Mineral Concentration and Content for No-Tillage Tobacco Following Simulated Excessive Rainfall and Supplemental Nitrogen Fertilizer

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ABSTRACT

Soil erosion and fertilizer nutrients can both result in environmental pollution without good crop production management. Leaching loss of N fertilizer from excessive rainfall events not only results in inadequate N available to maximize crop growth but also results in inefficient utilization of other crop nutrients. The objective of this research was to determine the plant nutrient concentrations and contents of no-tillage flue-cured tobacco *(Nicotiana tabacum)* transplanted into a winter cover crop of rye *(Secale cereale)* that had been treated with supplemental N rates following a large simulated rainfall event under two weed control treatments. An in-row subsoil no-tillage planter was followed by a conventional one-row Mechanical Brand Transplanter in a second operation. Diagnostic leaf concentrations of P, K, Mg, Fe, Mn, and Zn were all in the sufficiency range, Ca was on the borderline of being low, and Cu was low. Crop removal of macronutrients P, K, Ca, and Mg were generally greatest from herbicide-treated plots and from the application of 25 to 50 Ibs of supplemental sidedress N fertilizer. Contents of these nutrients were two to four times greater in leaves compared to stems. Greatest macronutrient whole plant content of the above elements at 25 lb supplemental N/a was in the order of K (range from 66 to 109 lb K/a) > Ca (range from 16 to 32 lb Ca/a) > Mg (range from 5.1 to 9.0 lb Mg/a) > P (range from 5.8 to 8.6 lb P/a). The apparent loss of N due to heavy rainfall not only resulted in a need for supplemental N to maintain yield but also resulted in increased uptake of other plant nutrients as well. Precise N fertilizer applications are important to the efficient use of all fertilizer elements, not only to protect the environment but also to maximize production of tobacco.

INTRODUCTION

Soil erosion can be excessive from conventional tillage flue-cured tobacco *(Nicotiana tabacum* L.) (Doyle and Worsham, 1986). No-tillage transplanting of tobacco into winter cover crops has been successful in North Carolina (Doyle and Worsham, 1986; Wiepke et al., 1988) and is presently receiving new emphasis in North Carolina (Worsham, 1995), Tennessee (Fowlkes, 1995; Krueger et al., 1995) and Kentucky (Pearce, 1995; Pearce et al., 1995) as well as in this work in Florida. This continued and renewed emphasis on conservation tillage tobacco as well as other crops is in part due to actions of the U.S. Congress in the passage of the Food Security Act (Anon., 1985) and the Food, Agriculture, and Conservation Trade Act (Anon., 1990). The Food Security Act (Anon., 1985) required farmers who want to remain eligible for U.S.D.A. program benefits and are farming highly erodible land to develop, actively apply, and fully implement a conservation plan according to schedule by the end of 1994. The Food, Agriculture, and Conservation Trade Act (Anon., 1990) reinforced these farm management requirements first required by the Food Security Act (Anon., 1985).

Precise and timely application of N fertilizer to crops grown on sandy soil is important in order to reduce leachmg and economic losses by farmers as well as possible ground water pollution from nitrates. Excessive rainfall or irrigation can leach applied N from root zones of soils used for tobacco in Florida and can be avoided to some extent by using multiple sidedress applications of small increments of N (Smith, 1980) or corrected by replacement of the leached N (Person and Whitty, 1982). Leaching losses can be excessive from heavy rainfall events in Florida and corn *(Zea mays* L.) and grain or forage sorghum *(Sorghum bicolor* L.) Moench) responded best to N being applied in three or four split applications from planting to layby (Gallaher et al., 1992; Lang, 1994). Winter cover crops in succession multiple cropping systems have been found to be effective in reducing nitrate leaching (Hargrove et al., 1992) and many cover crops can provide substantial supplemental N (Gallaher, 1993). The objective of this research was to determine the plant nutrient concentrations and contents of no-tillage transplanted flue-cured tobacco into a winter cover crop of rye *(Secale cereale* L.) that had been treated with supplemental N rates following a large simulated rainfall event under two weed control

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treatments.

