Assessment of Soil Incorporated Crimson Clover Hay as an Organic Fertilizer Source in the Production of Bush Bean

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ABSTRACT

Alternatives to crop fertilization practices reliant upon the use of synthetic materials that require high energy production cost and present potential agricultural pollution problems are increasingly being sought for inclusion into low input sustainable agricultural systems. For this purpose, an organic fertilization experiment was carried out under field conditions to determine the effect of soil incorporated air- dried chopped crimson clover *(Trifolium incarnatum)* on the yield of 'Blue Lake' bush bean *(Phaseolus vulgaris)* Clover was applied 10 d before planting at rate increments of 1000 lb/a for amendment levels ranging from 0 lbs/a up to 9000 lb/a. Analysis of soil and diagnostic leaf nutrient concentrations were made at 28 and 43 days after planting. Measurements of both fresh and dry yield for whole plant, pod, leaf, stem, and root components were taken. Highly significant yield effects in pod and total plant yield were observed ($P < 0.01$). Highest pod yield occurred with an application rate of 4000 lbs acre-' of air dried crimson clover. There appeared to be a threshold response to nutrient input at this level of amendment, as no significant increase in fresh or dry yield was realized at bigber treatment rates Diagnostic leaf nutrient levels were reflective of yield trends, although these trends were not significant. Soil N differences among treatments were significant with a probability of ($P=0.03$). There was also a highly significant positive correlation between Mehlich I extractable K soil concentration and clover application rate with a probability of ($P<0.01$).

INTRODUCTION

Common bush bean *(Phaseolus vulgaris* L.) is an important staple crop in nearly all parts of the world. In many areas where beans are grown as a subsistence crop, production is restricted to marginal soils, where sufficient nutrients are not available (Smithson et al., 1993).

Although bush bean is capable of fixing large amounts atmospheric N_2, some additional N provided through fertilizer is usually required for maximum yields (Tsai et al., 1993). Fertilizer inputs are costly and are often limiting in production systems of developing countries. Recently, interest in alternatives to growing crops without synthetic fertilizer inputs for environmental or aesthetic, rather than economic reasons has also increased. Concern about NO_3 pollution has been noted as a source of impetus for using legumes as an N source (Varco et al., 1993). The purpose of this study was to examine such a production system by providing nutrients to a bean crop by the addition of soil incorporated chopped air-dried crimson clover *(Trifolium incamaturn* L.). Several considerations to be made include nutrient content of the material used for fertilization, environmental factors and cultural practices which effect nutrient availability, and the specific nutrient requirements of the selected crop. Tissue analyses of crimson clover show that it is capable of providing significant amounts of N. Analyses also reveal that clover can also be a significant source of K. Although considerable research has been done in the investigation of clover use as a green manure, limited information is available on the ability of clover to provide K, or where plant material is dried and chopped before application and incorporation into the soil.

In comparison to allowing clover residues to remain on the soil surface, incorporation into the soil increase the decomposition and N release rate of crimson clover (Wilson and Hargrove, 1986) and also significantly reduces volatilization losses of NH_3 (Janzen and McGinn, 1991). Studies with soil incorporated white clover *(Trifolium repens* L.) have shown that 33% to 55% of the plant total N is readily decomposable, with a decomposition half-life of 9 to 11 days. (Breland, 1994). Management practices may be adapted to offset some of the N losses associated with no-till systems Allowing crimson clover to attain the late bloom stage prior to desiccation and crop planting, maximizes top growth N content and subsequent N release into a no-till system (Rannells and Wagger, 1992).

Several factors regarding bean production are worth noting when considering the production environment in which this experiment was conducted, and the nutrient amendment levels of N and K provided by this

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fertilization method. When well balanced nutritional conditions exist and soil fertility is high, addition of N has a synergistic effect on N_2 fixation even at high N rates. If nutritional conditions are unbalanced, N amendments have the effect of suppressing N_2 fixation (Tsai et al., 1993). In K-deficient soils, application of N and K has been shown to increase pod yield and leaf concentrations of these nutrients, but depress the concentrations of other major and minor elements in the leaves (Smithson et al., 1993). Excess application of K can exacerbate Mn toxicity when soils are too acid (Lemare, 1972). Deficiency in K results in increased shoot/root dry weight ratios (Cakmak et al., 1994). High bean yields are positively correlated with pH and exchangeable Ca and Mg, but shoot and root growth are negatively correlated with exchangeable Al, which occurs with low pH (Fageria et al., 1989). In one *study* highest yields and rates of NO_3- consumption for bean grown in a sand culture, occurred when Ca/K ratios of the nutrient solution approached 1.0. In the same experiment, Mg consumption decreased as Ca/K ratio increased (Penalosa et al., 1995).

