POTASSIUM COMPETITION IN A KUDZU-MERKER GRASS ASSOCIATION

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INTRODUCTION

The use of tropical kudzu (*Pueraria phaseoloides* (*javanica*) Benth.) as a legume in Puerto Rico has shown great promise for soil-erosion control, pasture, and silage. A chlorosis of tropical kudzu has been noted in several instances, when it was grown in association with grasses as a pasture crop, especially in the area of Río Piedras. This chlorosis was in evidence in field experiments with grass-legume associations on Fajardo clay at the García Méndez fields of the Agricultural Experiment Station at Río Piedras. It was brought to the attention of the authors because of a possibility that the chlorosis might have been caused by minor-element deficiencies and as they were then engaged in research on the minor-element needs of Puerto Rican crops.

An examination of the kudzu-Merker grass association revealed that the kudzu showed signs of chlorosis in the leaves, but there was no particular evidence of a chlorotic condition on the Merker grass (*Pennisetum purpureum* var. *Merkerii* Schumaker). The chlorosis on the kudzu was evidenced by a yellowing of the leaves, the older leaves being affected first. The leaves were yellow with some of the veins dark green. Some highly chlorotic leaves had a yellowish-brown marginal scorch. In general, the chlorosis was suggestive of potassium deficiency (4)[2].

A potassium deficiency had been noted before by the authors on kudzu growing as a ground cover in a coconut plantation at Dorado on a Cataño loamy sand. Kudzu, however, had failed to give significant yield responses on the Fajardo clay soils when potash was applied (5) in an experiment close to the site of the chlorotic kudzu-Merker grass association.

The question now arose whether the chlorosis occurred on the kudzu only when it was grown in association with a grass and not when it was seeded by itself on the Fajardo clay. It was also to be determined whether the deficiency caused the chlorosis, and how this might be corrected. An experiment was established at the García-Méndez field at Río Piedras to answer these questions.

PROCEDURES

The experiment consisted of eight treatments replicated five times in a split-plot design. The soil used was a Fajardo clay, an acid lateritic clay

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[2] Numbers in parentheses refer to Literature Cited, pp. 281–2.

with a pH 5.5. The treatments used are given in table 1. All treatments received 50 pounds of N per acre as ammonium sulfate and 100 pounds of P_2O_5 per acre as superphosphate (20 percent P_2O_5). The plots were fertilized

TABLE 1.—*The effect of fertilizers on the yields of tropical kudzu and Merker grass grown on Fajardo Clay at García-Méndez*

No.	Treatments[1] Pounds per acre	Yields of forage per acre, (green weight)				
		First cutting			Second cutting, Kudzu and Merker grass	Total kudzu and Merker
		Kudzu	Merker	Kudzu and Merker grass		
		Tons	*Tons*	*Tons*	*Tons*	*Tons*
1	Kudzu	2.24	0	2.24	1.64	3.88
2	Kudzu + 300 lbs. MgO	2.56	0	2.56	2.13	4.69
3	Kudzu + 50 lbs. borax	2.49	0	2.49	1.73	4.22
4	Kudzu + 300 lbs. K_2O	2.36	0	2.36	1.94	4.30
A	Mean of kudzu treatments	2.41	0	2.41	1.86	4.27
5	Kudzu and Merker grass	1.99	6.08	8.07	10.65	18.72
6	Kudzu and Merker grass + 300 lbs. MgO	1.50	6.39	7.89	10.28	18.17
7	Kudzu and Merker grass + 50 lbs. borax	1.42	7.19	8.61	11.44	20.05
8	Kudzu and Merker grass + 300 lbs. K_2O	2.51	5.50	8.01	12.82	20.83
B	Mean of kudzu and Merker grass treatments	1.86	6.29	8.15	11.30	19.45
Least significant differences needed for comparison of:						
Mean of A or B:	5-percent point	0.48		2.42	2.36	2.28
	1-percent point	.80		4.02	3.91	3.87
Treatments within A or B:	5-percent point	.80		1.26	2.31	1.86
	1-percent point	1.09		1.79	3.12	2.19

[1] All treatments received 50 lb. of N and 100 lb. of P_2O_5 per acre.

before planting; they were 8 by 20 feet, or $\frac{1}{272}$ of an acre in area, with plants set out 2 feet between rows and 3 feet between plants. The kudzu was germinated in paper cups filled with soil from the field and then transplanted into the field after the plants were 3 weeks old, on December 13, 1949. The Merker grass was planted from cuttings on March 16, 1950, after the kudzu had established a good stand.