MATERIALS AND METHODS

The field experiment was conducted in 1994 at the University of Florida's Green Acres Agronomy Farm near Gainesville, Florida. 'Wrens Abruzzi' rye was dnlled into a harrowed seedbed at 90 lb/a in November 1993 on an Arredondo fine sand (fine-sandy siliceous, Hyperthermic Grossarenic Paleudult). Rye received 500 lb/a of 12(N)-4(P_2O_5)-8(K_2O) on 10 January 1994 and 2 pt/a of 2-4-D to control winter broadleaf weeds 24 January 1994.

Two pints Gramoxone (Paraquat)/a plus labeled rate of nonionic surfactant was broadcast over the rye at early anthesis on 7 April 1994. Rows 48 in. wide were laid off on 11 April using an in-row subsoil no-tillage planter (Brown-Harden). This unit did a strip tillage 12 in. deep under the row and prepared a clean seedbed in the standing rye about 4 to 6 in. wide over the row. Rye was partially pressed down in the middles, especially near the strip tilled areas. Flue-cured tobacco cultivar 'K326' was transplanted at a spacing of 16 in. into the subsoil strips with a one-row Mechanical Brand Transplanter on 12 April. The transplanter had to be operated in the same direction as the no-tillage subsoil unit in order to eliminate dragging and disruption due to the compressed rye. Fertilization consisted of 650 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 28 April, 650 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 9 May and 300 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 16 May. This represented a total of 96 lb N + 42.5 lb P + 243 lb K/a and, under normal circumstances, should have been adequate for maximum flue-cured tobacco production under Florida conditions (Stocks and Whitty, 1992).

Whole-plot treatments consisted of application of the herbicide Poast (Sethoxydin) broadcast on 18 April at 1 pt formulated product/a with a nonphytotoxic oil versus a control that received no weed control. Subplot treatments consisted of a supplemental sidedress application of N as ammonium nitrate at rates of 0, 25, 50, and 75 lb N/a. The sidedress N was applied 19 June followed by 0.2 acre in of irrigation to immediately move the N into the root zone. Rainfall was supplemented by overhead sprinkler irrigation as needed once or twice per wk. The supplemental N was applied following a few days of heavy rainfall (1 acre inch on 18 June) and irrigation which simulated 2 acre in. of ramfall on 18 June and an additional 1 acre in. on 19 June.

The final subplot area was 22 ft long and 48 in. wide. Tobacco was topped at early flowering Suckers were chemically controlled by a broadcast spray of 3 lb a.i. Maleic hydrazide [MH(WSSA)] immediately after topping. One wk following topping, the top most leaf was collected at random from six plants in each subplot for N analysis. The end plants were removed between plots prior to harvest leaving 15 plants per 20-ft-long subplots. Bottom leaf harvest was on 13 July and top leaf harvest was on 27 July. Leaves were cured in a commercial tobacco barn Stalks were harvested on 27 July. All leaves and stalks were dried at 70 C in a forced air oven until dry weighed, chopped as necessary, and ground to pass a 2-mm stainless steel screen using a Wiley mill. Samples were stored in sterile air-tight plastic bags.

Nitrogen analysis was reported earlier (Whitty and Gallaher, 1995). Prior to mineral analyses, tissue was redned at 70 C for approximately 2 hr. After *dry* combustion preparation for mineral analyses (Gallaher et al., 1996) nutrient concentrations for Ca, Mg, Cu, Mn and Zn was by AA spectrophotometer. Potassium was analyzed by atomic flame emission spectrophotometer; P by colorimeter.

Data were tabulated, transformed as necessary, and ASCII files prepared using Quattro Pro (Anon., 1987). Analyses of total leaf and stem elemental concentrations were multiplied by total leaf and stem *dry* matter yields (Whitty and Gallaher, 1995) resulting in plant nutrient contents (total nutrient uptake or yield of nutrients removed by the crop on a per acre basis. Analysis of variance was conducted using MSTAT 4.0 (Freed et al., 1985).

RESULTS AND DISCUSSION

The no-tillage subsoil strip tillage transplanting of tobacco was successful with 100% survival of the seedlings. Tobacco plants appeared to have good root systems and experienced no lodging from the subsoil management. Fanners who are interested in this management should be able to utilize an in-row subsoil no-tillage planter with the transplanter units attached to the subsoiler frame. Because of the long distance from the rear of the tractor to the seats on the transplanter, one or two hydraulic helper wheels on the transplanter would likely be necessary to achieve successful planting in one operation.