MATERIALS AND METHODS

This experiment was conducted in the fall of 1996 at the University of Florida in Gainesville, in field plots having a sandy soil. The selected crop was 'Blue Lake' bush bean. A randomized complete block design, consisting of four replications with 10 treatments, was chosen. The treatments were variable levels of organic fertilization based on N inputs, with nutrients being supplied in the form of air-dried, chopped crimson clover hay harvested at early bloom stage. The previous crop in selected plot area was a summer planting of field *corn (Zea mays* L.). Corn stalks were mowed, and crop and weed residues were turned under with a moldboard plow. On 27 August, four-row plots were marked off at 8-ft long by 10-ft wide, with a 2-A alley between plots and a 4-ft alley between each block.

A preliminary composite soil sample was taken from each block. Samples were analyzed for determination of pH, P, K, and Mg (Mehlich, 1953). Potassium and Mg were analyzed by ICAP (Inductively Coupled Argon Plasma) spectroscopy, P was determined colorimetrically. and soil pH was determined using a 1:2 soil to water ratio by volume (Peech, 1965).

Treatments were applied on 29 August by uniformly hand spreading the air-dried chopped clover over each treatment plot. Rates of application ranged from 0 lbs/a to 9000 lbs/a, in increments of 1000 lbs a. The clover was incorporated into the topsoil by roto-tilling to a depth of 6 in. Blue Lake bush bean was planted at a rate of 7.5 seed/ row/ ft (130,000 seed/ a). Emergence results from the initial planting were inadequate. This was attributed to several factors including seed quality, pest pressure, and a excessive planting depth. Plots were replanted 10 days after initial application of treatments. Irrigation was applied to insure adequate soil moisture to a depth of 6 in during germination. Additional irrigation was applied as needed to supplement rainfall during the duration of the experiment.

On 26 September, 28 d after application of treatments, soil samples were taken from all treatments in all replications. Soil samples were analyzed for Mehlich I extractable nutrients (P, K, Ca, Mg, Na, Cu, Fe, Mn, and Zn). All extractable soil cation concentrations, except K and Na, were determined by atomic absorption spectophotomety. Potassium and Na were determined by atomic emission. Phosphorus was determined by colorimetry, soil organic matter content by a modified Walkley-Black procedure (Black, 1965; Horwitz, 1975; Jackson 1958), and soil cation exchange capacity by cation summation (Hesse, 1972; Jackson, 1958). Soil pH was determined by electrode with 1:2 soil to water ratio, and buffered pH using an Adams/Evans buffered solution. Analysis for N was by micro-Kjeldahl procedures and techniques described by Bremner (1965) and Gallaher et al.(1975).

At 43 days after planting (DAP), when bean plants were at early bloom stage of growth, 12 young mature complete trifoliate leaves were sampled. Leaves were washed using a four-step procedure to eliminate any possible contamination (Futch and Gallaher, 1994; Gallaher, 1995), dried at 70"C, and then ground to pass through a 2-mm stainless steel mesh screen. Diagnostic leaf tissues were analyzed for N by micro-Kjeldahl procedures. Leaf nutrients were extracted by dry ashing and wet acid digestion with 12.1*N* HCI . Solution nutrient concentrations were determined by atomic absorption or emission spectrophotometry as appropriate. Phosphorus determination was by colorimetry Nutrient content of the crimson clover used for the treatments had been previously determined using these same methods, except that the clover had been air dried versus being oven dried. Quantification of the total nutrient amendments made for each treatment rate were based on these analyses. Whole plants were harvested 64 DAP. Plants were separated into leaf, pod, stem and root components. Fresh weight and dry weight were obtained. Yield data was tabulated on a per plant basis and adjusted to represent a planting density of approximately 69,000 plants/a due to problems with stand establishment.

