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Yield Response of Pangolagrass Grown on Tiwiwid Fine Sand to Mg and Fritted Micronutrients[1]

H. A. D. Chesney[2]

ABSTRACT

With the recent availability of 30,000 ha of Tiwiwid fine sand (Type Quartzipsamment), a highly leached, excessively permeable, coarse-textured soil of poor natural fertility, it was necessary to evaluate the potential of this marginal soil for sustained agricultural production.

The effect of Mg and Fritted micronutrients (FTE 503) —singly and in combination—on the dry matter yield of pangolagrass (*Digitaria decumbens* Stent) was studied over an 18-month period by means of a 3^3 factorial experiment. The variables of Mg and FTE 503 were 0, 88, and 176 kg/ha/annum of MgO and FTE 503, respectively, applied in four equal increments at 12-week intervals. Yields were measured by cutting the grass at regular intervals.

Magnesium did not have a positive effect on yield at any harvest and actually depressed yields at some harvests. Magnesium × micronutrients interaction was also nonsignificant.

Up to 88 kg/ha/annum of FTE 503 generally and 176 kg/ha/annum during periods of heavy rainfall increased yields at all harvests, with the effect becoming progressively greater with time. Some micronutrient deficiencies were observed on the grass that did not receive micronutrients. Over the 18-month period FTE 503 increased total dry matter yield by 8,700 kg/ha over the control.

Additional key words: **Dry matter, Kieserite, Fritted micronutrients, Pasture grass.**

WITH the construction of the Soesdyke/McKenzie Highway in Guyana approximately 65,000 ha of hitherto-inaccessible land became available for cultivation. The dominant soil in this area is Tiwiwid fine sand occupying about 30,000 ha. This soil, developed under forest from coarse-textured sediments of the Berbice Formation, is an old soil that has been extensively leached. It is acid, of extremely low natural fertility, with a low CEC and small amounts of exchangeable bases. Apart from the organic matter in its top 15 cm, it has very little capacity for retaining applied fertilizers or water. It was therefore necessary to determine the potential of this marginal soil for sustained agricultural production.

The pasture grass pangola (*Digitaria decumbens* Stent) was considered as a possible crop for this soil, and experiments were set up to determine its fertilizer requirements. There is little work reported from the Tropical Americas on the effect of Mg on crops generally (1, 8), and grass particularly (2, 5, 8). The same situation exists with micronutrients, although researchers working on sandy soils in southern Florida have indicated that application of micronutrients improves the performance of grasses (4, 6).

The work reported here was designed to determine the effect of Mg and micronutrients on the dry matter production of pangolagrass. The fritted form of micronutrients was preferred for this work, because of the extremely permeable nature of the soil and the heavy rainfall in the area.

[1] Contribution from the Central Agricultural Station, Mon Repos, East Coast Demerara, Guyana. Received Feb. 19, 1971.

[2] Chemist.

MATERIALS AND METHODS

Soil

This investigation was carried out at the Long Creek Substation of the Ministry of Agriculture. The soil was Tiwiwid fine sand described (H. N. Ramdin and G. Steele, 1966. Soil Survey Report of the Atkinson/Mackenzie Area. Library Central Agricultural Station, Guyana) as an excessively drained regosol (Typic Quartizipsamment). The particle size distribution and some chemical properties of its profile are presented in Table 1. The chemical properties were obtained as follows: pH by a glass electrode in a 1:2.5 soil:water suspension; total-N by the macro-Kjeldahl method; Truog-P colorimetrically; organic matter by the Walkley-Black method; K was determined flamephotometrically after extraction with *N* NH_4OAC (7). Calcium and Mg were determined by titration with E.D.T.A. after displacement with *N* KCl. Potassium chloride acid was determined by leaching the soil with *N* KCl and titrating the leachate against 0.05 *N* KOH (3). Cation exchange capacity was calculated by totalling the salt displaceable cations Na, K, Ca, Mg, and KCl acid.

The high organic matter content of the soil and the lack of measurable concentrations of bases may appear inconsistent and need some explanation. The organic matter in this soil is made up of leaf litter from the forest trees. These trees have been growing for years in an old soil, highly leached and developed from infertile, coarse-textured sandstone sediments. It is therefore expected that after many years of recycling of the bases from the soil through the leaf litter back to the soil that the initial small concentrations of bases in the organic matter would become even smaller.

