	15		7.2	11.8	11.0		3.6	0.9	5.4
			4		60	63	85		101	87	81		5.0	4.0	6.0		20	13	11		8.6	9.2	8.2		3.2	1.2	1.1
	669	11	1	198	247	231	264	200	145	139	81	3.3	4.6	5.8	4.8	24	29	18	13	4.1	7.0	11.0	7.2	1.8	5.4	1.9	2.0
			2		228	190	197		146	100	136		3.8	5.8	4.6		21	18	15		5.0	9.6	10.6		2.0	1.1	3.7
			3		254	198	187		183	133	127		4.8	4.8	4.6		26	15	15		8.4	11.2	10.2		1.6	0.6	2.7
			4		269	186	182		122	104	201		4.7	5.8	5.0		28	16	10		5.0	7.8	8.6		1.0	0.1	3.8

Table VI-2. Continued.

Soil	Tailings Rate	P Rate	Replication	Cutting																							
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	- g/kg -	mg/kg		μg Mn/g				μg Fe/g				μg Cu/g				μg Zn/g				μg Ni/g				μg Cr/g			
Eight-lar	669	44	1	I	I	180	131	I	I	290	122	I	I	4.1	3.4	I	I	16	14	I	I	7.6	9.4	I	I	2.2	2.4
			2	I	I			I	I			I	I			I	I			I	I			I	I		
			3	I	I			I	I			I	I			I	I			I	I			I	I		
			4	I	I			I	I			I	I			I	I			I	I			I	I		
		178	1	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			3	180	267	350	354	174	191	390	552	0.4	2.8	4.0	5.4	53	31	21	20	I	4.6	28.4	20.1	4.9	4.8	1.0	2.5
			4			366	273			306	230			7.2	15.0			30	27	I		23.4	22.2			3.7	3.4
------	100%	11	1	I	I	228	239	I	I	122	163	I	I	4.8	5.8	I	I	16	16	I	I	10.4	7.0	I	I	2.0	3.1
			2	I	I	I	184	I	I	I	104	I	I	I	4.6	I	I	I	13	I	I	I	6.0	I	I	I	2.6
			3	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			4	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		44	1	128	157	151	116	123	115	77	94	2.0	4.0	3.2	5.0	16	17	13	11	1.4	3.4	8.2	6.8	6.3	1.8	0.4	2.7
			2			150	166			114	128			4.0	8.8			14	14			7.4	5.6			0.1	4.1
			3		185	182	146		117	160	101		4.4	4.8	7.8		33	13	12		6.8	9.2	6.6		5.6	1.2	2.7
			4			238	188			90	96			5.8	2.6			13	13			6.2	5.4			1.2	2.5
		178	1	I	I	I	103	I	I	I	113	I	I	I	4.2	I	I	I	13	I	I	I	5.6	I	I	I	1.2
			2	I	I	I	175	I	I	I	99	I	I	I	11.2	I	I	I	10	I	I	I	9.0	I	I	I	1.7
			3	I	I	103	96	I	I	150	86	I	I	3.2	6.8	I	I	16	12	I	I	8.0	7.0	I	I	2.0	0.8
			4	I	I	I	140	I	I	I	241	I	I	I	16.6	I	I	I	18	I	I	I	7.2	I	I	I	2.9

*Plant tissue replications combined to provide adequate plant sample for analysis.
I = insufficient plant material for chemical analysis.

Table VI-3. Nitrogen, phosphorus, calcium, and magnesium concentrations of tall fescue grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
1	1	3.78	2.98	1.14	1.27	0.30	0.14	0.27	0.30	0.44	0.54	0.47	0.43	0.41	0.59	0.33	0.55
	2	4.43	3.24	1.51	1.10	0.34	0.26	0.28	0.46	0.40	0.54	0.67	0.32	0.37	0.52	0.32	0.47
	3	4.00	2.73	1.62	1.20	0.27	0.22	0.31	0.30	0.34	0.50	0.62	0.51	0.43	0.57	0.39	0.52
3	1	4.00	2.51	1.87	1.42	0.39	0.21	0.35	0.63	0.48	0.60	0.52	0.51	0.37	0.48	0.32	0.50
	2	3.87	4.47	2.00	1.37	0.39	0.37	0.40	0.59	0.48	0.69	0.49	0.44	0.55	0.54	0.40	0.43
	3	3.98	2.64	1.51	1.28	0.33	0.31	0.32	0.66	0.50	0.60	0.49	0.44	0.50	0.46	0.37	0.44
5	1	3.91	2.90	1.95	1.16	0.27	0.18	0.32	0.40	0.57	1.02	0.47	0.58	0.41	0.68	0.42	0.52
	2	3.83	3.11	2.23	0.90	0.22	0.15	0.30	0.32	0.32	0.74	0.56	0.46	0.60	0.45	0.47	0.40
	3	4.28	3.69	3.56	1.09	0.27	0.13	0.32	0.28	0.70	0.87	0.64	0.51	0.45	0.55	0.45	0.43
7	1	3.98	2.96	1.84	1.18	0.34	0.19	0.39	0.49	0.60	0.58	0.53	0.53	0.51	0.54	0.40	0.54
	2	3.79	3.23	3.11	1.09	0.29	0.24	0.34	0.30	0.51	0.31	0.53	0.40	0.41	0.46	0.35	0.34
	3	3.96	2.89	2.12	1.01	0.32	0.20	0.36	0.38	0.66	0.47	0.55	0.51	0.41	0.38	0.37	0.40
9	1	3.91	1.78	1.62	1.29	0.23	0.31	0.37	0.49	0.34	0.15	0.38	0.52	0.37	0.22	0.33	0.61
	2	3.91	2.02	1.78	1.21	0.42	0.31	0.40	0.45	0.46	0.37	0.53	0.55	0.33	0.36	0.41	0.47
	3	3.91	1.53	1.28	1.34	0.26	0.32	0.37	0.50	0.47	0.47	0.41	0.49	0.46	0.42	0.43	0.61
11	1	2.82	1.64	1.70	1.21	0.27	0.32	0.50	0.50	0.39	0.49	0.50	0.49	0.30	0.38	0.44	0.59
	2	3.08	1.97	1.51	1.26	0.27	0.32	0.41	0.41	0.37	0.34	0.50	0.41	0.34	0.34	0.48	0.56
	3	3.45	1.57	1.62	1.32	0.26	0.30	0.39	0.44	0.31	0.35	0.50	0.45	0.35	0.34	0.41	0.58
13	1	4.21	2.68	1.98	1.03	0.29	0.24	0.28	0.33	0.35	0.62	0.56	0.45	0.43	0.65	0.44	0.51
	2	4.28	3.66	2.40	0.86	0.44	0.28	0.34	0.34	0.37	0.93	0.44	0.41	0.34	0.78	0.45	0.40
	3	4.51	3.55	3.17	0.36	0.35	0.24	0.33	0.22	0.45	0.70	0.46	0.42	0.47	0.67	0.49	0.38
14	1	4.06	3.06	2.00	1.00	0.37	0.26	0.36	0.49	0.34	0.64	0.65	0.52	0.39	0.60	0.46	0.52
	2	3.98	3.48	2.06	0.90	0.40	0.36	0.37	0.44	0.43	0.70	0.47	0.44	0.35	0.71	0.44	0.48
	3	4.24	2.89	1.73	1.09	0.48	0.26	0.34	0.54	0.31	0.67	0.59	0.50	0.36	0.56	0.43	0.52
15	1	4.06	3.64	3.33	1.13	0.30	0.33	0.38	0.27	0.69	0.67	0.62	0.53	0.56	0.58	0.52	0.59
	2	4.32	3.34	2.89	0.88	0.32	0.21	0.27	0.24	0.59	0.77	0.30	0.48	0.48	0.54	0.49	0.41
	3	4.28	3.04	3.22	1.72	0.39	0.27	0.26	0.33	0.69	0.80	0.74	0.54	0.40	0.49	0.50	0.57
16	1	4.21	3.18	2.92	0.88	0.35	0.20	0.42	0.32	0.51	0.68	0.77	0.44	0.53	0.61	0.47	0.45
	2	4.21	3.11	3.47	0.90	0.36	0.14	0.34	0.22	0.54	0.78	1.00	0.48	0.49	0.58	0.58	0.38
	3	4.28	3.04	3.61	1.00	0.40	0.25	0.37	0.29	0.50	0.75	0.60	0.46	0.43	0.56	0.50	0.42
17	1	4.04	2.89	1.78	0.99	0.30	0.20	0.28	0.30	0.44	0.40	0.38	0.44	0.40	0.48	0.30	0.59
	2	4.13	3.12	2.23	1.09	0.27	0.22	0.26	0.30	0.43	0.65	0.53	0.44	0.43	0.50	0.39	0.50
	3	3.37	3.15	1.67	1.26	0.27	0.16	0.27	0.30	0.43	0.47	0.25	0.45	0.43	0.54	0.35	0.66
18	1	3.33	2.28	1.17	1.13	0.35	0.26	0.27	0.54	0.43	0.42	0.43	0.48	0.49	0.44	0.32	0.69
	2	4.06	2.30	1.48	1.17	0.30	0.28	0.29	0.42	0.41	0.43	0.54	0.45	0.48	0.43	0.25	0.67
	3	3.45	1.71	1.34	1.08	0.29	0.28	0.26	0.39	0.41	0.38	0.38	0.49	0.40	0.37	0.34	0.63
19	1	4.22	3.12	2.84	0.94	0.36	0.26	0.36	0.25	0.33	0.26	0.65	0.50	0.38	0.66	0.53	0.51
	2	4.13	3.42	3.06	1.14	0.39	0.27	0.33	0.30	0.37	0.27	0.65	0.43	0.45	0.81	0.62	0.57
	3	4.56	2.93	3.03	1.02	0.39	0.28	0.30	0.24	0.43	0.25	0.66	0.47	0.54	0.56	0.60	0.55
20	1	3.33	2.65	2.30	0.87	0.36	0.21	0.42	0.47	0.34	0.58	0.52	0.36	0.39	0.63	0.53	0.42
	2	4.36	3.19	3.39	0.96	0.43	0.30	0.44	0.39	0.32	0.65	0.32	0.37	0.37	0.36	0.60	0.46
	3	4.74	3.26	3.53	1.09	0.45	0.30	0.42	0.36	0.33	0.72	0.65	0.42	0.58	0.83	0.64	0.56
21	1	4.51	3.57	3.78	1.39	0.37	0.23	0.37	0.26	0.94	0.78	0.58	0.51	0.56	0.64	0.64	0.72
	2	4.28	2.84	3.56	1.48	0.37	0.29	0.34	0.32	0.48	1.23	0.58	0.46	0.43	0.78	0.58	0.58
	3	4.36	3.37	2.50	1.58	0.36	0.27	0.33	0.28	0.71	1.04	0.75	0.49	0.56	0.64	0.66	0.61
22	1	4.27	3.37	3.59	1.05	0.37	0.29	0.41	0.21	0.66	0.83	0.68	0.54	0.50	0.58	0.74	0.62
	2	3.98	3.19	3.50	0.99	0.36	0.26	0.38	0.28	0.52	0.65	0.58	0.45	0.54	0.58	0.48	0.47
	3	4.36	3.34	2.14	1.57	0.38	0.28	0.26	0.34	0.48	1.03	0.60	0.47	0.51	0.74	0.56	0.59

Text on original is slanted. Best scan available.