Assessments of nutrient release, nutrient availability, and crop uptake, are based on observable yield and the analyses of diagnostic leaf and soil nutrient concentrations. Analysis of variance and determination of LSD at the 5% and 10% levels of significance was conducted using MSTAT 4.0 software (Freed et al., 1987). Interpretations of nutrient status are based upon sufficiency levels outlined by (Jones et al., 1991) and (Hochmuth et al., 1991).

RESULTS AND DISCUSSION

Soil Nutrient Analyses

Nutrient analyses of the air dryed crimson clover harvested at early bloom stage, revealed that with each 1000 lb/a increment of clover applied, 19.8 lb N, 3.4 lb P, 18.6 lb K, 7.8 1b Ca, 2.6 Ib Mg, 0.004 Ib Cu, 0.243 lb Fe, 0.039 Ib Mn, and 0.045 Ib of Zn were potentially made available to the crop (Table 1). At an application rate of 5000 lb/a, N and K are provided in excess of the recommendations of 90 lb N and 66 lb of Wa, suggested by the Inst. Food and Agr. Sci., Cooperative Extension Soil Testing Laboratory preliminary soil test results. The recommendation for K can be met by application of only 4000 lb/a of clover, which provides 74 lb K/a, but only 79 lb N/a. This rate of application appeared to be a threshold for total dry matter (DM) yield in Blue Lake bush bean (Table 2).

The cation exchange capacity (CEC) of the soil in all plots was quite low, typical for a sandy soil, with measurements ranging from 2.89 to 2.61 meq $100g^{-1}$. The soil pH was a relatively low 4.8, and may have had some negative affect on nutrient uptake ability of our crop in all treatments. The CEC and percentage of organic matter (%OM) of soil in the treatment plots were not significantly affected by the application of clover amendments. There were also no significant treatment effects for the parameters of pH, buffer pH, P, Na, Cu or Fe (Table 3).

There were significant differences among treatments for soil nutrient concentrations of Mg and Mn. Although there was a significant difference between the Mg concentration in the control and plots receiving a treatment level of 4000 lb/a, any definite trend in Mg concentration was difficult to establish. None of the levels of Mn concentration differed sigruficantly from the control, making it imprudent to suggest any correlation. A similar situation existed with the results involving Zn and Ca concentrations. Although highly significant differences occurred among treatments, suggesting any correlation to treatment rates would be difficult, especially considering the high CV values (Table 3). In all of these cases, nutrient concentrations among the control plots appeared to be at or slightly below the overall mean concentration level for all treatments. Nutrient concentrations decreased as treatment levels approached 4000 lb/a, increased significantly in the range between 4000 lb/a and 6000 lb/a, and then leveled off or began to decline again beyond this point (Table 3).

Soil N concentrations were significantly different between treatments (P= 0.03). There was some evidence of a positive correlation between N concentration and clover application rate. Nitrogen concentration increased from 0.044% in the control to 0.053% at a treatment rate of 7000 lb/a at a fairly constant rate before levels slightly decreased for the two highest treatment rates. The increases in N concentration were likely short lived. Any mineralized NH_4^+ would be loosely held on the few cation exchange sites available. This NH_4^+, and any aminized NH_4^+ in the soil solution would be rapidly converted to NO; and readily leached.

The most notable trend in soil nutrient concentrations occurred with K. There were highly significant differences in K concentrations among treatments (P<0.01) (Table 3). Soil K concentration increased from 28.4 ppm in the control plot to 50.3 ppm at the highest clover treatment level of 9000 lb/a. There was clear evidence of a strong positive correlation between soil K concentration and increased clover amendments.

Diagnostic Leaf Analyses

There were no significant differences among nutrient concentrations in diagnostic leaves of Blue Lake bush bean at different clover amendment rates with one lone exception. Differences in Mg concentration were highly significant with a probability of (P=0.01) (Table 4) . Any trend however, would have been one of decreasing Mg concentrations with increased clover treatment levels. Although there were no other significant differences among nutrient concentrations, a definite trend of decreased cation concentrations with increased clover application rates was evident. This reduction is most likely related to increased soil concentrations of K and tends to concur with the findings of (Smithson et al., 1993).