The treatments were divided between kudzu growing alone and a kudzu-

Merker grass association. The potassium treatments were utilized to determine whether the kudzu chlorosis was due to a potash deficiency. Magnesium in the form of the oxide was employed, as it was thought that certain of the symptoms, such as the chlorosis between the veins, appeared to be similar to those of a magnesium deficiency, and that, perhaps, there was a combined potassium and magnesium deficiency. The borax treatment was added because of the reported low boron content of the Fajardo clay as determined by the Soil Department using the sunflower-indicator test.

The first cutting of the experiment was harvested on July 18, 1950, at an age of 7 months. The experiment was then fertilized again as indicated, and a second cutting was made on December 12, 1950, at an age of 5 months. A representative sample was taken from the harvested plots and dried for calculations of the moisture content, dry-weight yields, and protein analyses.

RESULTS

Yields

The yields of kudzu growing alone were not influenced significantly by the treatments applied (see table 1). When grown in association with Merker grass, the kudzu gave half a ton more green forage in the first cutting when fertilized with potash (treatment 8 minus treatment 5, table 1). There was a reduction in yield of the Merker grass of 0.58 ton for the same treatment, so that the total yields of the combined kudzu and Merker grass showed no gain from the use of potash for the first cutting. In the second cutting, the combined kudzu-Merker grass yields rose 2.17 tons of green forage per acre when potash was applied. Unfortunately, the weights of the kudzu and Merker grass were not taken separately because of an error in procedure, therefore, it was impossible to determine whether the yield increases were in kudzu or Merker grass or both.

Kudzu grown alone decreased in yield for all treatments for the second cutting which grew for 5 months as compared with 7 months for the first. The combined kudzu-Merker grass treatments, however, all gave higher yields in the second cutting than in the first.

In the first cutting the kudzu definitely yielded less when grown in association with the Merker grass than when grown alone. The only treatment which produced no reduction was potash applications (treatment 8 compared to treatement 4, table 1).

If the potash treatments are excluded from the means of the first cutting, the kudzu growing alone had a mean yield of 2.43 tons of green forage per acre; when growing with Merker grass its yield was 1.64 tons per acre. The reduction in yield of kudzu growing in association with Merker grass, except where potash was applied, plus the increased yields of the kudzu-Merker grass combination when fertilized with potash, suggested that potash was of value to kudzu-Merker grass associations.

The use of borax or magnesium oxide did not appreciably influence yields of either kudzu or kudzu-Merker grass (see table 1).

TABLE 2.—*The effect of fertilizers on the nutrient content of tropical kudzu and Merker grass grown on Fajardo clay at García Méndez*

No.	Treatments (pounds per acre)	Plant material	Nutrient content of plant material (dry weight): First cutting, Protein	First cutting, Nitrogen	First cutting, Phosphorus	First cutting, Potassium	Second cutting, Protein	Second cutting, Nitrogen	Second cutting, Phosphorus	Second cutting, Potassium
			Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
1	Kudzu	Kudzu	20.7	3.31	0.45	3.60	15.6	2.50	0.34	3.04
2	Kudzu + 300 lbs. MgO	do.	21.1	3.38	.45	3.59	17.4	2.78	.32	2.21
3	Kudzu + 50 lbs. borax	do.	21.8	3.48	.47	2.95	18.7	2.99	.33	2.53
4	Kudzu + 300 lbs. K_2O	do.	19.8	3.16	.43	3.42	17.8	2.85	.32	3.36
	Mean of Kudzu treatments	do.	20.9	3.33	0.45	3.39	17.4	2.78	0.33	2.78
5	Kudzu and Merker grass	Kudzu	16.9	2.70	0.41	3.08	16.8	2.68	0.30	2.80
		Merker grass	9.1	1.45	.31	2.30	12.3	1.97	.39	1.97
6	Kudzu and Merker grass + 300 lbs. MgO	Kudzu	16.7	2.67	.38	2.26	19.0	3.04	.27	2.17
		Merker grass	8.2	1.31	.27	1.91	13.8	2.20	.38	2.50
7	Kudzu and Merker grass + 50 lbs. borax	Kudzu	17.2	2.75	.38	2.27	19.7	3.15	.30	2.31
		Merker grass	8.3	1.32	.28	2.21	11.6	1.86	.40	2.27
8	Kudzu and Merker grass + 300 lbs. K_2O	Kudzu	15.4	2.46	.38	2.53	16.3	2.61	.29	2.85
		Merker grass	7.2	1.15	.27	2.97	12.5	2.00	.39	2.97
	Mean of kudzu treatments		16.6	2.64	0.39	2.54	17.9	2.87	0.29	2.53
	Mean of Merker grass treatments		8.2	1.31	0.28	2.35	12.5	2.01	0.39	2.43

Chemical Analyses

The analyses of the first and second cuttings of the kudzu and the Merker grass are given in table 2. There was no appreciable difference in respect to protein nitrogen in the first cutting when the kudzu was grown in association with Merker grass, but this was not evident in the second cutting. A reduction in the protein content of kudzu growing with Merker grass was also noted by Warmke *et al.* (7) for a crop grown in Puerto Rico. The nitrogen and protein values were lowest in all cases for the potash treatments in the first cutting. In the second cutting, the nitrogen values were lowest for the kudzu grown without potash (treatment 1, table 2).