Table VI-3. Continued.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
23	1	4.17	3.24	3.06	0.82	0.34	0.22	0.26	0.25	0.49	0.47	0.45	0.35	0.52	0.55	0.50	0.45
	2	4.13	3.41	2.92	0.84	0.34	0.24	0.29	0.20	0.53	0.51	0.44	0.37	0.51	0.36	0.44	0.46
	3	3.98	3.64	3.22	0.88	0.35	0.22	0.28	0.23	0.49	0.52	0.34	0.24	0.50	0.55	0.45	0.38
24	1	4.51	2.19	2.72	1.00	0.44	0.23	0.40	0.47	0.39	0.45	0.50	0.38	0.53	0.55	0.45	0.52
	2	4.10	3.55	3.03	0.88	0.35	0.35	0.34	0.58	0.30	0.41	0.22	0.40	0.40	0.53	0.35	0.50
	3	4.13	3.26	3.34	1.02	0.39	0.30	0.37	0.27	0.32	0.59	0.18	0.29	0.41	0.61	0.44	0.36
25	1	4.06	2.08	1.73	1.19	0.27	0.16	0.32	0.51	0.54	0.49	0.43	0.51	0.54	0.65	0.34	0.55
	2	4.06	2.56	1.40	1.28	0.26	0.28	0.32	0.72	0.51	0.56	0.42	0.50	0.46	0.48	0.34	0.49
	3	3.98	2.36	1.73	1.25	0.28	0.24	0.34	0.54	0.57	0.76	0.47	0.44	0.60	0.71	0.37	0.45
27	1	3.60	2.65	1.87	1.32	0.34	0.31	0.37	0.53	0.50	0.50	0.45	0.40	0.43	0.40	0.36	0.43
	2	4.28	2.89	2.17	1.06	0.35	0.26	0.34	0.38	0.47	0.74	0.49	0.47	0.44	0.53	0.40	0.43
	3	4.21	3.34	2.35	1.00	0.30	0.19	0.38	0.41	0.52	0.54	0.34	0.38	0.57	0.64	0.36	0.44
29	1	4.21	2.40	1.59	1.01	0.20	0.16	0.32	0.38	0.30	0.68	0.54	0.53	0.54	0.61	0.37	0.48
	2	3.76	3.35	2.40	1.05	0.23	0.44	0.32	0.34	0.80	0.79	0.73	0.38	0.53	0.51	0.41	0.35
	3	3.91	2.87	2.23	1.08	0.28	0.27	0.31	0.36	0.68	0.76	0.56	0.38	0.40	0.46	0.41	0.31
31	1	3.91	3.00	1.70	1.10	0.28	0.23	0.34	0.35	0.63	0.77	0.59	0.47	0.41	0.66	0.34	0.45
	2	3.98	3.26	1.76	1.02	0.29	0.15	0.40	0.40	0.55	0.63	0.74	0.49	0.40	0.48	0.40	0.39
	3	4.32	3.55	2.78	1.03	0.32	0.20	0.32	0.30	0.66	0.88	0.50	0.30	0.44	0.63	0.41	0.38
33	1	3.79	2.10	1.56	1.35	0.24	0.19	0.34	0.37	0.37	0.32	0.48	0.38	0.39	0.31	0.40	0.49
	2	3.76	2.08	1.40	1.26	0.26	0.38	0.30	0.43	0.42	0.39	0.37	0.38	0.37	0.34	0.21	0.47
	3	4.66	2.12	1.25	1.24	0.23	0.30	0.25	0.37	0.46	0.54	0.46	0.42	0.47	0.35	0.31	0.51
35	1	2.85	1.71	1.78	1.18	0.30	0.35	0.35	0.38	0.27	0.27	0.24	0.39	0.28	0.33	0.19	0.56
	2	3.64	2.36	1.70	1.05	0.30	0.30	0.36	0.38	0.44	0.32	0.34	0.37	0.41	0.32	0.34	0.39
	3	4.28	2.45	1.84	1.52	0.25	0.46	0.37	0.49	0.38	0.47	0.31	0.43	0.33	0.45	0.41	0.51
37	1	4.21	2.96	2.00	1.08	0.29	0.20	0.34	0.29	0.40	0.64	0.61	0.40	0.44	0.60	0.40	0.41
	2	4.32	3.45	3.00	0.88	0.35	0.20	0.30	0.25	0.48	0.64	0.65	0.39	0.43	0.44	0.47	0.36
	3	3.91	2.89	2.78	1.28	0.38	0.31	0.27	0.25	0.93	0.63	0.40	0.44	0.50	0.51	0.49	0.42
38	1	3.72	2.90	1.95	0.99	0.38	0.26	0.35	0.44	0.35	0.56	0.43	0.35	0.45	0.70	0.39	0.45
	2	4.17	3.64	2.56	0.94	0.34	0.30	0.41	0.46	0.37	0.55	0.68	0.34	0.44	0.59	0.46	0.35
	3	4.06	2.52	2.42	0.82	0.40	0.35	0.38	0.24	0.49	0.48	0.31	0.32	0.56	0.56	0.43	0.37
39	1	4.13	3.41	3.45	1.02	0.34	0.24	0.28	0.21	0.73	0.73	0.66	0.45	0.55	0.59	0.51	0.51
	2	4.06	3.26	2.89	0.86	0.29	0.19	0.26	0.22	0.52	0.80	0.58	0.38	0.43	0.52	0.47	0.31
	3	4.32	3.48	2.92	0.90	0.30	0.33	0.23	0.21	0.54	0.79	0.66	0.41	0.40	0.52	0.50	0.49
40	1	4.10	3.32	2.40	0.93	0.37	0.22	0.42	0.35	0.64	0.70	0.61	0.45	0.52	0.55	0.46	0.39
	2	4.00	3.34	2.67	0.93	0.36	0.22	0.38	0.34	0.57	0.67	0.55	0.51	0.40	0.52	0.38	0.43
	3	4.13	3.23	3.42	0.96	0.33	0.34	0.32	0.25	0.64	0.30	0.64	0.47	0.56	0.59	0.47	0.45
41	1	4.24	3.06	1.59	0.99	0.38	0.28	0.28	0.26	0.40	0.79	0.29	0.45	0.41	0.72	0.40	0.60
	2	4.21	3.26	1.89	0.82	0.32	0.32	0.28	0.23	0.52	0.54	0.34	0.42	0.42	0.48	0.34	0.49
	3	4.02	2.82	2.12	1.04	0.32	0.21	0.24	0.28	0.45	0.47	0.57	0.41	0.41	0.54	0.38	0.53
42	1	3.93	1.21	1.59	0.97	0.32	0.16	0.31	0.34	0.36	0.42	0.33	0.36	0.36	0.43	0.29	0.42
	2	4.36	2.59	1.40	1.02	0.32	0.24	0.34	0.50	0.46	0.35	0.36	0.43	0.49	0.42	0.35	0.59
	3	3.98	2.82	1.78	1.00	0.34	0.32	0.34	0.41	0.32	0.42	0.24	0.41	0.37	0.46	0.34	0.49
43	1	4.58	3.04	3.45	1.11	0.32	0.38	0.35	0.23	0.49	0.64	0.56	0.43	0.44	0.51	0.56	0.43
	2	4.36	3.11	3.89	1.26	0.36	0.23	0.37	0.22	0.40	0.53	0.72	0.42	0.40	0.50	0.68	0.42
	3	4.40	3.08	3.78	1.51	0.38	0.19	0.34	0.24	0.34	0.51	0.53	0.54	0.42	0.45	0.50	0.54
44	1	4.74	2.08	2.92	1.08	0.30	0.51	0.45	0.34	0.51	0.58	0.77	0.38	0.49	0.55	0.58	0.42
	2	4.28	3.04	2.42	0.92	0.42	0.29	0.39	0.36	0.33	0.58	0.55	0.30	0.38	0.54	0.44	0.32
	3	4.02	2.82	2.48	0.94	0.33	0.33	0.42	0.38	0.34	0.59	0.36	0.33	0.37	0.59	0.47	0.33
45	1	4.06	3.17	3.45	1.35	0.36	0.26	0.32	0.23	0.46	0.36	0.60	0.43	0.41	0.57	0.62	0.58
	2	3.83	3.19	3.94	1.67	0.35	0.36	0.30	0.23	0.45	0.61	0.64	0.40	0.37	0.50	0.58	0.37
	3	4.13	3.04	1.42	1.24	0.31	0.37	0.30	0.24	0.56	0.70	0.60	0.41	0.41	0.48	0.51	0.51
46	1	4.28	1.21	3.72	1.29	0.36	0.14	0.41	0.36	0.51	0.77	0.76	0.46	0.46	0.48	0.51	0.53
	2	4.36	3.49	3.34	0.98	0.35	0.26	0.33	0.28	0.68	0.69	0.59	0.45	0.61	0.56	0.51	0.44
	3	4.43	3.85	3.72	1.00	0.44	0.54	0.38	0.27	0.47	0.75	0.53	0.39	0.42	0.55	0.50	0.40