Based on the nutrient sufficiency ranges outlined by (Jones et al., 1991), the diagnostic leaves had deficient concentration levels for the nutrients N, P, K, and Ca for all clover treatment rates. Nutrient concentrations of Mg, Cu, Fe, Mn and Zn however, were all within sufficiency ranges. If the guidelines Hochmuth et al (1991) were followed, the diagnostic leaves had sufficient nutrient concentrations of P, Mg, and Fe; and high concentrations of Mn and Zn for all clover treatment rates. There were deficiencies for N, K, Ca and Cu at all treatment rates, the only exception being a barely adequate N concentration of 2.6 % N at a treatment rate of 8000 lb/a (Table 4). The low pH conditions that existed probably resulted in increased solubility and availability of micronutrients.

Environmental Factors

The fact that deficiencies existed for N, K, and Ca under both sets of nutrient sufficiency guidelines is not surprisingly if the environmental factors that were present during production are considered. Almost 4.5 in of rainfall were recorded during a 12-d period of time between treatment application and 2 DAP. Given the quantities of nutrients applied in the clover treatments and the observed nutrient concentrations of the diagnostic leaves, it is apparent that there was a problem with nutrient recovery, and or availability in this study. If consideration is given to the soil temperatures that typically exist in Florida during the production period, a lag time of nearly 12d between application of treatments and germination, and the rainfall amounts recorded, it is not unreasonable to assume that asignificant majority of the N made available by the clover treatments had undergone nitrification and been subjected to leaching losses before the first trifoliate leaves appeared. The resultant reduction in initial plant growth rate, would be reflected in subsequent root growth, plant transpiration, and nutrient uptake rate of K and Ca. Potassium inputs provided by the clover treatments would also have been susceptible to significant leaching during this period of delayed crop establishment. Calcium concentrations in diagnostic leaves were at inadequate levels even at the relatively lower ranges set forth by (Hochmuth et al., 1991. Soil concentrations of Ca should have provided adequate amounts for sufficient uptake (Table 3). Because Ca uptake occurs by mass flow in young unsuberized root tips any conditions that inhibit root growth, such as other nutrient deficiencies, would also limit Ca uptake.

Yield

Because of problems in crop establishment, yield data was recorded on a per plant basis and adjusted to reflect a population density of 69,000 plants/a. This was representative of the population density achieved in the field of approximately one-half that of the seeding rate. This adjustment was necessitated by seed germination problems acknowledged by the seed supplier and pest problems. Stem damage was evident in many seedlings and was likely incurred from lesser corn stalk borer *(Elasmopalpus lignosellus)*. During harvesting a noticeable amount of incidental leaf damage caused by leaf roller larvae *(Platynota flavadena) was* also evident.

There were highly significant differences ($P<0.01$) in stem, leaf, pod and total dry matter (DM) yields among treatments. Root DM yield was significantly different among treatments at ($P = 0.07$) level of significance (Table 2). There was a strong positive correlation between total DM yield and increased clover application rates from 0 lb/a to 4000 lb/a. This correlation also applied to plant component DM yields. Pod DM and total DM yields were highest when clover was applied at a rate of 4000 lb/a (Table 2).

In examining leafweight data, it is interesting to note the trend of reduction in *dry* leaf weight yields with increasing clover application rates of above 5000 lb/a. No significant negative effect was observed on pod yield, because of decreased leaf weights, although some increase in yield could have been unrealized.

SUMMARY

Highest dry pod yields occurred with a soil incorporated air dried chopped clover amendment rate of 4000 lb/a. Increased clover application beyond 4000 lb/a had no significant effect on pod or total DM yield. At this treatment level, plant component yields were at, or not significantly different from the highest reported yields. Greatest rates of increase. in yield occurred as application rate of clover increased from 0 lb/a to 4000 lb/a. These trends were reflected in both soil and diagnostic leaf nutrient concentration levels. There appeared to be a threshold effect at the 4000 lb/a treatment rate. This effect may likely have been a response to K availability as much as a response to N. Increases in soil concentrations of K were positively correlated with clover applications. There was some evidence of decreased micronutrient cation uptake by the plant as a result of competition due to increased soil extractable K concentrations.