Either the 96 lb N/a applied earlier was not sufficient to maximize yield or the excessive simulated rainfall event leached needed N below the root zone (Whitty and Gallaher, 1995). Additionally, it was determined that from 50 to 75 lb N/a (depending upon the treatment) was required to maximize dry matter yield following the rainfall event (Whitty and Gallaher, 1995).

As was indicated earlier, a total of 42.5 lb P/a and 243 lb K/a was applied to the tobacco crop prior to the simulated ramfall event. The total N applied in the complete fertilizer was 96 lb/a and should have been adequate for high yield tobacco under Florida conditions. Leaf analysis showed that average N concentration increased by 76% from the 0 lb N/a treatment to the 75 lb N/a treatment (Table 1). This indicated that either not enough N was applied or that the excess rainfall/irrigation did, in fact, leach N below the tobacco roots.

Diagnostic leaf concentrations of P, K, Mg, Fe, Mn, and Zn were within reported sufficiency ranges for all treatments according to Jones et al. (1991). However, Ca was on the borderline of being below desired levels for adequate plant growth and Cu was low according to published sufficiency ranges (20 to 50 ppm) (Jones et al., 1991). None of the concentrations of P, K, Ca, Mg, Cu, Fe, Mn, and Zn in diagnostic leaf tissue were affected by weed control treatment nor supplemental N rates (Tables 1 and 2). This was not the case for diagnostic leaf N concentrations. Leaf N was in greater concentration for the herbicide-treated plots compared to the check at all levels of N fertilizer applied. This indicated that the greater amount of weeds in the check plots were competing with tobacco for N. Leaf N appeared to approach sufficient levels at the 50 lb N/a rate in the herbicide treated plots but would require 75 lb N/a or greater fertilizer N in the check plots (Whitty and Gallaher, 1995).

Nitrogen concentration in the diagnostic leaf was positively related to dry matter yield. Leaf yield responded to 50 lb supplemental N/a, stalk yield to between 25 and 50 lb N/a, and whole plant yield to 25 lb N/a (Table 2). Herbicide treatment resulted in greater leaf and total plant yield compared to the check. Twice as much N was recovered in the leaf dry matter at the 50 lb supplemental N/a rate compared to the control. "his relationship held true for the total plant as well. Consistently greater amounts of N was removed by tobacco parts and total plant from the herbicide treated plots compared to the control (Whitty and Gallaher, 1995).

Leaf and whole plant N contents of P, K, Ca and Mg were all increased by application of 25 to 50 lbs of supplemental N fertilizer/a (Tables 3 to 6). The increased yields of recovery of these elements ranged from 100 to 400% from addition of 25 lb N/a, showing the importance of adequate N for the efficient utilization of other fertilizer elements.

At the supplemental N fertilizer rate of 25 lb/a the tobacco plant removed 8.6 lb P/a for the herbicide-treated plots (Table 3). This represented a total of only 20% of P recovered in relation to 42.5 lb P/a that was applied in fertilizer. Since P concentrations (Table 1) were sufficient in the diagnostic leaftissue, data indicate that excess fertilizer P was likely applied to this crop. At the same 25 lb supplemental N/a the tobacco plant removed 108.5 lb Wa for the herbicide treated plots (Table 4). This represented 45% of the 243 lb Wa that was applied in fertilizer. As with P concentration, the K concentration (Table 1) was well within the sufficiency range in diagnostic tissue for good growth. Based on recovery (contents) of N, P, and K in relation to fertilizer applied in this study, the simulated rainfall event resulted in the need for additional N fertilizer, while apparent recoveries of P and K indicated that excess P and K were applied to this tobacco. Further testing could determine more precise amounts and timing of N, P and K fertilizer to maximize tobacco under no-tillage plantings into rye cover crop. Diagnostic leaf data indicate that the tobacco might have responded to an application of Cu (Table 2).