Table VI-3. Continued.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
47	1	4.36	3.30	3.34	1.12	0.33	0.25	0.30	0.25	0.36	0.51	0.45	0.29	0.39	0.54	0.49	0.42
	2	4.21	3.49	2.45	1.27	0.26	0.27	0.34	0.22	0.51	0.60	0.60	0.24	0.54	0.55	0.41	0.34
	3	4.28	2.86	3.45	1.30	0.32	0.42	0.27	0.18	0.48	0.63	0.50	0.22	0.50	0.54	0.43	0.33
48	1	3.83	2.89	1.95	0.93	0.35	0.26	0.34	0.24	0.39	0.44	0.35	0.29	0.37	0.51	0.31	0.37
	2	4.17	3.25	2.31	0.95	0.37	0.28	0.33	0.27	0.41	0.40	0.35	0.24	0.41	0.50	0.41	0.32
	3	4.28	3.70	1.84	0.94	0.34	0.53	0.34	0.37	0.34	0.46	0.20	0.22	0.46	0.48	0.33	0.32
49	1	3.94	2.40	1.54	1.21	0.27	0.32	0.36	0.64	0.49	0.50	0.68	0.46	0.52	0.44	0.38	0.53
	2	4.10	3.19	1.70	1.10	0.29	0.53	0.32	0.51	0.52	0.59	0.48	0.39	0.52	0.54	0.37	0.41
	3	3.91	3.37	2.56	1.24	0.29	0.42	0.48	0.64	0.59	0.61	0.45	0.47	0.58	0.58	0.32	0.47
51	1	4.17	2.51	1.62	1.32	0.28	0.33	0.41	0.86	0.74	0.53	0.38	0.44	0.64	0.45	0.33	0.58
	2	4.21	2.23	1.62	1.26	0.33	0.31	0.33	0.62	0.61	0.60	0.33	0.39	0.43	0.46	0.28	0.43
	3	4.13	3.64	1.64	1.38	0.36	0.14	0.33	0.59	0.52	0.63	0.48	0.38	0.48	0.56	0.30	0.39
53	1	4.28	2.79	1.56	1.13	0.35	0.29	0.33	0.48	0.67	0.56	0.61	0.57	0.48	0.54	0.32	0.58
	2	3.76	1.54	2.64	0.85	0.28	0.15	0.34	0.31	0.66	0.81	0.52	0.46	0.37	0.53	0.34	0.40
	3	4.43	3.52	3.28	1.08	0.32	0.24	0.36	0.33	0.64	0.65	0.36	0.45	0.48	0.49	0.44	0.40
55	1	3.68	3.27	1.87	1.15	0.35	0.25	0.41	0.46	0.62	0.68	0.67	0.55	0.50	0.63	0.41	0.50
	2	4.21	2.41	1.56	1.06	0.29	0.32	0.32	0.39	0.65	0.68	0.56	0.60	0.44	0.51	0.37	0.49
	3	4.36	3.15	1.45	1.09	0.36	0.36	0.39	0.32	0.72	0.68	0.69	0.41	0.50	0.71	0.41	0.35
57	1	3.11	1.64	1.51	1.29	0.30	0.36	0.38	0.51	0.38	0.37	0.36	0.42	0.35	0.35	0.37	0.64
	2	3.98	1.49	1.40	1.18	0.35	0.28	0.36	0.41	0.35	0.44	0.40	0.29	0.40	0.36	0.42	0.42
	3	3.76	1.71	1.62	1.35	0.25	0.34	0.39	0.51	0.66	0.47	0.37	0.42	0.52	0.34	0.45	0.56
59	1	2.96	1.79	1.73	1.51	0.32	0.33	0.46	0.70	0.29	0.36	0.44	0.35	0.31	0.38	0.38	0.53
	2	3.00	1.34	1.95	1.20	0.34	0.24	0.47	0.48	0.38	0.34	0.35	0.34	0.39	0.36	0.44	0.53
	3	3.38	1.64	1.73	1.32	0.30	0.39	0.48	0.54	0.38	0.38	0.51	0.41	0.35	0.35	0.44	0.65
61	1	4.37	3.01	1.95	1.19	0.38	0.31	0.31	0.51	0.56	0.46	0.36	0.43	0.41	0.57	0.37	0.55
	2	4.10	3.23	1.67	1.02	0.44	0.32	0.38	0.64	0.45	0.61	0.38	0.45	0.48	0.57	0.39	0.48
	3	4.10	3.12	2.23	1.13	0.40	0.31	0.38	0.50	0.51	0.64	0.37	0.51	0.46	0.51	0.39	0.49
62	1	3.76	2.90	1.67	1.27	0.42	0.31	0.41	0.80	0.50	0.50	0.53	0.34	0.52	0.52	0.36	0.47
	2	4.13	2.97	1.89	1.10	0.40	0.23	0.41	0.70	0.40	0.49	0.48	0.40	0.38	0.55	0.37	0.45
	3	3.83	2.94	1.67	1.05	0.44	0.10	0.44	0.88	0.41	0.59	0.39	0.42	0.42	0.56	0.33	0.45
63	1	4.10	3.33	1.67	1.07	0.42	0.29	0.38	0.48	0.69	0.71	0.45	0.42	0.55	0.61	0.40	0.48
	2	3.57	3.11	3.31	1.09	0.23	0.28	0.40	0.36	0.66	0.83	0.76	0.42	0.41	0.61	0.48	0.43
	3	4.17	3.42	4.06	1.06	0.40	0.25	0.42	0.27	0.57	0.36	0.63	0.56	0.42	0.55	0.53	0.47
64	1	4.17	3.45	2.42	0.94	0.37	0.26	0.46	0.37	0.60	0.71	0.57	0.53	0.51	0.52	0.48	0.48
	2	3.98	3.38	2.50	1.04	0.38	0.20	0.51	0.48	0.68	0.77	0.42	0.40	0.40	0.54	0.45	0.40
	3	4.36	3.08	2.06	1.08	0.39	0.28	0.38	0.44	0.50	0.75	0.69	0.45	0.49	0.65	0.43	0.41
65	1	4.43	1.79	1.25	1.19	0.34	0.33	0.39	0.70	0.30	0.28	0.49	0.36	0.41	0.40	0.41	0.71
	2	3.94	2.52	1.54	1.17	0.33	0.34	0.32	0.38	0.48	0.40	0.39	0.33	0.45	0.40	0.35	0.48
	3	4.13	1.16	1.45	1.32	0.37	0.34	0.46	0.52	0.53	0.49	0.41	0.39	0.44	0.47	0.43	0.67
66	1	2.93	1.75	1.62	1.30	0.52	0.42	0.50	0.65	0.31	0.25	0.43	0.44	0.37	0.33	0.43	0.73
	2	3.60	1.75	1.17	1.10	0.39	0.38	0.38	0.54	0.30	0.34	0.28	0.41	0.38	0.40	0.36	0.53
	3	4.21	2.30	2.26	1.18	0.38	0.38	0.37	0.37	0.33	0.34	0.48	0.44	0.36	0.39	0.34	0.68
67	1	4.10	3.08	2.12	1.05	0.43	0.34	0.44	0.83	0.73	0.63	0.53	0.39	0.62	0.71	0.51	0.53
	2	3.98	3.30	2.12	1.05	0.35	0.31	0.38	0.75	0.50	0.55	0.54	0.46	0.57	0.57	0.38	0.52
	3	3.91	3.04	1.73	0.94	0.33	0.34	0.37	0.50	0.36	0.59	0.30	0.31	0.39	0.64	0.33	0.39
68	1	4.21	3.21	3.28	1.15	0.37	0.65	0.36	0.74	0.37	0.47	0.36	0.45	0.44	0.65	0.35	0.53
	2	4.06	3.11	1.81	0.95	0.40	0.58	0.41	0.85	0.34	0.50	0.76	0.41	0.39	0.58	0.34	0.46
	3	4.21	2.23	1.76	1.06	0.38	0.66	0.26	0.76	0.50	0.57	0.25	0.29	0.48	0.66	0.33	0.42
69	1	3.83	3.30	2.75	0.93	0.42	0.30	0.41	0.42	0.54	0.63	0.46	0.41	0.49	0.61	0.50	0.47
	2	3.91	3.69	3.81	1.14	0.44	0.13	0.40	0.36	0.60	0.66	0.66	0.42	0.36	0.52	0.58	0.48
	3	4.13	3.19	3.61	1.02	0.42	0.37	0.36	0.34	0.62	0.72	0.57	0.42	0.41	0.53	0.52	0.43
70	1	3.98	3.61	2.34	0.91	0.45	0.26	0.50	0.44	0.40	0.64	0.64	0.45	0.43	0.58	0.47	0.45
	2	3.98	3.47	3.64	1.07	0.43	0.32	0.43	0.42	0.35	0.61	0.64	0.37	0.37	0.50	0.42	0.37
	3	4.21	3.37	3.61	1.03	0.42	0.28	0.43	0.45	0.40	0.71	0.76	0.36	0.43	0.52	0.50	0.37

Table VI-3. Continued.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
71	1	3.93	3.49	1.70	1.15	0.36	0.32	0.44	0.79	0.46	0.39	0.37	0.40	0.42	0.55	0.38	0.67
	2	3.98	3.21	1.59	1.25	0.40	0.32	0.34	0.50	0.53	0.48	0.24	0.29	0.61	0.53	0.34	0.58
	3	4.28	3.26	2.17	1.09	0.35	0.32	0.39	0.41	0.48	0.39	0.47	0.41	0.52	0.44	0.36	0.54
72	1	3.89	3.07	1.81	1.16	0.40	0.43	0.39	0.70	0.39	0.35	0.23	0.45	0.35	0.48	0.39	0.67
	2	3.83	3.49	1.76	1.09	0.36	0.33	0.44	0.54	0.32	0.50	0.49	0.36	0.44	0.62	0.37	0.54
	3	3.83	1.15	1.51	1.15	0.37	0.15	0.34	0.66	0.31	0.35	0.33	0.45	0.36	0.45	0.30	0.69
73	1	4.13	2.56	1.56	1.30	0.36	0.23	0.28	0.64	0.51	0.54	0.53	0.61	0.52	0.60	0.38	0.58
	2	4.24	2.79	1.78	1.29	0.42	0.25	0.30	0.47	0.48	1.28	0.60	0.63	0.48	0.32	0.48	0.51
	3	3.76	2.75	1.67	1.02	0.30	0.20	0.28	0.32	0.41	0.88	0.70	0.57	0.42	0.75	0.46	0.41
75	1	4.36	2.14	1.62	1.28	0.36	0.30	0.32	0.62	0.49	0.56	0.40	0.45	0.53	0.54	0.39	0.47
	2	4.17	2.28	1.45	1.24	0.36	0.31	0.37	0.52	0.45	0.60	0.46	0.44	0.44	0.49	0.33	0.56
	3	4.06	2.01	1.54	1.16	0.36	0.28	0.34	0.44	0.47	0.52	0.52	0.44	0.42	0.50	0.31	0.45
77	1	4.17	3.26	1.67	1.07	0.32	0.24	0.29	0.34	0.74	0.97	0.62	0.76	0.46	0.63	0.42	0.49
	2	4.17	3.26	2.78	1.15	0.37	0.24	0.32	0.33	0.67	0.88	0.75	0.65	0.50	0.53	0.45	0.43
	3	4.17	3.26	2.92	1.26	0.32	0.24	0.36	0.36	0.75	0.88	0.72	0.68	0.57	0.60	0.48	0.44
79	1	4.66	3.30	1.67	1.21	0.43	0.22	0.36	0.38	0.78	1.03	0.73	0.81	0.48	0.71	0.42	0.50
	2	3.87	3.17	1.56	1.06	0.30	0.29	0.28	0.38	0.56	0.95	0.73	0.62	0.39	0.69	0.48	0.29
	3	3.91	1.94	1.67	1.11	0.31	0.16	0.21	0.46	0.61	0.83	0.53	0.78	0.38	0.58	0.35	0.40
81	1	3.60	1.54	1.40	1.27	0.22	0.27	0.35	0.48	0.50	0.64	1.14	0.61	0.51	0.54	0.38	0.53
	2	3.68	1.61	1.56	1.24	0.22	0.20	0.40	0.50	0.57	0.50	0.64	0.53	0.38	0.26	0.46	0.51
	3	3.60	1.49	1.20	1.34	0.24	0.26	0.30	0.40	0.51	0.57	0.54	0.57	0.40	0.40	0.38	0.52
83	1	3.15	1.06	1.40	1.19	0.28	0.22	0.42	0.46	0.45	0.70	0.44	0.53	0.47	0.55	0.32	0.46
	2	2.52	0.99	1.67	1.24	0.23	0.23	0.34	0.47	0.48	0.65	0.70	0.51	0.33	0.44	0.41	0.47
	3	3.49	1.12	1.81	1.32	0.29	0.20	0.36	0.40	0.43	0.59	0.40	0.56	0.41	0.41	0.49	0.40
85	1	4.00	2.95	1.45	1.03	0.38	0.28	0.27	0.33	0.45	0.86	0.69	0.71	0.40	0.78	0.44	0.44
	2	4.21	3.26	2.45	1.01	0.35	0.16	0.36	0.35	0.45	0.75	0.58	0.67	0.48	0.71	0.46	0.42
	3	4.43	3.26	2.12	1.03	0.37	0.27	0.33	0.29	0.46	0.65	0.47	0.61	0.44	0.56	0.41	0.39
86	1	3.87	2.45	1.62	1.11	0.42	0.33	0.33	0.53	0.34	0.45	1.58	0.48	0.43	0.57	0.60	0.54
	2	4.02	2.52	1.87	0.98	0.39	0.24	0.40	0.46	0.42	0.51	0.61	0.46	0.38	0.51	0.41	0.48
	3	3.33	2.48	1.51	1.16	0.34	0.28	0.31	0.64	0.42	0.33	0.46	0.46	0.46	0.71	0.33	0.48
87	1	3.83	3.06	2.06	1.06	0.34	0.23	0.32	0.33	0.58	0.70	0.43	0.69	0.44	0.62	0.42	0.40
	2	4.21	3.04	1.89	1.04	0.42	0.26	0.34	0.36	0.76	0.78	0.71	0.73	0.53	0.54	0.50	0.51
	3	3.94	3.57	3.61	0.98	0.36	0.27	0.35	0.27	0.56	0.89	0.58	0.59	0.44	0.59	0.48	0.37
38	1	4.02	2.53	3.28	1.02	0.44	0.38	0.40	0.30	0.65	0.75	0.76	0.97	0.52	0.53	0.50	0.47
	2	4.00	3.11	1.84	1.03	0.41	0.21	0.32	0.37	0.60	0.92	0.68	0.63	0.38	0.56	0.45	0.42
	3	4.06	3.12	2.23	1.10	0.37	0.26	0.38	0.32	0.70	0.82	0.78	0.72	0.51	0.48	0.40	0.34
89	1	3.00	2.95	1.28	1.26	0.33	0.27	0.28	0.39	0.51	0.56	0.75	0.78	0.41	0.49	0.38	0.76
	2	3.83	1.83	1.34	1.22	0.30	0.25	0.28	0.38	0.52	0.47	0.83	0.73	0.40	0.41	0.36	0.56
	3	3.91	2.60	1.48	1.29	0.27	0.22	0.26	0.38	0.67	0.59	0.74	0.92	0.54	0.44	0.36	0.61
90	1	3.76	2.62	1.17	1.21	0.32	0.28	0.26	0.38	0.45	0.40	0.70	0.72	0.39	0.46	0.34	0.63
	2	4.23	2.55	1.67	1.11	0.40	0.26	0.35	0.37	0.42	0.80	0.65	0.92	0.35	0.56	0.40	0.66
	3	4.06	2.68	1.51	1.15	0.38	0.29	0.30	0.40	0.61	0.61	0.67	0.78	0.55	0.45	0.43	0.43
91	1	4.06	3.33	2.89	1.10	0.43	0.31	0.37	0.28	0.34	0.59	0.55	0.62	0.40	0.54	0.51	0.54
	2	4.36	2.82	4.61	0.93	0.46	0.36	0.48	0.22	0.35	0.61	0.64	0.56	0.35	0.48	0.66	0.52
	3	3.91	3.26	3.42	1.02	0.44	0.34	0.42	0.25	0.42	0.49	0.56	0.50	0.48	0.55	0.48	0.49
92	1	4.28	3.52	2.03	1.02	0.47	0.29	0.40	0.42	0.40	0.60	0.56	0.61	0.43	0.60	0.50	0.46
	2	3.94	3.23	1.92	0.92	0.34	0.27	0.40	0.37	0.89	0.68	0.54	0.65	0.46	0.61	0.42	0.39
	3	4.36	3.26	2.70	0.98	0.47	0.28	0.44	0.37	0.45	0.60	0.58	0.52	0.44	0.57	0.46	0.38
93	1	4.17	3.07	3.34	0.94	0.45	0.28	0.38	0.29	0.62	0.78	0.90	0.69	0.49	0.54	0.66	0.45
	2	3.83	2.82	1.70	1.12	0.36	0.30	0.30	0.42	0.63	0.74	0.70	0.70	0.49	0.49	0.52	0.48
	3	4.02	3.12	3.67	1.32	0.36	0.31	0.33	0.26	0.73	1.03	0.73	0.64	0.52	0.54	0.53	0.50
94	1	4.32	2.89	2.56	1.02	0.49	0.34	0.42	0.38	0.39	0.69	0.67	0.55	0.42	0.55	0.60	0.41
	2	3.83	2.13	3.78	1.00	0.40	0.24	0.41	0.23	0.48	0.83	0.87	0.52	0.34	0.53	0.53	0.46
	3	4.21	3.12	2.03	1.00	0.50	0.36	0.31	0.30	0.50	0.82	0.77	0.59	0.35	0.49	0.45	0.38