Due to limiting factors such as pest pressure, low pH , low CEC, and timing of application relative to germination, it is highly probable that there was some unrealized potential response to clover application rates exceeding 4000 Ib/a. This experiment did demonstrate, however, that soil-incorporated clover could be a viable alternative nutrient source for bush bean production. It would be insightful to repeat this study in a cropping environment with less negative pressure.

LITERATURE CITED

Black, C.A. 1965. Methods of soil analysis, Part I and II. Amer.Soc.of Agronomy. Madison WI.

Breland, T. A., 1994. Enhanced mineralization and denitrification as a result of heterogenous distribution of clover residues in soil. Plant and Soil 166:l-12.

Bremner, J.M. 1965. Total nitrogen. *In* C.A. Black, ed. Methods of Soil Analysis. Part II Amer. Soc. of Agronomy. Madison, WI.

Cakmak, I., C. Hengeler, and H. Marschner. 1994. Partitioning of shoot and root *dry* matter and carbohydrates in bean plants suffering from phosphorus, potassium, and magnesium deficiency. J. Exp. Botany 45(278):1245-1250.

Fageria, V. C., N. K. Baligar, and R. J. Wright. 1989. Growth and nutrient concentrations of alfalfa and common bean as influenced by soil acidity. Plant and Soil 119:331-333.

Freed, R., S.P. Eisensmith, S. Goetz, D. Reicosky, V.W. Smail, and P. Wolberg. 1987. User's Guide to MSTAT (version 4.0). Michigan State Univ., East Lansing, MI.

Futch, S.H., and R.N. Gallaher. 1994. Citrus leaf wash comparison of zinc nutritionals and nutrient uptakeanalysis. Agronomy Research Report AY-94-06. Agronomy Dept., IFAS, Univ. of Florida, Gainesville, FL.

Gallaher, RN., C.O. Weldon, and F.C. Futral. 1975. An Aluminum block digester for plant and soil analysis. Soil Sci. Soc. Am. Proc. 39:803-806.

Gallaher, RN. 1995. Comparison of Zn nutritional spray treatments for citrus leaf Zn adsorption and absorption. Agronomy Research Report AY-95-02. Agronomy Dept., IFAS., Univ. of Florida, Gainesville, FL

Hesse, P.R., 1972. A Textbook of Soil Chemical Analysis. Chemical Publishing Co. New York,

Hochmuth G., D. Maynard, C. Vavrina, and E. Hanlon. 1991. Plant tissue analysis and interpretation for vegetable crops in Florida SS-VEC-42. Soil Sci. Dept., IFAS., Univ. of Florida, Gainesville, FL.

Horwitz, W. *(ed.).* 1975. Official Methods of Analysis of the AOAC. 12th Edition. Washington, DC.

Jackson, M.L. 1958. Soil Chemical Analysis, Prentice-Hall, Inc., Englewood Cliffs, NJ.

Janzen H. H., and S. M. McGinn. 1991. Volatile loss of nitrogen during decomposition of legume green manure. Soil Biol. Biochem 23(3):291-297.

Jones, J.B., Jr., B. Wolf, and H.A. Mills. 1991. Plant Analysis Handbook. Micro-Macro Publishing, Inc., Athens, GA.

Le Mare, P. H. 1972. A long term experiment on soil fertility and cotton yield in Tanzania. Experimental Agriculture 8:299-310.

Mehlich, A 1953. Determination of P, Ca, Mg, K, N, and NH,. North Carolina State Soil Test Division (Mimeo, 1953). North Carolina State Univ., Raleigh, NC.

Peech, M. 1965. Hydrogen-ion activity. *In:* C.A. Black, *(ed.).* Methods of Soil Analysis, Part II. Amer. Soc. of Agronomy, Madison, WI.

Penalosa J. M. , M. D. Caceres, and M. J. Sarro, 1995. Nutrition of bean plants in sand culture: Influence of Ca/K ratio in the nutrient solution. J. Plant Nutrition 18:2023-2032.

Ranells, N. N., and M. J. Wagger. 1992. Nitrogen release form crimson clover in relation to plant growth stage and composition. Agron. J. 84:424-430.

Smithson, J. B., O. T. Edjue, and K. E. Giller. 1993. Diagnosis and correction of soil nutrient problems of common bean *(Phaseolus vulgaris)* in the Usambara Mountains of Tanzania. J. Agronomic Science 120:233-240.