The field capacity of the top 15 cm is 24%; the magnitude of this value is mainly due to the large quantities of decomposing, and lesser amounts of decomposed organic matter mixed with the mineral soil. The percolation rate is about 45 cm of water per hour.

Climate and Vegetation

The climate is tropical humid with uniformly high rainfall, humidity, and temperature. The average annual rainfall is 250 cm, distributed in a long wet season from mid-April to mid-August and a short wet season from mid-November through January. The rainfall data for the experimental period are presented in Table 2.

The vegetation consists mainly of woody shrubs called "muri bush" and primary forest; the main species in the latter is *Dacama* sp.

Table 1. Particle size analysis and some chemical properties of Tiwiwid fine sand.

Depth (cm)	Sand	Silt	Clay	pH	Total N	Organic matter	CEC*	Exch. K	Exch Mg	Exch. Ca	KCl acid	PBS†	Truog -P
	%	%	%		%	%	meq/100g						ppm
0- 12	98	0	2	4.7	0.03	1.4	0.4	0.0	0.0	0.0	0.4	0	3
12- 35	98	1	1	5.3	0.01	0.4	0.2	0.0	0.0	0.0	0.2	0	2
35- 72	99	1	0	5.8	0.01	0.2	0.5	0.0	0.0	0.0	0.5	0	2
72-120	99	1	0	5.7	0.01	0.2	0.2	0.0	0.0	0.0	0.1	0	4

* CEC = Cation Exchange Capacity. † PBS = Percentage Base Saturation

Table 2. Monthly rainfall data during the experimental period (as available).

Month	Rainfall, cm	Month	Rainfall, cm	Month	Rainfall, cm
1969 February	5.2	1969 August	17.1	1970 January	32.6
March	6.5	September	27.0	February	9.2
April	22.9	October	8.6	March	7.4
May	32.0	November	6.7	April	17.6
June	16.9	December	20.8	May	32.2
July	30.2				

Experimental Design and Procedures

The experiment was a 3^2 factorial with three replicates and treatments randomized within each replicate. The variables were Mg, 0, 88, and 176 kg MgO/ha/annum; and micronutrients (FTE 503)[3], 0, 88, and 176 kg/ha/annum, applied in four increments of 0, 22, and 44 kg/ha each. Mg was applied as kieserite (28% MgO). Typical analysis of F.T.E. 503 is as follows: boron, 3.83%; copper, 2.97% iron, 17.98%; manganese, 7.36%; molybdenum, 0.26%; and zinc, 7.03%. All plots were limed initially with calcitic limestone (1,100 kg/ha) and fertilized with 55 kg N/ha, 33 kg P/ha, and 33 kg K/ha per application. Sources of N, P, and K were urea, triple superphosphate, and muriate of potash, respectively.

The site selected was cleared of natural forest vegetation, with care taken not to remove the top soil. The soil was immediately limed and harrowed approximately 3 weeks before planting the grass on 27 December, 1968. Grass was planted by clumps spaced 0.6 by 0.6 m in plots 3 by 1.5 m. Appropriate amounts of fertilizers were broadcast immediately after planting and after every 12 weeks. Where times of harvesting and fertilizing coincided, harvesting was done first.

The grass was sampled by cutting three 60-cm squares, chosen at random from each plot at 3 months after planting and then at 6-week intervals. These were bulked to give one sample per plot. Samples were cut to a height of approximately 7 cm with the remainder of the plot cut to the same height. All grass cuttings were removed from the experimental site. Samples were weighed fresh and again after ovendrying at 80 C for 48 hours. Yields were analyzed statistically according to Yates (10). The experiment lasted 18 months.

RESULTS AND DISCUSSION

The effects of Mg, fritted micronutrients, and their interaction on the dry matter production (kg/ha) over the 18-month period are presented in Table 3.

Magnesium

Total dry matter production over the 18-month period at the Mg_1 level was significantly lower than at the Mg_0 and Mg_2 levels, with no significant difference between the latter two levels. This pattern, which was similar for individual harvests, is not immediately explainable.