Table VI-3. Continued.

Treatment Number	Replication	Cutting 1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
95	1	4.21	3.00	2.34	1.05	0.42	0.26	0.36	0.28	0.51	0.88	0.45	0.81	0.49	0.67	0.34	0.52
	2	4.32	3.11	2.56	1.00	0.32	0.25	0.35	0.30	0.45	0.59	1.03	0.98	0.44	0.42	0.39	0.54
	3	3.98	1.94	1.67	1.09	0.35	0.17	0.28	0.25	0.43	0.53	0.58	0.92	0.43	0.50	0.41	0.66
96	1	3.91	2.26	1.54	1.04	0.37	0.15	0.30	0.35	0.41	0.61	0.48	0.81	0.43	0.52	0.35	0.59
	2	3.83	2.17	1.40	1.24	0.35	0.31	0.32	0.45	0.36	0.48	0.62	0.78	0.39	0.44	0.38	0.56
	3	4.21	2.35	1.76	1.02	0.39	0.27	0.32	0.29	0.35	0.54	0.55	0.83	0.36	0.58	0.37	0.59
97	1	3.76	1.97	1.40	1.24	0.26	0.26	0.30	0.54	0.59	0.76	0.41	0.42	0.41	0.56	0.34	0.49
	2	3.60	2.47	1.67	1.21	0.22	0.18	0.25	0.53	0.54	0.62	0.73	0.42	0.42	0.40	0.34	0.40
	3	3.45	1.46	1.78	1.34	0.26	0.28	0.39	0.61	0.56	0.52	0.56	0.49	0.50	0.39	0.37	0.46
99	1	3.53	2.19	1.45	1.18	0.24	0.22	0.32	0.37	0.74	0.53	0.62	0.56	0.41	0.39	0.33	0.57
	2	3.98	2.67	1.59	1.15	0.16	0.19	0.32	0.40	0.57	0.68	0.63	0.50	0.40	0.41	0.37	0.37
	3	3.60	2.71	1.59	1.07	0.14	0.16	0.32	0.36	0.65	0.63	0.75	0.52	0.35	0.43	0.34	0.41
101	1	2.93	1.75	1.51	1.43	0.16	0.28	0.36	0.41	0.35	0.42	0.25	0.44	0.37	0.41	0.16	0.66
	2	3.76	2.06	1.67	1.24	0.18	0.24	0.32	0.42	0.29	0.57	0.50	0.49	0.45	0.54	0.44	0.55
	3	3.68	1.71	1.73	1.26	0.17	0.22	0.35	0.40	0.51	0.37	0.62	0.46	0.27	0.41	0.42	0.60

Table VI-4. Manganese, copper, and nickel concentrations of tall fescue grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cutting 1	2	3	4	1	2	3	4	1	2	3	4
		µg Mn/g				µg Cu/g				µg Ni/g			
1	1	67	108	219	308	3.8	2.5	4.0	3.4	2.4	2.4	2.4	2.4
	2	70	61	117	314	1.0	0.5	4.8	4.2	3.7	2.4	2.4	3.6
	3	87	141	287	415	3.8	0.5	5.8	3.5	8.1	2.4	5.3	3.7
3	1	67	82	134	289	5.1	1.5	5.8	4.8	2.4	2.4	5.3	3.6
	2	75	92	146	227	1.0	2.5	6.6	4.2	2.4	2.4	2.4	3.8
	3	77	106	122	248	1.0	0.5	4.8	3.8	2.4	2.4	2.4	2.6
5	1	69	88	106	254	2.4	9.7	4.8	3.6	2.4	2.4	2.4	3.2
	2	52	67	63	142	3.8	4.6	5.8	3.0	2.4	2.4	2.4	2.4
	3	61	79	42	102	3.8	2.5	4.8	2.8	5.3	2.4	2.4	3.0
7	1	60	85	120	236	3.8	2.5	4.0	4.0	5.3	2.4	5.3	2.0
	2	49	62	50	73	2.4	4.6	5.8	3.0	5.3	2.4	2.4	2.8
	3	61	78	69	182	6.5	1.5	4.8	3.2	5.3	2.4	2.4	1.4
9	1	56	57	150	175	1.0	0.2	3.2	3.6	5.3	2.4	2.9	4.0
	2	60	75	99	170	2.4	1.5	4.1	2.4	2.4	2.4	2.8	2.6
	3	62	81	115	180	2.4	3.6	8.0	1.6	5.3	2.4	5.3	0.9
11	1	52	128	218	226	3.8	2.5	3.2	4.8	6.6	2.4	2.9	4.8
	2	59	86	145	126	1.0	5.6	4.8	1.9	5.3	2.4	4.8	1.4
	3	61	103	203	176	2.4	0.5	4.8	3.4	5.3	2.4	2.4	3.1
13	1	95	201	260	581	2.4	0.5	4.0	3.2	2.6	2.4	2.4	5.4
	2	114	232	227	469	6.5	2.5	4.8	2.6	5.3	2.4	2.4	3.6
	3	103	225	282	467	2.4	2.5	4.8	2.6	2.4	2.4	2.4	3.2
14	1	71	146	220	601	2.4	3.6	6.6	3.4	5.3	2.4	5.3	4.8
	2	92	165	162	526	3.2	2.5	4.8	2.8	5.3	2.4	2.4	3.6
	3	79	159	235	641	5.1	0.2	4.8	3.6	5.3	2.4	2.4	3.8
15	1	99	165	121	108	3.8	0.5	6.6	3.4	2.4	2.4	2.4	2.0
	2	102	231	164	239	3.8	2.5	4.8	2.6	5.3	2.4	2.4	1.8
	3	100	177	130	110	3.8	2.5	5.8	4.2	5.3	2.4	2.4	2.6
16	1	82	148	120	245	3.8	0.5	7.2	2.8	5.3	2.4	5.3	3.0
	2	86	120	110	180	3.8	5.6	8.0	2.8	8.1	2.4	5.3	5.4
	3	88	135	78	138	3.8	0.5	4.8	3.0	8.1	2.4	2.4	3.0
17	1	145	185	197	450	2.4	2.5	3.2	3.0	5.3	5.3	5.3	4.4
	2	108	164	104	217	1.0	0.5	5.8	3.2	5.3	2.4	2.4	2.2
	3	116	161	163	422	2.4	1.5	3.2	2.4	5.3	2.4	2.4	6.8
18	1	115	120	157	389	2.4	4.5	3.2	6.4	8.1	2.4	2.4	4.8
	2	126	133	168	296	2.4	2.5	4.0	4.0	9.5	2.4	5.3	7.6
	3	108	153	183	341	3.2	1.5	3.2	2.5	8.1	2.4	2.4	2.1
19	1	96	225	248	615	5.1	2.5	4.0	2.4	10.0	2.4	2.4	4.2
	2	110	270	261	341	3.8	6.6	4.0	2.4	2.4	5.3	8.1	3.6
	3	91	234	246	646	4.6	0.2	3.2	2.4	2.4	2.4	8.1	2.2
20	1	89	171	208	520	2.4	0.5	4.8	2.4	5.3	2.4	2.4	3.8
	2	101	64	206	359	2.4	2.5	4.0	2.8	5.3	2.4	5.3	5.4
	3	93	210	223	370	3.8	4.6	4.0	2.8	2.4	2.4	5.3	5.2
21	1	137	284	166	172	1.0	2.5	6.6	3.4	8.1	2.4	2.4	3.4
	2	112	229	153	126	3.8	2.5	4.0	2.6	5.3	2.4	2.4	4.4
	3	135	303	186	150	3.8	3.6	4.0	2.8	5.3	2.4	2.4	5.0
22	1	108	212	185	229	3.8	4.5	5.8	4.2	9.8	2.4	2.4	5.0
	2	115	185	122	99	5.1	4.6	4.8	2.8	10.0	2.4	2.4	3.0
	3	122	216	146	135	3.8	2.5	4.8	4.0	8.1	5.3	5.3	5.4
23	1	142	214	197	286	7.9	4.6	4.8	2.2	9.2	2.4	2.4	4.4
	2	148	285	204	345	3.3	3.6	4.0	5.0	9.1	5.3	2.4	4.2
	3	153	275	187	285	1.0	2.5	6.6	2.2	8.1	5.3	5.3	6.2

Table VI-4. Continued.