Tsai , S. M. , R. Bonetti, S. M. Agabala, and R. Rosetto. 1993. Minimizing the effect of mineral nitrogen on biological nitrogen fixation in common bean by increasing nutrient levels. Plant and Soil 152:131-138.

Varco, J. J., W. W. Fry, M. S. Smith, and C. T. MacKown. 1993. Tillage effects on legume decomposition and transformation of legume and fertilizer nitrogen-15. Soil Sci. Soc.Am. J. 57:750-756.

Wilson, D. O., and W. L. Hargrove. 1986. Release of nitrogen from crimson clover under two tillage systems. Soil Sci. *Soc. Am.* J. 50:1251-1254.

Table 1. Plant nutrient analyses of air dried crimson clover used as an organic fertilizer for Blue Lake bush bean, Gainesville, Florida, 1996.

	Nutrient Concentration								
Crimson Clover	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	%					ppm			
	1.98	0.34	1.86	0.78	0.26	4	243	39	45

	Nutrient Content								
Clover Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
lb/a	lb/a								
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	19.8	3.4	18.6	7.8	2.6	0.004	0.243	0.039	0.046
2000	39.6	6.8	37.3	15.7	5.3	0.008	0.485	0.079	0.091
3000	59.4	10.2	55.9	23.6	7.9	0.012	0.728	0.118	0.137
4000	79.2	13.6	74.6	31.4	10.5	0.016	0.971	0.157	0.182
5000	99.0	17.0	93.2	39.3	13.2	0.020	1.213	0.196	0.228
6000	118.8	20.3	111.9	47.1	15.8	0.024	1.456	0.236	0.273
7000	138.6	23.7	130.5	55.0	18.4	0.028	1.698	0.275	0.319
8000	158.4	27.1	149.2	62.8	21.0	0.032	1.941	0.314	0.364
9000	178.2	30.5	167.8	70.7	23.7	0.036	2.184	0.353	0.410

Nutrient concentration values are the average of four replications. The average concentration value **was** used to calculate the plant nutrient contents applied as crimson clover organic fertilizer for Blue Lake bush bean.

Table 2. Dry Blue Lake bush bean yield at 69,000 plants per acre from rates of soil incorporated air dried crimson clover harvested at the early bloom stage.

Clover Rate	Plant Part				
	Root	Stem	Leaf	Pod	Total
----- lbs/a-----	--- lbs/a ---				
0	47.3	90.1	107.1	62.5	306.0
1000	49.1	125.8	128.5	99.9	403.3
2000	58.0	179.3	181.1	133.8	552.3
3000	57.0	187.4	199.0	142.8	584.4
4000	70.5	232.0	230.2	173.1	705.7
5000	69.6	221.3	244.5	141.9	677.2
6000	74.9	215.0	228.4	143.6	662.9
7000	61.6	244.5	231.1	151.7	689.7
8000	65.1	229.3	217.7	168.6	680.7
9000	81.2	236.4	210.6	165.1	693.2
CV%	24.0	19.4	18.6	24.9	15.7
Significance	+	**	**	**	**
Probability	0.07	0.00	0.00	0.00	0.00
LSD	18.7	55.3	53.5	50.0	135.6

LSD values given at the bottom of each column of means are significantly different at P = 0.05; Data is adjusted to 69,000 plants/a. + = significant at P = 0.10; and ** = significance at P = 0.01.

Table 3. Soil pH, buffer pH, CEC, organic matter, Kjeldahl N and Mehlich I extractable elements from soil of plots ammended with air dried crimson clover and planted in Blue Lake bush bean, Gainesville, Florida, 1996.