The failure of Mg to increase yields of tropical grasses has been previously reported (2, 5, 8). Unlike other reported work, however, the present results are obtained on a soil that is extremely low in 'available' Mg and that, because of its low clay content (2%), would be expected not to have much 'fixed' Mg that may have become available to the grass with time. Tissue analyses of pangolagrass growing on Tiwiwid fine sand without Mg fertilization show that Mg fluctuated from 0.15 to 0.44% over a 2-year period after its establishment (H.A.D. Chesney, unpublished data). This suggests that pangolagrass in the Mg_0 plots was able to utilize the 'fixed' Mg in the clay fraction of the soil, indicating that pangolagrass is a very efficient forager of soil Mg. It appears, therefore, that tropical grasses need relatively little 'exchangeable' Mg in the soil for optimum dry matter production. This is supported by the fact that other crops such as citrus (1), pineapple (B.W. Megilley, 1963. The effect of fertilizer applications on mineral content and growth of pineapple leaves. D.T.A. Report. University of West Indies), and tomato (A.M. Osman, 1963. A manurial trial on tomatoes under Trinidad conditions. D.T.A. Report, University of West Indies.) grown on similar soils have responded positively to Mg. Therefore, it will seem that Mg needs to be applied only to tropical grasses in quantities large enough to keep its concentration in the grass adequate for livestock needs.

[3] With the compliments of Ferro Agricultural Chemicals, 450 East 56th St., Cleveland, Ohio.

Table 3. The effect of magnesium and fritted micronutrients on the dry matter production of pangolagrass over an 18-month period.

	Mg_0	Mg_1	Mg_2	Average
	kg/ha			
FTE_0	9,609	6,014	7,262	7,726
FTE_1	19,429	14,936	18,934	17,766
FTE_2	17,281	13,993	16,256	16,510
Average	15,440	11,647	14,818	
	Mean of nine plots	Mean of three plots		
$LSD_{0.05}$	2100	3187		

Micronutrients

Total dry matter production was increased by FTE 503 up to the FTE_1 level. This pattern was similar for individual harvests except (i) at one harvest (taking place in a period when fertilization was followed by 82 cm of rainfall) where dry matter production was increased up to the FTE_2 level and (ii) the effect of FTE became greater with time. In the FTE_0 plots, the grass quickly showed stunted growth and eventual browning and dying out in patches; visual appearance indicated at least Zn and Fe deficiencies. From these results it seems that unless there is heavy rainfall, 88 kg/ha/annum FTE 503 is adequate to provide maximum dry matter production of pangolagrass on Tiwiwid fine sand. In the heavy rainfall months the equivalent of 176 kg/ha/annum FTE 503 must be applied.

For the individual harvests it is worthwhile to mention that in all cases FTE 503 had a positive effect on both harvests after fertilization, notwithstanding the heavy rainfall in the area and the excessive permeability of the soil. This can be attributed to the form of this fertilizer that allows a slow and gradual release of the micronutrients to the grass. Over the experimental period, the equivalent of 88 kg/ha/annum FTE 503 increased yields by approximately 10,000 kg/ha, as compared to the control.

The positive effect of FTE 503 is not surprising, because of the origin, composition, and natural infertility of the soil. Also, the fact that the effect of micronutrients became greater with time indicates that any small quantities of micronutrients present were quickly exhausted. Further work is now in progress to determine which particular micronutrient(s) caused the increased yield.

Mg × Micronutrient Interaction

The Mg × micronutrient interaction was not significant for the total dry matter production, although the difference in yields between the Mg_0 and Mg_1 levels was slightly less at the FTE_2 level. Only at two individual "harvest" intervals was this interaction significant. Examination of the interaction gave different effects for the two intervals. This interaction is therefore too inconsistent to warrant discussion.

Despite the low fertility of the soil, the dry matter production of pangolagrass (17,766 kg/ha) obtained over the experimental period on the better plots (88 kg/ha/annum) compares favorably with yields report-

ed elsewhere (2, 9) on more fertile soils. This may be attributed to the very favorable rainfall distribution in the area, which in the driest month (February 1969) was 6.2 cm.