There was no apparent change in the phosphorus content of either the

FIG. 1.—A potassium chlorosis of tropical kudzu growing in association with Merker grass.

kudzu or Merker grass that could be attributed to any of the treatments. The kudzu growing alone and with Merker grass decreased in phosphorus content at the second cutting. Merker grass increased in phosphorus content in the second cutting.

The potassium analyses revealed no consistent difference attributable to the treatments when the kudzu was grown alone. However, when it was grown in association with the Merker grass, the kudzu had lower potassium values in both cuttings. The kudzu-Merker grass treatments (treatment 8 minus treatment 5, table 2) produced higher potassium values for the

TABLE 3.—*The nutrient content of tropical kudzu leaves with and without deficiency symptoms, growing alone and with Merker grass*

No.	Treatments[1]	Condition of leaf[2]	Nutrient content of kudzu (dry weight)		
			Nitrogen	Phosphorus	Potassium
			Percent	*Percent*	*Percent*
1	Kudzu	Normal	3.64	0.40	2.20
		Chlorotic	3.49	.31	1.28
2	Kudzu and Merker grass	Normal	3.08	.36	2.75
		Chlorotic	3.11	.30	1.50
3	Kudzu + 300 lbs. MgO	Normal	3.62	.37	2.73
		Chlorotic	3.49	.33	1.79
4	Kudzu and Merker grass + 300 lbs. MgO	Normal	3.11	.31	2.11
		Chlorotic	3.14	.29	1.20
5	Kudzu + 50 lbs. borax	Normal	3.55	.38	2.53
		Chlorotic	3.56	.32	1.39
6	Kudzu and Merker grass + 50 lbs. borax	Normal	2.90	.31	2.16
		Chlorotic	2.86	.31	1.49
7	Kudzu + 300 lbs. K_2O	Normal	3.17	.43	3.42
		Chlorotic	—	—	—
8	Kudzu and Merker grass + 300 lbs. K_2O	Normal	3.20	.31	2.60
		Chlorotic	—	—	—

[1] All treatments received 50 lb. of N and 100 lb. P_2O_5 per acre.

[2] A normal leaf is one having no visual symptoms of any nutritional deficiency; a chlorotic leaf is one which showed yellowing with the veins remaining green, burning of the edges, and necrotic spots.

Merker grass on the potash-treated plots. The kudzu showed no consistent increase in potassium content when potash was applied.

There were chlorotic kudzu plants in all plots which did not receive potash applications. The symptoms of chlorosis were similar to those seen on the previous kudzu-Merker grass associations and consisted of a yellowing of the older leaves and a burning of the margins of the leaves. The chlorosis was present both in kudzu growing alone and kudzu growing with

Merker grass (see fig. 1). The degree of chlorosis was more severe for the second cutting than for the first. The rainfall was less for the second than for the first cutting, and the chlorosis was at its height during the drier period.

Samples were taken of chlorotic and normal kudzu leaves from the various plots 2 weeks prior to harvesting the second cutting. The results of the chemical analyses of these are given in table 3. Chlorotic leaves were found in abundance in all plots except those receiving potash applications (treatments 7 and 8, table 3). The outstanding difference in the chemical analyses of the normal and chlorotic leaves was the lower potassium values of the latter. The average potassium content of the normal leaves was 2.56 percent while that of those from chlorotic kudzu was 1.44, a reduction of 44 percent. The potassium in the harvested kudzu (table 2) was higher than the values given for the chlorotic leaves (table 3), even though these plots received no potash. However, the values in table 2 represented total kudzu harvested including vines and leaves, whereas, the values in table 3 were for kudzu leaves only.

The chemical analyses of leaves representing the magnesium oxide and boron treatments failed to show any appreciable differences in either tables 2 or 3. Work performed by the authors using white beans as an indicator crop in a greenhouse experiment disclosed no response to magnesium applications for Fajardo clay. Bonnet (2) found these soils to have 180 p.p.m. available magnesium and 849 p.p.m. available calcium.