Treatment	pH	**BpH**	CEC	OM	N	P	Ca	Mg	K	Na	Cu	**Fe**	Mn	Zn
Ib/a			meq/100g	%	%	-----------------	-----------------	-----------------	-----------------	ppm	-----------------	-----------------	-----------------	-----------------
0	4.8	7.72	2.83	1.04	0.044	78.5	63	15.3	28.4	21.4	0.84	36.6	4.70	1.22
1000	4.9	7.74	2.65	1.08	0.044	78.8	62	14.5	30.6	18.5	0.78	39.3	4.00	1.04
2000	4.8	7.74	2.61	1.02	0.044	76.9	52	13.3	31.4	16.8	0.73	31.8	3.80	0.98
3000	4.9	7.73	2.76	1.09	0.048	78.8	61	15.8	36.5	21.3	0.77	37.0	4.10	1.03
4000	4.8	7.74	2.84	1.17	0.047	80.9	80	18.6	40.0	19.8	0.79	31.1	5.30	1.28
5000	4.8	7.73	2.89	1.16	0.051	80.0	76	17.3	40.9	18.2	0.86	33.8	5.10	1.15
6000	4.9	7.77	2.67	1.06	0.049	77.2	74	19.5	39.4	22.9	0.65	28.4	5.40	1.32
7000	4.8	7.75	2.78	1.22	0.053	75.8	76	17.9	45.8	20.3	0.72	28.8	5.20	2.04
8000	4.8	7.76	2.64	1.04	0.047	15.4	67	16.9	43.9	20.5	0.67	24.0	4.30	1.39
9000	4.7	7.75	2.75	1.09	0.049	80.2	69	17.5	50.3	20.6	0.74	36.5	5.10	1.28
CV Yo =	3.0	**0.3**	7.2	9.0	7.8	6.2	18.4	15.9	18.2	15.6	18.6	15.4	18.4	26.5
Significance	NS	NS	NS	NS	*	NS	**	+	**	NS	NS	NS	+	**
Probability		0.15		0.11	0.03		0.00	0.06	0.00	0.36	-	0.14	0.09	0.00
LSD @ p = 0.10								3.1					1.0	
LSD @ **p** = 0.05					,002		18.7		10.1					0.48

CV = Coefficient of variation, NS = Non significant; + = significant at **p** 0.10; * = significant at **p** 0.05;
** = Significant at **p** 0.01; CEC = Cation exchange, **meg/100g** soil; OM = organic matter

Table 4. Plant nutrient analyses of the diagnostic leaf of bush bean treated with air dried crimson clover, **Gainesville, FL, 1996.**

Clover Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
kg/ha	%					ppm			
0	2.26	0.32	1.49	1.37	0.43	10.0	138	143	60.0
1000	2.39	0.33	1.52	1.17	0.44	10.5	143	143	54.0
2000	2.38	0.32	1.54	1.25	0.38	10.5	123	130	59.0
3000	2.40	0.33	1.59	1.39	0.43	11.0	155	150	58.0
4000	2.35	0.34	1.71	1.38	0.37	11.3	145	133	62.3
5000	2.22	0.32	1.5	1.17	0.37	9.3	140	143	50.3
6000	2.43	0.34	1.66	1.20	0.42	9.5	140	135	57.8
7000	2.38	0.33	1.71	1.24	0.38	9.8	123	121	54.8
8000	2.60	0.34	1.79	1.17	0.39	11.0	128	116	55.5
9000	2.16	0.31	1.55	1.14	0.33	9.8	135	134	48.8
CV%	8.9	8.3	11.7	16.7	10.3	18.0	14.7	18.3	16.2
Significance	NS	NS	NS	NS	**	NS	NS	NS	NS
Probability	0.24	-		0.36	0.01		0.43		
LSD @ p = 0.05					0.06				
	Sufficiency Ranges by Jones et al., 1991								
Low range	4.24 4.99	0.25 0.34	1.80 2.19	2.00 2.24	0.25 0.29	4 6	40 49	15 49	18 19
Sufficient range	5.00 6.00	0.35 0.75	2.20 3.00	2.25 4.00	0.30 1.00	7 30	50 300	50 300	20 200
High	>6.00	>0.75	>3.00	>4.00	>1.00	>30	>300	>300	>200
	Sufficiency Ranges by Hochmuth et al., 1991								
Low	<2.50	<0.20	<2.00	<1.50	<0.25	<15	<25	<20	<20
Adequate range	2.50 4.00	0.20 0.40	2.00 4.00	1.60 2.50	0.25 0.45	15 40	25 200	20 100	20 40
High	>4.00	>0.40	>4.00	>2.50	>0.45	>40	>200	>100	>40

CV = Coefficient of variation; NS = Non significant; + = significant at p = 0.10; * = significant at p = 0.05; ** = significant at p = 0.01; Refer to literature cited section for Jones, et al., 1991 and Hochmuth, et al., 1991