SUMMARY AND CONCLUSIONS

Erosive soils and national U.S. Policy may necessitate that some farmers adapt conservation tillage management for tobacco as has been done for other crops. This study demonstrated that no-tillage subsoil transplanted tobacco into rye cover crop could be successful in Florida. Modification of existing equipment should make this management practical for erosion prone soils. Weed control is essential to reduce competition with tobacco under these conditions. The herbicide treatment consistently gave larger leaf contents of P, K, Ca, and Mg. However, even the herbicide treatment had some weeds that may have been controlled with a second application of the same herbicide. Excess application of water from either rainfall, irrigation, or both can result in losses of fertilizer N either due to leaching or erosion. Based on the results of this study it is recommended that 50 lb supplemental N/a be sidedressed immediately on tobacco, if rainfall/irrigation amounts of 3 acre inches or more are received in a 3day period within a 2 to 3 week period prior to flowering. These data showed that supplemental application of N resulted in significant recovery of P, K, Ca, and Mg. However, only 20% of the P and 45% of the K were recovered in relation to the amount of fertilizer applied at the 25 lb N/a rate. This would indicate, based on yield response, that this tobacco was under-fertilized with N and over-fertilized with P and K. More precise fertilizer practices need to be determined under conservation tillage management.

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Table 1. No-tillage tobacco diagnostic leaf macro nutrient concentrations from weed control and supplement N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		% P				
Yes	Leaves	0.27	0.25	0.29	0.26	0.27 NS
No	Leaves	0.27	0.26	0.27	0.28	0.27
Average	Leaves	0.27 a	0.25 a	0.28 a	0.27 a	
LSD (0.05) among P means = NS						
CV sub plot N means = 11.12%						
		% K				
Yes	Leaves	3.17	3.09	2.89	2.92	3.02 NS
No	Leaves	2.76	2.89	3.17	3.04	2.96
Average	Leaves	2.96 a	2.99 a	3.03 a	2.98 a	
LSD (0.05) among K means = NS						
CV sub plot K means = 14.97%						
		% Ca				
Yes	Leaves	0.94	0.85	0.86	0.83	0.87 NS
No	Leaves	0.74	0.88	0.94	0.94	0.88
Average	Leaves	0.84 a	0.87 a	0.90 a	0.87 a	
LSD (0.05) among N means = NS						
CV sub plot Ca means = 15.51%						
		% Mg				
Yes	Leaves	0.30	0.28	0.31	0.28	0.29 NS
No	Leaves	0.24	0.29	0.30	0.31	0.29
Average	Leaves	0.27 a	0.29 a	0.31 a	0.30 a	
LSD (0.05) among N means = 0.05						
CV sub plot Mg means = 13.70%						

Values among average N fertilizer means not followed by the same letter are significantly different according to LSD test at the 5% level. No significant interactions occurred between weed control treatments and N treatments. NS = no significant difference between herbicide means @ p = 0.05.

Table 2. No-tillage tobacco diagnostics leaf micronutrient concentrations from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
				ppm Cu		
Yes	Leaves	10.8	9.0	12.3	10.5	10.6 NS
No	Leaves	12.8	10.5	12.3	12.3	11.9
Average	Leaves	11.8a	9.8 a	12.3 a	11.4 a	

LSD (0.05) among N rate means = NS
CV sub plot N rate means = 20.24%

				ppm Fe		
Yes	Leaves	55	58	63	60	59 NS
No	Leaves	53	55	60	63	58
Average	Leaves	54 a	56 a	61 a	61 a	

LSD (0.05) among N rate means = NS
CV sub plot N rate means = 11.29%

				ppm Mn		
Yes	Leaves	61	76	75	83	74 NS
No	Leaves	60	72	70	88	72
Average	Leaves	61 a	74 a	73 a	75 a	

LSD (0.05) among N rate means = NS
CV sub plot N rate means = 15.64%

				ppm Zn		
Yes	Leaves	40	36	43	48	41 NS
No	Leaves	47	39	45	42	43
Average	Leaves	44 a	38 a	44 a	45 a	

LSD (0.05) among N rate means = 0.05
CV sub plot N rate means = 14.74%

Values among average N fertilizer means not followed by the same letter are significantly different according to LSD test at the 5% level. No significant interactions occurred between weed control treatments and N treatments. NS = no significant difference between herbicide means @ p = 0.05.

