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PIGEONPEA (*CAJANUS CAJAN* (L) MILLSP.) NUTRIENT ACCUMULATION AS INFLUENCED BY RHIZOBIUM INOCULATION AND NITROGEN APPLICATION IN ANTIGUA SOILS

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ABSTRACT

Methods which improve the nutrient status of pigeonpea plants without the addition of expensive commercial fertilizer can benefit farmers in the Caribbean and other tropical areas. Yields of this grain legume have been shown to increase significantly when the crop received adequate nutrition. Studies were conducted to evaluate the nutrient status of pigeonpea plants treated with various combinations of nitrogen fertilizer levels and Rhizobium inoculants. Rhizobium strains influenced nitrogen content of plants grown at two Antigua sites. Plants treated with strain 3384 produced nodules which were more effective nitrogen fixers than other strains tested. This resulted in higher levels of nitrogen in the stems and leaves of the tested plants. Plots treated with 45 kg/ha nitrogen showed significant reduction in nodulation. Shoot accumulation of P, K. Ca and Al was influenced by Rhizobium inoculation. Plants treated with Strain 3384 had the highest P and K accumulation and those receiving no inoculum had the highest Al content.

INTRODUCTION

The nodulation and nitrogen fixation of several tropical legumes are influenced by the availability of combined nitrogen (Summerfield, et al. 1977). The need for additional nitrogen in an effective nodulating system has also been reported (Ssali and Keya 1980). Excessive N application rates reduce N_2 fixation, decrease leaf K content and increase plant Ca and Mg content (Stewart 1969). Phosphorus has been reported to be a limiting factor in some tropical soils (Hernandez and Focht 1985). This limitation may cause reduced plant growth typical of nitrogen deficiency. Pigeonpea showed varied response to P when grown in different soil type (Hernandez et al. 1982). There are several synergistic relationships between various essential plant nutrients. Demeterio et al. (1972) reported a direct relationship between P and Zn in improving N_2 fixation. Antagonistic effects were also reported by Narwal et al. (1985). They showed that K application and absorption reduced the uptake and utilization of Ca. Increase in N_2 fixation under field conditions will result in increased N availability to present and future crops. Quilt and Dalal (1979) reported increased yield of inoculated pigeonpea grown in soils low in mineral N.

This study was conducted to determine the effect of various nitrogen levels and Rhizobium strains on the growth and nutrient accumulation of field grown pigeonpea plants.

MATERIALS AND METHODS

Pigeonpea cultivar Chaguaramas Pearl was grown at two experimental sites in Antigua. These were Betty's Hope Experimental Station and Sanderson's Farm, with soil pH of 7.6 and 7.7 respectively. Experiments were conducted as a split plot design with N as the main plot and Rhizobium as the sub plot. Each experiment was replicated 4 times and had treatments consisting of three nitrogen levels (0, 22.5 and 45 kg/ha), three Rhizobium strains and a no-inoculum treatment. The unamended soils had test results of 2.2 and 3.8% organic matter at Sanderson and Betty's Hope, respectively (Table 1). K was not applied to the experiment area, however, 40 kg/ha of P (P_2O_5) was applied preplant and incorporated to a depth of 15 cm. The appropriate N treatment was applied uniformly over the individual 3 row plot area and incorporated to a 15cm depth. Each plot measured 1.5m wide by 6.0m long.

Three Rhizobium strains USDA 3384, USDA 3473 and USDA 3474 were obtained from the USDA Laboratory at Beltsville Maryland. They were selected for their effectiveness in producing nodules and fixing nitrogen. Rhizobium cultures were grown on yeast mannitol broth (Vincent 1970) to a population of 10^9 cells per ml and used to prepare peat base inoculant using gama radiated sterile peat (United Agri. Product. Denver, Colorado).

Surface sterilized seeds (Vincent 1970) were inoculated with the appropriate Rhizobium strain by mixing seeds with peat base inoculant. Excess inoculant was placed in the furrows before covering seeds. Seeds were planted 30 cm within row and 4 cm deep. They germinated over a 21 day period as a result of sporadic rainfall during the growing period. After germination, uniform spacing was obtained by thinning to 4 plants per meter. To avoid plot to plot contamination a 1.5 m alley was allowed on all sides of each plot. Data were taken from plants in the center row of each plot over three sampling dates. The first sample date was when 70% of the plants showed first bloom. Sampling was repeated at mid and full bloom. Whole plants were removed from the center row taking care to keep the root system intact. Leaf and stem dry weight were determined after oven drying for 48hrs. at 70°C. Dried samples were ground separately in a Stainless Steel Wiley mill to pass through a 40 mesh sieve and stored in polyethylene bags prior to elemental analysis by ICPL.