DISCUSSION

Competition for nutrients in grass-legume associations has been reported by many workers. Blaser and Brady (1) found competition for potassium in grass-legume mixtures in New York State. They were of the opinion that competition might result in legumes being retarded or eliminated on soils containing insufficient available potassium. If maintenance of the legume is a primary objective, potash should be adequately supplied to mixed stands of grasses and legumes.

Warmke, Freyre, and García (7), working with tropical grass-legume associations in Puerto Rico, encountered similar competition for potassium between grass and legume. They obtained a 38-percent decrease of potassium in kudzu grown in association with Merker grass as compared with kudzu growing alone.

Parsons, *et al.* (6) stated that competition for potassium between desirable forage species and undesirable weedy species had a pronounced influence on the longevity of the stand. After 3 crop years, they found that Ladino clover comprised less than 5 percent of the vegetation on low-potash plots which originally grew pure stands of Ladino clover. The remaining vegetation was predominantly the weedy grasses, Kentucky bluegrass, and bentgrass.

It appears that grass wins out in the competition for potassium between grass and legume growing in association. The grass will obtain potassium first from the available soil supply and the legume must take the remainder. If the total supply of available potash in the soil is high, then neither plant species suffers. However, if the grass-legume association is planted on soils containing sufficient supplies of potash for only one of the crops, they will show a deficiency of potassium. It appears that insufficient supplies of soil potash are available in Fajardo clay to support a kudzu-Merker grass association in a healthy condition. The supply of available soil potash becomes even lower during the drier weather encountered in part of the growing season. This fixation of potassium in the soil by drying has been demonstrated by Joffe and Kolodny (3).

Consideration should be given to the available potash supply in the soil when growing grass-legume associations in Puerto Rico. This is especially true if continued good stands of the legume are to be obtained in a mixed grass-legume stand.

SUMMARY

Examination of a competition for potassium in a kudzu-Merker grass association on Fajardo clay at Río Piedras showed:

There were no significant responses in yields to the application of potash, magnesium oxide, or borax by either kudzu or a kudzu-Merker grass mixture for two cuttings.

The highest gain in yield was obtained when potash was applied to the kudzu-Merker grass association.

A chlorosis of the kudzu evidenced by a yellowing of the older leaves with marginal leaf-burning was found on all plots not receiving potash. This chlorosis was more severe during the drier weather than in the rainy season.

Leaf analysis of the kudzu and Merker grass at harvesttime revealed no appreciable difference in protein, nitrogen, or phosphorus contents attributable to any of the treatments.

Potassium values were all lower for the kudzu grown with Merker grass than for that grown alone.

Samples of chlorotic kudzu leaves taken before harvest contained less potassium than normal kudzu leaves taken from the same plots.

Evidence is presented of the competition for potassium by grasses and legumes as was found by other workers. The authors also discuss the importance of this competition in establishing legumes in grass-legume mixtures for soils low in available potash in Puerto Rico.

RESUMEN

Las investigaciones relacionadas con la competencia entre el kudzu y la yerba Merker por el potasio, cuando se desarrollaron asociadas en una arcilla Fajardo en Río Piedras, demostraron lo siguiente:

Las aplicaciones de potasio, óxido de magnesio, y borax no afectaron los rendimientos del kudzu ni los de la asociación kudzu-yerba Merker, cuando se cortaron dos veces sucesivamente.

Los mayores aumentos en los rendimientos se obtuvieron cuando se aplicó potasio a la asociación kudzu-yerba Merker.

En todas las parcelas que no recibieron aplicaciones de potasio, se observó clorosis en el kudzu, la cual estuvo caracterizada por una amarillez de las hojas más viejas. Estas aparentemente desarrollaron lesiones, como quemaduras, a lo largo de las márgenes. El estado clorótico se manifestó con mayor intensidad durante las épocas de sequía y con menor durante las de lluvia.

Los análisis foliares de las muestras del kudzu y de la yerba Merker, tomadas simultáneamente durante el corte, señalaron diferencias importantes en el contenido de proteína, nitrógeno y fósforo que bien podrían atribuírsele a los tratamientos.

El kudzu en asociación con la yerba Merker tuvo, en todos los casos, un contenido más bajo de potasio que el que creció solo.

Los análisis de las muestras de hojas cloróticas de kudzu recogidas antes del corte, tuvieron un contenido menor de potasio que los de las hojas no cloróticas o normales obtenidas de la misma parcela.

En este trabajo se presentó evidencia conseguida por varios investigadores relacionada con la competencia entre yerbas y leguminosas por el potasio. Los autores discuten también la importancia de dicha competencia para el desarrollo de las leguminosas en asociación con las yerbas en aquellos suelos que contengan poco potasio asimilable.

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