Table 3. No-tillage tobacco plant P content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb P/a				
Yes	Leaves	4.31	5.98	5.94	5.38	5.40 NS
No	Leaves	3.58	3.85	6.02	5.42	4.72
Average	Leaves	3.95 a	4.91 ab	5.98 a	5.40 a	
LSD (0.05) for N rate means = 1.21; CV for N rate means = 22.87%						
Yes	stalks	2.10	2.63	2.34	2.40	2.36 NS
No	stalks	2.59	1.96	3.04	2.36	2.48
Average	Stalks	2.34 a	2.29 a	2.69 a	2.38 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 21.39%						
Yes	Plant	6.41	8.61	8.28	7.78	7.76 NS
No	Plant	6.17	5.82	9.06	7.78	7.20
Average	Plant	6.29 b	7.21 ab	8.66 a	7.68 ab	
LSD (0.05) for N rate means = 1.55; CV for N rate means = 19.75%						

Values among aver N means within a weed treatment not followed by the same letter are significantly different according to LSD test **at the** 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at **the** 0.05 level. NS = no significant difference between herbicide means @ **p** = 0.05.

Table 4. No-tillage tobacco plant K content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb K/a				
Yes	Leaves	51.1	77.4	66.1	69.5	66.0 *
No	Leaves	39.5	44.2	67.8	57.4	52.2
Average	Leaves	45.2 b	60.8 a	67.0 a	63.50 a	
LSD (0.05) **for** N rate means = 14.8; CV for N rate means = 23.94%						
Yes	stalks	23.9	31.1	24.6	28.4	27.0 NS
No	stalks	26.8	22.1	28.8	23.9	25.4
Average	Stalks	25.3 a	26.5 a	26.6 a	26.2 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 25.98%						
Yes	Plant	74.9	108.5	90.7	97.9	93.0 NS
No	Plant	66.4	66.2	96.6	81.2	77.6
Average	Plant	70.6 a	87.4 a	93.6 a	89.6 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 22.17%						

Values among average N means within a weed treatment not followed by the **same** letter are significantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at **the** 0.05 level. * = significant difference between herbicide means @ **p** = 0.05. NS = no significantrence between herbicide means @ **p** = 0.05.

Table 5. No-tillage tobacco plant Ca content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb Ca/a				
Yes	Leaves	16.3	26.3	22.9	25.3	22.7 *
No	Leaves	11.0	12.7	20.3	18.8	15.7
Average	Leaves	13.7 b	19.6 a	21.6 a	22.10 a	
LSD (0.05) **for** N rate means = 5.0; CV for N rate means = 24.68%						
Yes	stalks	4.69	5.59	5.40	6.98	5.66 NS
No	stalks	5.59	3.77	5.87	4.73	4.99
Average	stalks	5.15 a	4.68 a	5.63 a	5.86 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 25.36%						
Yes	Plant	21.0	31.9	28.3	32.3	28.3 *
No	Plant	16.6	16.4	26.2	23.5	20.6
Average	Plant	18.8b	24.1 ab	27.2 a	27.8 a	
LSD (0.05) **for** N rate means = 6.0; CV for N rate means = 23.29%						

Values among average N means within a weed treatment not followed by the same letter are significantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at the 0.05 level. * = sigxuficant difference between herbicide means @ **p** = 0.05. NS = no sigxuficant difference between herbicide means @ **p** = 0.05.

Table 6. No-tillage tobacco plant Mg content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate, lb/a 0	25	50	75	Average
		lb Mg/a				
Yes	Leaves	4.08	6.72	6.16	6.44	5.84 *
No	Leaves	2.82	3.64	5.71	5.26	4.30
Average	Leaves	3.46 b	5.17 a	5.82 a	5.86 a	
LSD (0.05) for N rate means = 1.34; CV for N rate means = 25.79%						
Yes	stalks	1.60	2.28	2.36	2.86	2.28 NS
No	Stalks	1.76	1.44	2.39	2.18	1.94
Average	Stalks	1.68 c	1.86 bc	2.38 ab	2.52 a	
LSD (0.05) for N rate means = 0.56; CV for N rate means = 25.85%						
Yes	Plant	5.68	9.00	8.52	9.30	8.12 *
No	Plant	4.60	5.08	7.88	7.44	6.24
Average	Plant	5.14 b	7.04 a	8.20 a	8.36 a	
LSD (0.05) for N rate means = 1.75; CV for N rate means = 23.19%						

Values among average N means within a weed treatment not followed by the same letter are sigxuficantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatment at the 0.05 level. * = sigxuficant difference between herbicide means @ **p** = 0.05. NS = no sigxuficant difference between herbicide means @ **p** = 0.05.