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Influence of Mulch on Postharvest Soil Temperatures and Subsequent Regrowth of Alfalfa (*Medicago sativa* L.)[1]

P. D. Evenson and M. D. Rumbaugh[2]

ABSTRACT

A study was initiated to evaluate the influence of postharvest soil temperatures on alfalfa (*Medicago sativa* L.) regrowth. Wheat (*Triticum aestivum* L.) straw was applied to alfalfa in a variety trial following the second 1968 harvest to reduce soil temperature. Yield increases of mulched plots over unmulched plots were smallest on first harvests (<7%) and largest (43% in 1969 and 1970) on third harvests. Annual yield increases were 11% in 1969 and 17% in 1970. Straw mulch increased plant height, delayed maturity, and increased soil moisture, but did not affect alfalfa stands. Soil temperatures were as much as 9 C lower in mulched as compared to unmulched plots. Largest yield increases from mulching occurred when temperature differentials between the control and mulched plots were the greatest. Apparently, high soil temperatures are a major factor in controlling alfalfa yields.

Additional index words: **Soil moisture, Lime, Straw mulch.**

ALFALFA (*Medicago sativa* L.) yields normally decrease from first cutting to last in the Northern Great Plains (3, 7). These reductions occur even with adequate soil moisture (3). High soil temperatures were suspected as a major factor in causing this decrease. Jensen et al. (5) evaluated the influence of constant soil temperatures on alfalfa growth in a greenhouse study and found that high soil temperatures (24 and 32 C) depressed dry matter yields under a dry moisture regime, while the largest yields were produced at 24 C under a wet regime. Baharani and Taylor (1) reported a sharp increase in mean daily soil temperature at the 10-cm depth following alfalfa harvest. Soil temperatures immediately following harvest are of particular interest, since a large portion of the soil surface is exposed to direct solar radiation at this time. Soil temperatures influence many of the physiological processes within plants. For example, Skene and Kerridge (8) found a difference in cytokinin activity in exudates from grape (*Vitis vinifera* L.) roots grown at 20 C compared to those grown at 30 C. The study to be reported was developed to evaluate the influence of postharvest soil temperatures on alfalfa regrowth and as an initial approach in evaluating the influence of soil temperatures on physiological processes in alfalfa.

MATERIALS AND METHODS

An alfalfa variety trial established on a Vienna Loam soil in the spring of 1964 was selected for this study. It contained nine varieties ('Beaver,' 'Cayuga,' 'Cherokee,' 'Culver,' 'Ladak,' 'Uinta,' 'Vernal,' and 'Williamsburg') in a randomized block design with four replications. Each four-row plot was 120 cm wide (30 cm between rows) and 7.3 m long. Dimensions of each replication were 10.8 by 7.3 m. Dolomitic mason's lime was applied at the rate of 2,830 kg/ha to one half of each replication on June 17, 1968, immediately following alfalfa harvest. The resulting experimental design was a stratified split-plot with the sub-plots being one half of the original plot size. Rain destroyed the reflective surfaces of the limed plots by mixing the lime with the soil. Wheat (*Triticum aestivum* L.) straw was applied to the limed plots on July 24, 1968 at the rate of 6,700 kg/ha and was replenished on June 19, 1970 at the rate of 4,000 kg/ha. A number of investigators (6, 9, 10, and 11) have used straw mulches to significantly alter soil temperatures.

Plants from the center two rows of the plots were used to determine dry matter yields, plant heights, percent stand, and percent bloom. Soil moisture samples were collected from the 0- to 15-cm and 15- to 90-cm soil depths in single subplots randomly selected from both mulched and unmulched plots in each of four replications. The soil samples were obtained the day following the third harvest in 1968, 1969, and 1970.

Soil temperature measurements were made in mulched and control plots within one varietal plot selected at random from each of the four replications. Measurements were taken at a soil depth of 2.5 cm, midway between rows and at depths of 2.5 and 7.5 cm in the row. Temperatures at the 2.5-cm depth in the row approximate the temperature at the crown of the plant. Temperatures were recorded from July 20 through August 9, 1968 and during most of the 1969 growing season. Measurements were made during daylight hours at 9:30, 11:30, 1:30, 3:30, and 5:30 in 1968 and at 9:00, 11:00, 1:00, 3:00, and 5:00 in 1969. Air temperature was measured 1.5 m above the soil at these same hours after June 5, 1969. Four copper-constantan thermo-

[1] Contribution from the Plant Science Department. South Dakota Agricultural Experiment Station, Brookings, S. D. Journal Paper No. 1014. Received April 13, 1971.

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