Treatment Number	Replication	Cutting											
		1	2	3	4	1	2	3	4	1	2	3	4
		µg Mn/g				µg Cu/g				µg Ni/g			
24	1	152	246	200	456	7.9	2.5	4.8	3.0	13.0	5.3	5.3	6.6
	2	140	231	142	425	2.4	6.6	4.8	3.2	13.0	2.4	3.8	6.2
	3	171	380	230	211	3.8	2.5	4.0	2.8	8.1	2.4	2.4	4.0
25	1	93	157	224	344	3.8	3.6	4.8	4.0	2.4	2.4	2.4	2.6
	2	70	100	160	255	2.4	2.5	3.2	4.2	8.1	2.4	2.4	2.6
	3	96	155	200	313	2.4	2.5	4.8	3.6	5.3	2.4	2.4	2.2
27	1	58	104	147	251	3.8	2.5	4.8	4.0	5.3	2.4	2.4	2.6
	2	78	69	134	189	2.4	0.5	5.8	3.4	2.4	2.4	2.4	3.4
	3	73	79	116	252	2.4	1.5	3.2	2.4	8.1	2.4	2.4	3.2
29	1	47	62	85	146	2.4	3.6	4.8	3.0	0.4	2.4	2.4	2.4
	2	43	59	63	204	2.4	6.6	6.5	3.0	1.7	2.4	2.4	3.0
	3	67	60	100	94	2.4	2.5	4.8	2.8	0.4	2.4	2.4	3.2
31	1	47	56	95	177	3.8	3.6	4.0	3.6	0.4	2.4	2.4	4.4
	2	45	58	100	194	3.8	4.6	4.8	2.8	1.7	2.4	2.4	2.4
	3	60	62	62	143	5.1	4.6	6.6	3.8	1.7	2.4	2.4	4.2
33	1	63	73	164	166	2.4	2.5	2.9	3.4	0.4	2.4	1.9	2.4
	2	74	73	62	125	3.8	2.5	3.2	3.8	1.7	2.4	5.3	2.0
	3	65	80	131	239	7.9	0.5	4.0	3.3	4.4	2.4	5.3	1.6
35	1	67	121	84	245	2.4	0.5	3.2	4.4	0.4	2.4	5.3	5.6
	2	61	95	116	118	6.5	5.6	3.2	2.4	7.0	2.4	5.3	2.8
	3	69	97	135	186	6.5	2.5	3.2	4.0	4.4	5.3	4.8	6.8
37	1	103	198	291	446	2.4	1.5	4.8	2.8	0.4	5.3	2.4	3.6
	2	95	216	205	312	2.4	6.6	6.6	2.4	0.4	2.4	2.4	3.6
	3	93	251	245	361	2.4	4.6	3.2	2.8	1.7	2.4	2.4	4.0
38	1	71	129	208	397	3.8	2.5	4.8	2.8	3.8	2.4	2.4	4.6
	2	84	116	158	370	2.4	2.5	4.8	2.6	2.4	2.4	5.3	4.4
	3	92	186	214	339	5.1	2.5	4.0	2.6	5.1	2.4	2.4	2.8
39	1	88	196	163	150	3.8	2.5	5.8	2.6	3.0	2.4	2.4	2.6
	2	79	150	101	134	9.3	2.5	4.0	2.4	0.4	2.4	2.4	3.6
	3	85	193	120	109	3.8	6.6	7.2	2.8	3.0	2.4	5.3	3.2
40	1	65	99	102	230	3.8	0.5	5.8	2.4	1.7	2.4	2.4	4.6
	2	78	92	64	211	5.1	8.7	4.8	3.2	1.7	2.4	2.4	2.4
	3	85	96	84	168	2.4	6.6	6.6	3.0	1.7	2.4	2.4	3.4
41	1	99	137	107	308	3.8	2.5	4.0	3.8	1.7	2.4	2.4	4.8
	2	122	141	104	274	3.8	6.6	4.8	2.6	1.7	2.4	5.3	3.4
	3	104	129	155	204	3.8	2.5	4.0	2.4	1.7	2.4	2.4	3.2
42	1	113	135	129	272	2.4	3.6	4.0	3.0	3.0	2.4	2.4	4.8
	2	119	116	134	364	2.4	1.5	4.0	3.1	3.0	2.4	2.4	4.0
	3	125	165	113	294	2.4	5.6	4.0	3.2	3.0	2.4	2.4	4.8
43	1	100	209	269	497	5.1	6.6	4.8	2.2	1.7	2.4	2.4	4.4
	2	106	216	285	299	3.8	0.5	5.8	1.8	4.4	2.4	2.4	3.8
	3	104	231	260	355	2.4	10.7	4.8	2.6	3.0	2.4	2.4	2.8
44	1	92	211	255	417	3.8	5.6	5.8	2.4	0.4	2.4	5.3	3.6
	2	93	211	171	316	2.4	6.6	4.8	2.0	1.7	2.4	2.4	3.0
	3	89	174	198	382	1.0	1.5	4.8	2.2	1.7	2.4	2.4	3.4
45	1	133	277	243	213	3.8	2.5	4.8	3.0	1.7	2.4	2.4	3.2
	2	109	260	188	242	2.4	6.6	5.8	3.2	1.7	2.4	5.3	4.2
	3	114	276	221	200	3.8	6.6	5.8	2.6	3.0	5.3	8.1	3.0
46	1	110	203	170	242	2.4	2.5	5.8	3.8	1.7	2.4	5.3	5.4
	2	98	195	123	211	1.0	2.5	5.8	2.6	3.0	2.4	8.1	4.0
	3	105	147	126	171	5.1	0.5	7.2	2.4	3.0	2.4	2.4	4.8

Table VI-4. Continued.

Treatment Number	Replication	Cutting											
		1	2	3	4	1	2	3	4	1	2	3	4
		------- µg Mn/g -------				------ µg Cu/g ------				------- µg Ni/g ---------			
47	1	159	288	239	257	2.4	1.5	7.2	2.6	4.4	2.4	5.3	5.0
	2	156	189	140	89	5.1	2.5	4.8	2.4	3.0	2.4	5.3	4.0
	3	140	246	191	114	1.0	2.5	4.8	2.0	1.7	2.4	8.1	3.6
48	1	128	225	202	347	3.8	2.5	5.8	2.8	3.0	5.3	8.1	5.8
	2	128	219	177	270	6.5	5.6	5.8	2.6	7.0	5.3	2.4	3.6
	3	165	272	196	331	3.8	2.5	3.2	2.2	3.0	5.3	2.4	3.2
49	1	60	106	194	253	2.4	2.5	5.8	4.0	1.7	2.4	2.4	2.2
	2	53	98	211	219	3.8	2.5	4.0	3.2	0.4	2.4	2.4	1.8
	3	71	93	130	226	2.4	2.5	4.8	3.4	0.4	2.4	2.4	2.4
51	1	70	113	182	265	2.4	4.6	4.0	4.0	0.4	2.4	2.4	2.4
	2	63	78	163	193	3.8	0.5	3.2	3.0	0.4	2.4	2.4	1.8
	3	68	91	79	211	2.4	3.6	4.8	3.8	1.7	2.4	2.4	2.6
53	1	42	61	101	168	2.4	2.5	5.8	3.4	0.4	2.4	2.4	2.8
	2	27	54	47	86	2.4	2.5	4.0	3.2	0.4	2.4	2.4	2.0
	3	48	62	115	116	5.1	3.6	6.6	2.8	1.7	2.4	2.4	3.2
55	1	47	71	93	184	3.8	6.6	4.8	3.6	0.4	2.4	2.4	2.6
	2	42	74	87	213	3.2	0.5	4.8	2.8	0.4	2.4	2.4	3.6
	3	41	58	108	90	3.8	0.5	4.8	3.0	0.4	2.4	2.4	2.0
57	1	46	82	105	164	2.4	1.5	4.8	4.8	0.4	2.4	4.8	2.8
	2	54	73	231	93	2.4	1.5	3.9	3.8	0.4	2.4	4.8	1.6
	3	59	73	63	85	2.4	3.6	6.6	4.4	0.4	2.4	5.3	1.2
59	1	53	132	146	206	2.4	0.5	4.1	4.8	0.4	2.4	2.0	3.6
	2	43	94	90	102	1.0	2.5	6.8	4.0	0.4	2.4	5.3	2.8
	3	41	72	98	109	1.0	0.5	3.2	2.0	0.4	2.4	2.4	1.0
61	1	101	175	178	413	5.1	2.5	4.0	5.2	1.7	2.4	2.4	2.0
	2	85	104	123	327	3.8	2.5	4.0	3.2	0.4	2.4	2.4	2.4
	3	78	129	201	388	3.8	1.5	4.8	3.4	0.4	2.4	5.3	1.8
62	1	75	118	175	252	2.4	2.4	4.8	3.6	0.4	2.4	2.4	3.2
	2	78	122	143	388	3.8	2.4	5.8	3.0	0.4	2.4	2.4	3.2
	3	69	100	102	267	1.0	5.3	4.8	3.4	1.7	5.3	2.4	2.2
63	1	34	64	80	166	5.1	2.5	4.8	3.4	0.4	2.4	2.4	1.4
	2	52	59	47	90	1.0	0.5	4.8	3.4	0.4	8.1	2.4	2.6
	3	45	88	70	109	6.5	2.5	5.8	2.8	1.7	2.4	2.4	2.4
64	1	37	61	56	133	3.8	0.5	4.8	3.0	0.4	2.4	2.4	2.6
	2	43	53	41	120	2.4	0.5	6.6	3.2	0.4	2.4	5.3	2.4
	3	45	54	43	115	2.4	5.6	6.6	3.0	0.4	2.4	5.3	1.4
65	1	84	98	96	293	3.8	0.5	3.2	4.8	4.4	2.4	4.8	4.8
	2	56	54	88	119	1.0	0.5	4.8	2.2	1.7	2.4	2.4	2.2
	3	50	63	98	152	1.0	3.6	4.8	2.8	0.4	2.4	4.8	2.8
66	1	51	84	152	210	3.8	1.5	3.2	4.8	1.7	0.0	2.4	4.4
	2	49	79	112	185	3.8	0.5	3.2	3.6	1.7	2.4	5.3	3.2
	3	43	76	89	167	2.4	2.5	4.8	3.4	1.7	2.4	2.4	1.4
67	1	99	158	191	455	2.4	0.5	7.2	3.0	3.0	2.4	2.4	3.2
	2	92	142	155	433	2.4	1.5	4.8	3.0	1.7	2.4	2.4	1.4
	3	77	152	120	268	2.4	2.5	4.8	2.6	2.4	2.4	8.1	2.8
68	1	62	116	130	373	2.4	2.5	4.8	3.2	0.4	2.4	2.4	1.6
	2	52	82	137	263	3.8	2.5	4.0	3.2	0.4	2.4	2.4	2.0
	3	64	94	134	269	3.8	3.6	4.0	2.8	3.0	2.4	2.4	1.2
69	1	111	193	63	74	3.8	8.7	4.8	2.4	3.0	2.4	2.4	1.4
	2	47	60	61	64	3.8	2.5	4.8	2.0	1.7	2.4	2.4	1.4
	3	56	75	65	83	3.8	2.5	5.8	2.2	3.0	2.4	5.3	2.8

Table VI-4. Continued.