RESULTS AND DISCUSSIONS

Throughout the experimental plots at the Betty's Hope experimental station Fe chlorosis was observed. This general chlorosis could have masked nitrogen deficiency symptoms in plots receiving no nitrogen and no inoculum. Analysis of the data showed no significant interaction between nitrogen levels and Rhizobium. The leaf dry weight from both experimental sites showed that dry matter accumulation increased as nitrogen content increased (Table 2). This was also true for stem dry weight for plants growing at Sanderson's Farm. This result is contradictory to that of Hernandez et al. (1982) who showed little or no response to nitrogen application. At both sites the leaf dry weights in plots receiving 22.5 kg/ha were significantly higher than those in control plots. However, stem dry matter increased only for plants at the Sanderson site when N fertilizer was supplied. Varying reactions to added nutrient by pigeonpea has also been reported by Donawa and Quilt (1981).

Increase in N application rate did not alter the leaf nitrogen content. (Table 3). The high organic matter content at both locations (Table 1) may have influenced N uptake as shown by Dalal and Quilt (1977). Grain yield was significantly higher when plants received N than when they did not at the Betty's Hope site (Table 3). The decreased yield experienced at the Sanderson's site may have been a result of a poor response to N fertilization. This lack of yield response of pigeonpea to applied N was also reported by Hernandez et al. (1982).

The effectiveness of the introduced Rhizobium varied with strains. Plants inoculated with strain 3473 showed increased N accumulation in leaf and stem at both experimental sites (Table 4). Response to the introduced Rhizobium strains activities may have been reduced by indigenous populations of the cowpea rhizobia at Betty's Hope site. Similar results were published by Norris (1965).

Shoot accumulation of P,K,Ca and Al varied with inoculation (Table 5). Plants seemed to accumulate more of these elements when inoculated. Plants inoculated with Rhizobium strain 3384 had the highest P,K and Al content, while uninoculated plants had the highest Ca in the tissue. Norris (1959) reported that Ca has a positive influence on nodulation by affecting the infection process. This may be true for our studies with the high population of indigenous Rhizobium. Except for Al the accumulation of most nutrients in pigeonpea pods was not significantly affected by inoculation. Further research is necessary to fully understand the effects of the Rhizobium efficiency in tropical soils with varying nutrient content.

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Table 1. Soil nutrient levels at trial sites in Antigua.

Sites	pH	OM %	P Bray 1 kg/ha	Ca kg/ha	Mg kg/ha	K kg/ha	$SO_4.S$ ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm
Sanderson	7.7	2.2	21.2	18480	1365	328	30.3	0.3	3.5	2.3	1.1
Betty's Hope	7.6	3.8	2.2	19712	640	397	14.3	0.3	3.9	3.3	1.4

Table 2. The effect of varying nitrogen levels on the stem and leaf dry weight g/plant of pigeonpea.

Nitrogen Levels (kg/ha)	Leaf 1[z]	Leaf 2	Stem 1[z]	Stem 2
0	1.8	2.8	14.1	11.8
22.5	2.6	3.8	14.8	15.8
45.0	3.1	4.2	12.9	17.8
LSD 0.05	0.6	0.9	NS	3.1

[z] Research sites: 1 = Betty's Hope
2 = Sanderson

Table 3. The effect of varying nitrogen levels on the leaf nitrogen accumulation (%) and grain yield (g/plot) of pigeonpea.

Nitrogen Levels (kg/ha)	Nitrogen 1[z]	Nitrogen 2[z]	Yield 1[z]	Yield 2[z]
0	2.7	3.2	1750	901
22.5	2.7	3.9	2300	825
45.0	2.4	3.4	3300	730
LSD 0 .05	NS	NS	259	158

[z] Research Sites: 1 = Betty's Hope
2 = Sanderson

Table 4. The effect of Rhizobium inoculation on the nitrogen (%) content of pigeonpea leaf and stems.

Rhizobium	Leaf Experimental Site 1[z]	Leaf Experimental Site 2	Stem Experimental Site 1[z]	Stem Experimental Site 2
3384	1.2	2.8	0.8	1.1
3473	2.4	3.1	1.4	2.7
3474	1.3	1.5	0.6	1.5
0	1.4	1.6	0.8	1.3
LSD 0.05	0.2	1.1	0.3	0.7

[z] Research Sites: 1 = Betty's Hope
2 = Sanderson

Table 5. Rhizobium treatment effects on nutrient accumulation (ppm) in field grown pigeonpea shoots at Betty's Hope.

	Shoot				Pod			
Rhizobium	P	K	Ca	AL	P	K	Ca	AL
3384	2108	11182	13961	15.8	1498	11789	4201	16.0
3473	2050	11168	12731	77.3	1539	11712	4157	18.7
3474	1956	10975	13281	14.4	1527	11877	4195	13.0
0	1831	9392	14405	16.0	1480	12820	4064	13.4
LSD 0.05	156	201	558	3.5	NS	NS	NS	2.4