Treatment Number	Replication	Cutting 1	2	3	4	1	2	3	4	1	2	3	4
		µg Mn/g				µg Cu/g				µg Ni/g			
70	1	53	72	55	154	6.5	3.6	4.8	2.8	3.0	2.4	2.4	2.6
	2	43	70	43	98	2.4	2.5	5.8	2.6	0.4	2.4	5.3	1.4
	3	63	85	76	112	2.4	2.5	5.8	2.6	0.4	5.3	2.4	3.6
71	1	75	78	75	181	2.4	3.6	4.8	2.8	1.7	5.3	2.4	8.0
	2	60	74	56	150	3.8	0.5	4.0	3.2	3.0	2.4	5.3	5.6
	3	62	63	62	139	2.4	1.5	2.0	3.2	1.7	2.4	8.1	3.2
72	1	57	90	103	193	2.4	0.5	4.0	4.0	0.4	5.3	2.4	2.8
	2	87	87	140	132	2.4	2.5	4.8	3.0	1.7	2.4	2.4	2.6
	3	60	67	80	184	3.8	0.2	4.0	3.6	0.4	5.3	2.4	3.2
73	1	117	191	170	497	3.8	2.6	4.8	4.4	0.4	5.3	2.4	3.6
	2	103	48	168	333	3.8	3.6	4.8	3.8	0.4	2.4	2.4	3.0
	3	75	172	167	332	2.4	1.5	5.8	3.2	0.4	2.4	2.4	2.8
75	1	83	123	244	295	3.8	2.5	5.8	4.4	0.4	5.3	5.3	2.4
	2	79	128	237	104	3.8	2.5	4.8	4.2	4.4	2.4	5.3	2.1
	3	67	97	204	300	2.4	0.5	4.8	4.0	0.4	2.4	2.4	1.8
77	1	63	67	89	229	3.8	2.5	4.0	4.2	1.7	2.4	2.4	2.8
	2	58	67	58	118	2.4	3.6	6.6	3.6	1.7	8.1	2.4	2.8
	3	75	67	103	189	1.0	2.5	5.8	4.2	0.4	2.4	2.4	4.6
79	1	103	76	132	165	5.1	3.6	4.8	5.2	1.7	2.4	2.4	3.4
	2	53	75	110	145	1.0	2.5	4.0	3.6	1.7	2.4	2.4	2.8
	3	70	78	104	185	1.9	3.1	4.0	3.2	0.4	2.4	2.4	3.8
81	1	152	278	172	440	2.4	6.6	5.4	4.4	0.4	5.3	2.8	4.4
	2	71	91	167	186	2.4	4.6	5.3	2.0	0.4	5.3	4.8	1.4
	3	79	137	176	313	2.4	2.5	5.8	3.2	1.7	2.4	3.6	2.9
83	1	80	159	162	261	2.4	1.5	4.0	1.4	3.0	2.4	2.4	1.7
	2	56	103	193	125	2.4	2.5	4.8	2.2	0.4	2.4	4.8	2.2
	3	108	156	254	273	3.2	2.5	4.8	1.7	1.7	2.4	10.6	2.8
85	1	121	235	260	1074	5.1	1.5	4.8	3.6	1.7	2.4	2.4	3.8
	2	122	286	265	738	1.0	6.6	7.2	4.2	7.0	2.4	2.4	3.0
	3	133	290	270	674	2.4	2.5	5.8	3.2	0.4	2.4	2.4	2.6
86	1	82	154	212	496	2.4	3.6	6.1	3.6	0.4	2.4	4.0	1.8
	2	88	121	162	407	5.1	1.5	5.8	3.8	0.4	2.4	2.4	2.8
	3	73	135	261	469	3.8	6.6	3.2	3.6	1.7	2.4	2.4	3.6
87	1	100	160	170	459	5.1	0.5	4.8	3.8	0.4	2.4	2.4	4.2
	2	100	184	216	503	2.4	2.5	4.0	3.8	0.4	2.4	2.4	3.4
	3	117	260	163	303	1.0	4.6	4.0	3.2	1.7	2.4	2.4	3.0
88	1	126	230	136	467	7.9	2.5	6.6	3.8	3.0	2.4	2.4	2.6
	2	118	166	220	377	5.1	1.5	4.8	2.4	3.0	2.4	2.4	5.8
	3	115	190	189	323	3.8	4.6	6.6	3.8	0.4	2.4	2.4	3.2
89	1	156	186	346	1077	3.8	1.5	5.8	2.7	1.7	8.1	2.4	1.2
	2	110	182	432	614	1.0	6.6	4.3	4.8	0.4	2.4	1.6	5.6
	3	138	189	260	1312	2.4	3.5	6.6	2.5	3.0	2.4	5.3	1.9
90	1	195	317	310	1027	3.8	2.5	6.6	4.4	0.4	2.4	5.3	3.6
	2	173	254	320	689	5.1	2.5	5.0	4.0	0.4	2.4	10.6	5.2
	3	156	237	421	626	5.1	1.5	4.8	1.6	1.7	2.4	2.4	0.8
91	1	127	257	343	795	2.4	2.5	4.8	3.0	2.4	2.4	2.4	2.8
	2	119	275	308	646	3.8	8.7	4.0	3.2	3.8	5.3	2.4	2.4
	3	109	272	285	498	7.9	6.6	5.8	3.4	7.9	2.4	5.3	2.0
92	1	104	205	257	850	6.5	2.5	5.8	5.0	5.1	2.4	2.4	2.4
	2	111	226	276	960	2.4	3.6	4.8	3.2	0.4	2.4	2.4	3.8
	3	119	230	240	701	10.7	2.5	4.8	3.4	1.7	2.4	2.4	2.6

Table VI-4. Continued.

Treatment Number	Replication	Cutting											
		1	2	3	4	1	2	3	4	1	2	3	4
		------ ug Mn/g ------				------- μg Cu/g ------				------- μg Ni/g --------			
93	1	125	305	280	565	7.9	1.5	5.5	3.0	5.1	2.4	2.4	3.4
	2	95	267	210	557	2.4	4.6	5.3	7.4	3.0	2.1	5.3	1.6
	3	112	280	210	165	1.0	6.6	4.0	3.6	0.4	5.3	2.4	2.6
94	1	198	266	460	964	5.1	6.6	6.6	3.2	0.4	2.4	2.4	4.0
	2	158	243	246	172	3.8	5.6	7.2	3.2	1.7	2.4	2.4	3.0
	3	138	290	162	310	5.1	5.1	5.8	4.2	1.7	2.4	2.4	1.9
95	1	215	450	380	1868	5.1	2.5	4.0	3.3	3.0	2.4	2.4	5.3
	2	171	253	260	870	2.4	6.6	4.8	8.5	1.7	2.4	5.3	3.8
	3	114	401	320	1941	3.8	5.6	4.8	2.0	0.4	5.3	5.3	5.2
96	1	168	350	460	1618	10.7	3.6	6.0	2.8	5.7	2.4	2.4	3.2
	2	180	330	530	1430	3.8	4.6	4.8	2.2	1.7	2.4	2.4	2.4
	3	187	342	360	1521	5.1	1.5	3.2	3.6	1.7	2.4	2.4	3.2
97	1	66	90	195	230	5.1	2.5	4.8	3.8	0.4	1.0	5.3	3.2
	2	62	90	149	147	3.8	3.6	4.8	4.8	0.4	2.4	2.4	1.2
	3	72	117	242	203	2.4	4.6	6.6	2.8	1.7	1.0	5.3	2.0
99	1	58	61	125	183	3.8	0.5	4.8	5.0	0.4	2.4	2.4	3.0
	2	51	65	59	103	2.4	4.6	4.0	4.0	1.7	1.0	5.3	2.8
	3	44	56	66	105	2.4	12.8	8.0	3.8	0.4	1.0	2.4	3.2
101	1	50	63	44	253	2.4	8.7	3.2	4.0	1.7	2.4	2.4	7.6
	2	66	68	85	100	1.7	2.5	3.2	2.5	1.7	2.4	2.4	2.0
	3	87	66	65	176	1.0	5.6	3.2	3.2	1.7	2.4	2.4	4.8

Table VI-5. Nitrogen, phosphorus, calcium, and magnesium concentrations of white clover grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
2	1	5.04	3.89	3.97	3.53	0.34	0.34	0.33	0.26	1.83	1.54	1.36	1.52	0.40	0.35	0.35	0.53
	2	4.66	4.00	4.11	3.42	0.34	0.28	0.36	0.26	1.76	1.40	1.27	1.44	0.47	0.39	0.31	0.50
	3	4.85	4.22	4.17	3.64	0.35	0.30	0.37	0.29	1.58	1.64	1.22	1.50	0.41	0.37	0.43	0.51
4	1	4.44	3.85	4.44	3.06	0.37	0.38	0.41	0.40	1.42	0.75	1.34	1.65	0.31	0.50	0.38	0.59
	2	4.66	4.17	3.86	3.12	0.38	0.35	0.45	0.30	1.40	1.37	1.50	1.81	0.36	0.40	0.42	0.53
	3	3.68	4.07	3.72	3.10	0.34	0.40	0.42	0.34	1.46	1.58	1.25	1.72	0.36	0.41	0.40	0.58
6	1	4.59	4.22	3.86	3.55	0.32	0.30	0.37	0.37	1.74	2.12	1.54	1.89	0.28	0.38	0.29	0.52
	2	4.96	4.37	4.00	3.52	0.31	0.30	0.39	0.39	1.80	1.78	1.61	1.64	0.31	0.28	0.28	0.46
	3	5.26	4.26	3.89	3.40	0.34	0.30	0.36	0.36	1.52	1.71	1.39	1.69	0.32	0.29	0.27	0.45
8	1	5.04	4.26	3.70	3.52	0.34	0.36	0.39	0.30	1.80	2.00	1.76	1.73	0.39	0.35	0.30	0.46
	2	4.81	4.15	4.33	3.52	0.40	0.32	0.38	0.25	1.64	1.83	1.90	2.07	0.47	0.41	0.38	0.53
	3	4.63	3.93	3.94	3.78	0.35	0.33	0.44	0.34	1.68	0.84	1.52	1.76	0.31	0.14	0.30	0.50
10	1	4.43	4.15	3.56	2.22	0.38	0.34	0.29	0.19	1.50	1.14	1.15	1.46	0.33	0.26	0.27	0.43
	2	4.04	3.63	3.81	3.29	0.30	0.28	0.31	0.20	1.19	0.88	1.22	0.54	0.29	0.45	0.27	0.42
	3	4.96	3.64	3.59	3.55	0.38	0.28	0.31	0.22	1.18	0.61	1.13	1.64	0.26	0.64	0.27	0.44
12	1	4.21	3.57	3.75	3.40	0.42	0.32	0.37	0.20	1.44	1.04	1.15	1.61	0.40	0.28	0.26	0.47
	2	3.83	3.67	3.22	3.54	0.36	0.32	0.36	0.22	1.29	1.23	1.16	1.52	0.28	0.27	0.28	0.45
	3	4.41	4.07	3.67	3.22	0.37	0.38	0.30	0.22	1.31	1.23	1.06	1.58	0.29	0.29	0.31	0.41
26	1	4.70	3.63	3.78	3.80	0.38	0.34	0.34	0.28	1.40	1.77	1.24	1.61	0.35	0.42	0.33	0.53
	2	4.43	3.85	3.75	3.58	0.34	0.27	0.32	0.28	1.74	1.99	1.46	1.65	0.44	0.41	0.35	0.53
	3	4.36	4.07	3.94	3.78	0.30	0.28	0.36	0.29	1.41	1.76	1.31	1.37	0.32	0.41	0.33	0.54
28	1	3.39	4.00	3.97	3.74	0.32	0.29	0.36	0.27	1.33	0.64	1.42	1.65	0.26	0.61	0.35	0.50
	2	4.22	1.79	3.89	3.81	0.28	0.10	0.35	0.28	1.50	1.86	1.38	1.57	0.32	0.48	0.36	0.56
	3	3.98	0.85	3.89	3.52	0.31	0.03	0.36	0.28	1.39	1.45	1.25	1.40	0.37	0.36	0.37	0.54
30	1	5.19	4.44	4.33	3.57	0.35	0.37	0.35	0.26	1.52	1.70	1.61	1.98	0.26	0.25	0.26	0.44
	2	5.04	3.89	3.67	3.30	0.37	0.38	0.35	0.25	1.40	1.64	1.31	2.09	0.26	0.31	0.38	0.57
	3	4.51	4.09	2.17	3.68	0.32	0.26	0.34	0.25	1.54	1.54	1.38	1.67	0.33	0.30	0.28	0.49
32	1	4.51	4.00	4.00	3.53	0.37	0.35	0.36	0.29	1.62	1.57	1.71	1.74	0.26	0.28	0.25	0.49
	2	4.81	3.85	3.61	3.56	0.36	0.32	0.40	0.29	1.76	1.99	1.53	1.90	0.32	0.35	0.33	0.45
	3	4.96	4.62	3.80	3.92	0.34	0.30	0.38	0.32	1.36	2.31	1.54	1.79	0.30	0.38	0.31	0.45
34	1	5.11	3.19	3.31	3.10	0.39	0.40	0.32	0.20	1.26	0.90	0.81	1.00	0.38	0.32	0.33	0.51
	2	4.63	3.70	3.45	3.43	0.36	0.36	0.30	0.21	1.31	1.76	1.14	1.57	0.26	0.38	0.29	0.41
	3	4.74	3.63	3.61	3.54	0.36	0.41	0.30	0.21	1.36	1.19	1.00	1.33	0.35	0.29	0.29	0.41
36	1	4.96	3.98	3.14	3.44	0.36	0.33	0.32	0.22	1.24	1.26	1.18	1.41	0.28	0.25	0.25	0.40
	2	3.00	3.63	3.67	3.40	0.32	0.35	0.32	0.22	1.28	1.28	1.15	1.60	0.28	0.30	0.28	0.46
	3	4.06	3.63	3.94	2.31	0.33	0.45	0.33	0.22	1.19	1.32	1.13	1.47	0.29	0.30	0.26	0.39
50	1	4.51	4.24	3.94	3.72	0.35	0.37	0.36	0.33	1.46	1.55	1.31	1.41	0.34	0.39	0.30	0.47
	2	4.28	3.96	3.83	3.49	0.34	0.49	0.38	0.28	1.36	1.32	1.33	1.50	0.37	0.31	0.31	0.32
	3	4.74	3.85	3.94	3.61	0.29	0.47	0.36	0.25	1.70	1.48	1.55	1.55	0.40	0.33	0.36	0.53
52	1	4.74	3.65	4.00	3.71	0.42	0.54	0.40	0.40	1.52	1.39	1.36	1.61	0.31	0.36	0.35	0.52
	2	4.37	3.19	4.23	3.51	0.40	0.42	0.45	0.32	1.42	1.24	1.43	1.67	0.30	0.33	0.32	0.50
	3	4.96	4.11	3.83	3.12	0.45	0.67	0.39	0.35	1.39	1.26	1.43	1.50	0.33	0.32	0.34	0.56
54	1	4.58	3.45	3.28	3.38	0.33	0.49	0.30	0.30	1.58	2.02	1.54	1.72	0.33	0.36	0.29	0.45
	2	4.66	4.00	4.17	2.66	0.32	0.45	0.37	0.33	1.81	1.59	1.45	1.82	0.33	0.25	0.29	0.45
	3	4.74	4.47	3.89	3.53	0.36	0.30	0.38	0.32	1.59	2.07	1.43	1.80	0.30	0.34	0.34	0.48
56	1	4.13	3.56	4.06	3.55	0.32	0.29	0.38	0.32	1.51	1.73	1.51	1.80	0.24	0.29	0.30	0.43
	2	4.59	3.52	4.00	3.57	0.37	0.17	0.38	0.37	1.56	2.00	1.63	1.76	0.36	0.35	0.30	0.43
	3	5.07	3.48	4.00	3.94	0.36	0.30	0.45	0.35	1.92	1.46	1.53	1.70	0.46	0.27	0.32	0.49
58	1	4.66	3.45	3.50	3.24	0.37	0.33	0.33	0.26	1.29	1.23	1.28	1.81	0.26	0.33	0.30	0.51
	2	3.83	2.89	3.78	3.30	0.33	0.22	0.31	0.22	1.20	1.41	1.19	1.58	0.26	0.36	0.27	0.45
	3	4.21	2.97	3.67	3.12	0.35	0.29	0.33	0.23	1.15	1.05	0.95	1.47	0.24	0.28	0.27	0.52

Table VI-5. Continued.

Treatment Number	Replication	Cutting															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		% N				% P				% Ca				% Mg			
60	1	4.28	3.87	3.72	3.46	0.47	0.40	0.35	0.25	1.18	1.23	1.14	1.51	0.29	0.32	0.27	0.42
	2	3.60	3.56	3.56	3.58	0.39	0.39	0.39	0.27	1.19	1.27	1.16	1.56	0.29	0.34	0.31	0.47
	3	3.53	3.64	3.83	3.46	0.39	0.37	0.47	0.26	1.25	1.10	1.21	1.46	0.35	0.35	0.30	0.48
74	1	4.74	4.17	4.17	3.55	0.30	0.27	0.32	0.28	1.58	1.67	1.65	1.63	0.36	0.41	0.33	0.56
	2	4.21	4.36	4.17	3.83	0.30	0.28	0.32	0.28	1.59	1.78	1.32	1.57	0.41	0.46	0.37	0.58
	3	4.58	3.45	3.22	3.80	0.30	0.33	0.28	0.29	1.52	1.87	1.36	1.46	0.40	0.42	0.33	0.52
76	1	4.06	3.48	4.44	3.58	0.32	0.36	0.35	0.25	1.51	1.83	1.43	1.62	0.38	0.48	0.38	0.58
	2	4.21	3.70	4.00	3.67	0.28	0.32	0.36	0.32	1.38	1.85	1.51	1.72	0.40	0.46	0.37	0.57
	3	4.21	3.74	3.64	2.55	0.32	0.40	0.34	0.25	1.70	1.54	1.30	1.61	0.42	0.37	0.37	0.52
78	1	4.81	4.22	3.83	2.64	0.30	0.38	0.40	0.23	1.85	2.10	1.72	2.01	0.29	0.30	0.30	0.60
	2	4.77	3.70	3.72	3.35	0.35	0.28	0.33	0.28	1.98	1.79	1.80	2.02	0.34	0.26	0.28	0.45
	3	4.59	3.96	4.17	3.53	0.34	0.33	0.36	0.26	1.66	1.93	1.74	1.90	0.27	0.29	0.23	0.48
80	1	4.43	3.93	3.39	3.72	0.40	0.33	0.40	0.29	1.83	1.99	1.65	2.06	0.30	0.32	0.31	0.59
	2	4.66	3.63	3.89	3.61	0.38	0.36	0.37	0.30	1.81	1.93	1.53	2.14	0.31	0.29	0.32	0.44
	3	4.74	4.30	3.56	3.32	0.39	0.34	0.34	0.28	1.60	1.78	1.66	1.80	0.34	0.31	0.32	0.46
82	1	4.10	3.34	3.78	3.28	0.35	0.24	0.31	0.22	1.28	1.30	1.35	1.74	0.30	0.29	0.26	0.44
	2	3.83	3.81	3.83	3.38	0.29	0.31	0.31	0.20	1.42	1.22	1.35	1.72	0.33	0.29	0.28	0.42
	3	3.76	3.45	3.56	3.55	0.27	0.29	0.28	0.21	1.24	1.10	1.19	1.62	0.28	0.29	0.27	0.42
84	1	3.60	4.06	3.94	3.10	0.34	0.37	0.34	0.20	1.41	1.32	1.24	1.48	0.32	0.34	0.33	0.44
	2	3.15	3.56	4.08	3.41	0.29	0.32	0.30	0.20	1.34	1.09	1.28	1.61	0.30	0.30	0.26	0.38
	3	3.68	2.54	3.61	3.18	0.36	0.34	0.29	0.21	1.51	1.45	1.28	1.77	0.25	0.33	0.27	0.46
98	1	4.19	3.85	4.11	3.52	0.29	0.30	0.34	0.28	1.34	1.58	1.30	1.50	0.27	0.35	0.30	0.46
	2	3.53	3.55	4.11	3.21	0.29	0.28	0.34	0.35	1.60	1.48	1.31	1.60	0.36	0.34	0.39	0.55
	3	4.43	3.04	4.11	3.46	0.34	0.24	0.33	0.24	1.64	1.51	1.33	1.58	0.36	0.32	0.32	0.53
100	1	4.36	4.58	3.70	3.70	0.33	0.30	0.34	0.25	1.50	1.50	1.33	1.78	0.23	0.30	0.26	0.38
	2	4.74	3.93	3.89	3.34	0.30	0.32	0.36	0.26	1.30	1.39	1.54	1.71	0.22	0.25	0.22	0.38
	3	5.26	3.78	3.39	3.55	0.29	0.27	0.36	0.23	1.40	1.52	1.28	1.79	0.22	0.27	0.28	0.43
102	1	4.28	3.12	4.00	2.94	0.32	0.25	0.27	0.13	1.06	1.36	1.24	1.27	0.25	0.30	0.25	0.25
	2	4.06	3.23	4.06	3.45	0.30	0.25	0.26	0.14	1.19	1.42	1.13	1.27	0.23	0.27	0.29	0.24
	3	3.68	3.45	3.27	2.98	0.28	0.26	0.23	0.14	1.05	1.54	1.21	1.33	0.25	0.30	0.22	0.28

Table VI-6. Manganese, copper, and nickel concentrations of white clover grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cutting											
		1	2	3	4	1	2	3	4	1	2	3	4
		µg Mn/g				µg Cu/g				µg Ni/g			
2	1	84	75	63	62	3.8	4.6	6.6	6.6	3.0	2.4	5.3	4.2
	2	61	65	69	70	2.4	2.5	5.6	6.8	4.4	2.4	2.4	4.0
	3	90	75	36	64	3.8	0.5	6.6	7.0	1.7	2.4	2.4	3.6
4	1	80	90	74	90	2.4	2.5	6.6	7.6	0.4	2.4	2.4	5.0
	2	76	76	78	100	1.0	3.6	5.8	8.6	1.7	2.4	5.3	5.4
	3	61	73	72	92	3.8	2.5	8.0	7.2	1.7	2.4	5.3	4.8
6	1	53	51	56	86	5.1	2.5	5.8	8.0	4.4	5.3	5.3	4.0
	2	43	49	50	59	6.5	2.5	9.6	6.6	4.4	2.4	5.3	4.2
	3	45	52	57	73	1.0	4.6	6.6	6.8	1.7	2.4	2.4	3.4
8	1	62	72	48	66	6.5	2.5	7.2	7.4	1.7	2.4	2.4	3.4
	2	91	92	61	59	2.4	0.5	6.6	6.6	1.7	2.4	2.4	2.6
	3	43	36	50	68	5.1	0.2	7.2	7.2	4.4	2.4	2.4	4.0
10	1	52	66	31	94	2.4	5.6	5.8	6.2	1.7	2.4	2.4	6.4
	2	35	64	71	83	3.8	2.5	7.2	6.2	1.7	2.4	2.4	5.0
	3	37	65	55	92	1.0	2.5	6.6	8.8	1.7	5.3	8.1	5.4
12	1	52	78	60	100	3.8	6.6	6.6	6.4	3.0	5.3	2.4	6.8
	2	44	80	72	97	5.1	7.7	7.2	6.0	3.0	2.4	2.4	5.4
	3	46	61	60	111	5.1	2.5	5.8	5.8	1.7	2.4	2.4	7.0
26	1	75	97	79	71	2.4	3.6	4.8	7.4	0.4	2.4	5.3	7.4
	2	59	81	59	79	2.4	4.6	6.6	4.8	0.4	2.4	2.4	6.8
	3	64	65	123	58	3.8	0.5	6.6	4.2	3.0	2.4	2.4	6.6
28	1	49	167	66	75	3.8	0.5	4.8	7.2	0.4	2.4	2.4	5.0
	2	56	81	74	74	6.0	6.6	6.6	7.6	3.0	2.4	2.4	4.2
	3	54	67	81	77	3.8	5.6	4.8	7.4	1.7	2.4	2.4	5.0
30	1	49	44	58	73	2.4	4.6	7.2	7.2	0.4	2.4	2.4	4.6
	2	41	57	64	80	5.1	5.6	7.2	7.2	1.7	2.4	5.3	4.0
	3	48	55	50	79	1.0	6.6	4.8	8.2	0.8	5.3	5.3	4.2
32	1	49	64	68	71	3.8	6.6	7.2	3.6	1.7	2.4	2.4	2.4
	2	50	53	55	75	3.8	2.5	8.0	6.0	3.0	2.4	2.4	4.4
	3	60	71	60	75	3.8	4.6	4.8	7.6	0.4	2.4	2.4	4.8
34	1	95	77	84	147	6.5	4.6	3.8	6.2	4.4	2.4	1.8	7.8
	2	42	64	77	105	5.1	2.5	6.6	6.2	3.0	2.4	2.4	5.6
	3	51	72	65	109	2.4	2.5	5.8	6.0	1.7	5.3	2.4	5.2
36	1	46	69	85	89	2.4	3.6	5.8	6.0	1.8	2.4	2.4	6.2
	2	40	71	52	105	3.8	7.7	7.2	4.8	1.8	2.4	2.4	6.6
	3	51	82	86	103	3.8	6.6	6.6	6.8	3.0	2.4	5.3	6.0
50	1	65	84	28	63	3.8	5.6	4.8	7.2	0.4	2.4	2.4	2.7
	2	52	69	76	62	3.8	4.0	5.8	7.2	1.7	2.4	2.4	3.8
	3	67	63	77	72	3.8	2.5	8.0	6.8	3.0	2.4	2.4	4.4
52	1	65	62	67	72	2.4	1.5	6.6	7.0	1.7	2.4	2.4	4.4
	2	63	66	64	81	2.4	2.5	7.2	7.8	1.7	2.4	2.4	3.6
	3	73	83	86	69	3.8	6.6	8.0	6.2	0.4	2.4	2.4	3.2
54	1	33	53	71	75	2.4	6.6	8.0	6.0	1.7	2.4	2.4	3.2
	2	46	55	65	64	2.4	2.5	5.8	7.2	0.4	2.4	2.4	2.8
	3	39	59	48	71	3.1	2.5	5.8	7.4	4.4	2.4	5.3	3.8
56	1	42	55	75	68	1.0	2.5	7.2	6.4	1.7	2.4	11.0	2.2
	2	39	62	75	60	3.8	4.6	5.8	6.4	1.7	2.4	2.4	3.6
	3	45	58	21	63	1.0	1.5	7.2	7.0	1.7	2.4	2.4	4.0
58	1	33	53	71	76	1.0	3.6	4.8	4.6	0.4	2.4	2.4	4.2
	2	36	51	67	77	3.8	3.6	6.6	5.6	1.7	2.4	2.4	4.4
	3	41	56	70	92	3.8	8.7	4.0	5.4	4.4	2.4	5.3	4.4

Table VI-6. Continued.

Treatment Number	Repli-cation	Cutting											
		1	2	3	4	1	2	3	4	1	2	3	4
		µg Mn/g				µg Cu/g				µg Ni/g			
60	1	42	65	56	75	2.4	4.6	4.8	4.8	1.7	5.3	2.4	2.0
	2	39	51	68	87	1.0	4.6	6.6	6.6	1.7	2.4	2.4	3.6
	3	43	73	75	91	3.8	6.6	5.8	5.6	1.7	2.4	2.4	2.6
74	1	63	68	83	70	3.1	2.5	6.2	6.2	4.4	2.4	5.3	2.8
	2	122	148	109	99	3.2	2.5	7.4	7.4	1.7	2.4	8.1	3.6
	3	128	136	100	81	5.1	0.5	6.8	6.8	3.0	2.4	2.4	5.2
76	1	87	101	106	82	2.4	4.6	7.2	6.4	1.7	2.4	2.4	3.2
	2	73	104	81	91	2.4	1.5	6.6	6.6	3.0	2.4	2.4	5.2
	3	71	95	79	89	2.4	2.5	5.8	6.6	1.7	2.4	2.4	5.2
78	1	69	57	46	79	5.1	6.6	6.6	7.2	1.7	5.3	5.3	4.0
	2	64	57	72	67	2.4	2.5	7.2	6.4	1.7	2.4	5.3	4.6
	3	57	72	70	89	2.4	2.5	6.6	7.2	1.7	2.4	8.1	3.0
80	1	62	64	67	86	2.4	3.6	5.8	6.8	1.7	2.4	2.4	3.4
	2	68	81	79	85	3.2	2.5	4.8	6.8	1.7	2.4	2.4	3.2
	3	56	68	34	74	2.4	2.5	6.6	6.4	1.7	2.4	5.3	3.2
82	1	61	94	83	114	2.4	4.6	7.2	6.2	3.0	2.4	8.1	4.0
	2	61	78	74	106	3.8	8.7	5.8	6.8	0.4	2.4	2.4	5.6
	3	64	71	78	126	3.8	3.6	5.8	6.2	4.4	2.4	5.3	3.2
84	1	92	101	72	119	3.8	6.6	4.8	6.2	3.0	5.3	2.4	3.8
	2	60	96	75	117	2.4	4.6	6.6	6.6	0.4	5.3	5.3	4.4
	3	64	85	61	125	2.4	5.6	7.2	5.6	1.7	2.4	2.4	4.0
98	1	57	56	35	60	3.8	8.7	6.6	6.6	1.7	5.4	2.4	4.2
	2	72	74	56	75	2.4	2.5	6.6	7.6	1.7	3.3	2.4	4.0
	3	52	81	71	72	2.4	12.8	5.8	7.8	1.7	7.6	2.4	4.2
100	1	27	46	67	60	1.0	1.5	6.6	7.0	0.4	1.0	2.4	3.8
	2	39	56	55	66	2.4	3.6	8.0	6.8	1.7	1.2	2.4	2.8
	3	33	40	50	79	1.7	2.6	5.8	7.8	1.1	2.4	2.4	2.4
102	1	39	61	61	61	5.1	6.6	7.2	5.8	1.7	2.4	5.3	1.8
	2	37	63	62	72	3.8	8.7	8.0	7.2	0.4	2.4	2.4	3.0
	3	31	74	63	66	4.4	6.6	6.6	5.6	1.1	2.4	2.4	2.8

Table VI-7. Zinc and chromium concentrations of tall fescue and white clover grown on soils amended with fertilizer materials.

Treatment Number	Replication	Cutting							
		1	2	3	4	1	2	3	4
		------ µg Zn/g ------				-------- µg Cr/g -------			
2	1	51	43	33	22	2.4	1.2	1.2	1.2
	2	32	26	40	30	3.0	3.8	8.8	1.7
	3	32	39	46	24	2.4	6.5	10.2	1.3
6	1	37	34	38	25	2.5	4.4	8.0	1.3
	2	32	36	34	22	3.4	4.4	20.1	1.4
	3	81	35	30	32	6.4	4.4	4.4	1.8
10	1	41	34	38	26	4.2	6.5	5.2	0.8
	2	27	39	64	19	2.9	7.6	4.2	1.3
	3	91	38	33	20	5.0	7.6	5.2	1.0
19	1	32	31	36	23	5.0	1.2	2.0	1.5
	2	35	46	46	19	3.0	2.3	1.8	0.8
	3	39	41	49	20	3.9	2.3	2.4	1.0
21	1	39	25	34	20	3.9	1.2	3.0	2.7
	2	38	43	54	20	3.4	3.3	2.4	2.1
	3	32	28	34	22	2.0	4.4	1.8	0.9
23	1	44	16	27	9	2.5	2.3	1.0	1.7
	2	39	22	32	12	2.1	8.6	8.0	1.2
	3	26	24	23	9	1.3	1.2	8.2	1.1
26	1	36	66	31	28	3.4	5.4	8.2	1.7
	2	61	70	42	34	3.9	4.4	0.8	1.7
	3	36	74	38	22	2.4	3.3	3.4	3.3
30	1	86	19	58	28	3.4	7.6	2.2	1.4
	2	170	20	33	23	11.8	12.8	2.4	1.0
	3	31	25	25	21	17.6	13.9	2.0	2.4
34	1	57	18	38	25	4.9	10.7	0.5	1.6
	2	25	14	46	20	2.0	5.4	0.6	1.1
	3	33	21	40	34	2.9	6.5	2.0	3.0
43	1	37	30	53	13	2.5	5.4	0.8	1.1
	2	42	30	35	17	4.4	1.2	3.6	0.8
	3	40	30	53	22	0.8	9.7	1.4	1.8
45	1	42	25	48	16	1.0	4.4	0.8	1.7
	2	43	31	84	11	1.0	6.5	4.8	1.1
	3	39	65	26	20	0.8	16.0	8.0	1.7

Table VI-7. Continued.

Treatment Number	Replication	Cutting							
		1	2	3	4	1	2	3	4
		------ µg Zn/g ------				------- µg Cr/g --------			
47	1	32	21	35	7	4.4	7.6	1.4	2.0
	2	31	25	33	7	0.8	3.3	6.2	1.4
	3	34	37	21	9	2.5	7.6	4.0	0.9
50	1	33	33	34	37	7.4	9.7	3.0	1.5
	2	32	35	38	34	2.4	5.4	8.0	1.0
	3	50	34	33	29	5.0	2.3	5.0	1.2
54	1	29	23	41	20	3.9	6.5	5.0	1.6
	2	27	26	42	29	2.1	3.3	8.6	1.9
	3	36	36	60	23	3.4	3.3	10.2	2.2
58	1	25	28	29	24	5.9	7.6	2.4	1.1
	2	26	23	26	23	2.9	6.5	3.8	1.4
	3	27	20	27	22	4.2	12.8	2.2	3.2
67	1	39	18	39	13	3.9	12.8	0.8	8.0
	2	40	28	22	19	0.8	2.3	10.4	2.2
	3	37	21	43	7	2.4	14.9	3.8	0.8
69	1	37	22	38	16	2.5	1.2	8.8	1.7
	2	29	20	31	15	2.1	3.3	6.4	1.6
	3	44	16	27	13	2.5	10.7	3.8	1.7
71	1	20	16	22	23	3.4	7.6	0.6	4.2
	2	18	12	32	9	3.9	6.5	6.4	13.5
	3	44	5	25	10	2.5	13.9	5.0	1.0
74	1	41	26	30	29	2.5	11.8	3.4	1.9
	2	44	42	46	33	1.5	4.4	7.4	2.6
	3	37	36	47	28	2.9	2.3	5.4	2.0
78	1	31	41	42	33	6.7	8.6	8.8	1.5
	2	47	33	32	29	2.4	2.3	8.8	2.1
	3	21	39	38	28	4.6	5.4	6.0	1.4
82	1	41	18	38	20	3.4	4.4	3.2	1.2
	2	23	21	35	36	5.4	3.3	3.4	3.4
	3	20	15	36	31	2.9	4.4	7.4	1.5
91	1	51	50	48	21	3.0	4.4	4.2	1.5
	2	32	47	42	18	2.5	6.5	5.6	1.7
	3	37	52	38	14	4.9	4.4	6.4	0.8
93	1	46	27	38	16	0.8	4.4	9.0	1.0
	2	30	66	32	13	0.8	11.8	2.4	1.2
	3	38	46	47	22	0.8	5.4	1.6	1.1

Table VI-7. Continued.

Treatment Number	Replication	Cutting 1	2	3	4	1	2	3	4
		------ µg Zn/g ------				-------- µg Cr/g --------			
95	1	36	50	20	22	4.9	3.3	2.6	1.1
	2	31	37	36	16	2.5	6.5	2.2	1.8
	3	34	26	20	22	3.7	5.4	3.2	1.2
97	1	56	18	27	14	1.7	10.7	2.8	2.0
	2	64	35	30	12	1.6	5.4	7.4	1.6
	3	73	36	40	10	1.5	19.2	2.4	2.7
98	1	31	36	37	30	2.1	5.4	0.4	1.5
	2	37	31	47	29	1.3	3.3	4.2	4.1
	3	43	52	40	36	3.4	7.6	8.0	4.0
99	1	27	21	22	12	3.9	9.7	9.2	3.4
	2	33	34	26	9	2.5	6.5	1.4	0.9
	3	24	20	26	15	2.1	11.8	7.6	0.9
100	1	26	33	39	33	5.3	9.7	5.2	1.2
	2	26	34	28	29	2.9	9.7	5.6	1.0
	3	26	25	35	26	3.1	9.7	3.8	1.3
101	1	35	48	40	18	2.5	9.7	0.4	13.0
	2	25	21	38	12	1.8	6.5	2.6	1.0
	3	17	26	29	15	1.0	8.1	4.4	7.0
102	1	39	27	31	19	4.4	11.8	0.2	1.6
	2	34	20	26	20	3.9	12.8	3.0	0.9
	3	24	26	33	16	4.2	4.4	10.0	1.5