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Nitrogen, Potassium, Sulfur Fertilization, and Protein Content of Sweet Potato Roots[1]

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Abstract. **An increase in the rate of applied N to plantings of sweet potato [*Ipomoea batatas*(L.) Lam.] caused an increase in root N content but did not affect the non-protein N/total N ratio. An increase in the rate of applied K caused an increase in root yield but did not affect root N content nor the non-protein N/total N ratio. Sulfur had no effect on yield or composition of the roots.**

Large field-to-field differences in crude protein (N × 6.25) content of 'Jewel' and 'Centennial' sweet potatoes occur in North Carolina (12). The cause of these differences were not explained. Water availability (2) and the amount of applied N (1, 2) may influence the amount of N stored in the roots.

When S was the limiting element in soil, uptake of N by corn (13) and other grains (5, 14) was controlled by amounts of available S. The effect of S on the N content of sweet potatoes has not been reported. Potassium has been observed to produce a linear yield response in sweet potatoes (3, 6). Increased yield, i.e., increased storage of carbohydrate, may result in decreased N concentration in the roots.

As much as 40% of the N in 'Jewel' sweet potatoes may be in non-protein N (10). The major component of the non-protein N is asparagine (ca 60%), suggesting that this fraction may be a N pool (7, 11). When sweet potatoes are eaten, the ingested asparagine can furnish N for biosynthesis of non-essential amino acids; thus, it contributes to protein value of the sweet potatoes only when essential amino acids are not limiting. The non-protein N fraction contains such small amounts of the essential amino acids that it would have little nutritional value (10). However, sweet potato protein has high nutritional value (9). Thus, differences in total N content may not reflect the nutritional value of the roots. If application of N resulted only in storage of more non-protein N, there would be no advantage to applications beyond that needed for maximum yield.

If application of S caused formation of more protein, then there would be a nutritional advantage. If the increased growth due to application of K caused more N to be incorporated into protein for support of the growth, there would be a yield advantage without loss of nutritional quality. The experiments reported herein were designed to determine the effects of N, S,

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and K applications on total N and non-protein N contents of 'Jewel' sweet potato roots and yield of roots.

Materials and Methods

Sweet potato production, 1977 season. 'Jewel' sweet potatoes were planted as slips in a Norfolk sandy loam (Typic Paleudult, fine, loamy, siliceous, thermic) at the Central Crops Research Station of the North Carolina Agricultural Research Service near Clayton, North Carolina, with 7.6-m rows (1.07 m between rows) and plants at 25.4-cm intervals. N was applied in a 10N-4.3P-8.3K commercial fertilizer with K as KCL at 0, 56, and 112 kg N/ha, supplemented with KH_2PO_4 and K_2CO_3 to give all plots 112 and 112 kg per ha of P and K, respectively. Sulfur was applied as Na_2SO_4 to give 0 or 34 kg S/ha. There were 2 replicates of each treatment. One-half of the fertilizer was applied in the row before planting (June 2), and the rest as side dressing July 4 and September 5. the roots were harvested October 27.

Production of roots, 1978 season. 'Jewel' sweet potatoes were planted in Wagram loamy sand (Arenic Paleudult, loamy siliceous, thermic) at 2 sites on farms in eastern North Carolina, 1 site in Johnston County, and 1 site in Sampson County. The experimental design for the N and S rate study was a split plot with N rates of 0, 51, and 101 kg/ha combined with S levels of 0 and 63 kg/ha. Three replications of 4 row plots 4.2 × 9.0 m were used at both sites. K and P were held constant at 167 kg K/ha and 40 kg P/ha. K response was evaluated at the Sampson County site with rates of 0, 56, 112, 168, 223, and 280 kg K/ha with constant rates of 101 kg N/ha, 0 kg S/ha, and 40 kg P/ha. Fertilizer sources were NH_4NO_3, K_2SO_4, KCl, and triple superphosphate. All of the P, one-third of the N, and one-fifth of the K and S were applied in the row before planting (May 11, Sampson County and June 19, Johnston County). The remainder was applied as side dressing approximately 45 days after planting.

Preliminary soil tests prior to fertilization showed low K levels of 0.10 meq/100 cc at the Johnston County site and 0.05 meq/100 cc at the Sampson County site. S contents were moderately low at 14 and 8 μg/cc for Jonnston and Sampson County sites, respectively. Cultural practices were those presented by Nicholaides et al. (8).

Harvest, sampling and analyses. At harvest, all roots in each plot were weighed to determine yield. U.S. no. 1 roots from each plot were collected, cured at 30°C for 5 days and stored at 13° until analyzed (4). The analyses described below were run on 2 replicates each consisting of 6 washed and dried roots each.

Total N was determined by the macro-Kjeldahl procedure, and non-protein N was determined by precipitation with trichloroacetic acid, as previously described (11). Measurements of nitrate N with nitrate reductase indicated that nitrate N was less than 1% of the total N (unpublished); therefore, data are not presented.

All analyses were run in duplicate to provide a constant check on procedures. Differences between duplicates were found to be so small that means were used for statistical analyses. Data were analyzed by appropriate ANOVA and regression techniques (15).

Results and Discussion

A significant linear relationship (r = 0.724*) between percent total N in the roots and N application was found for sweet potatoes grown in 1977 (Table 1). The relationship was described as:

Table 1. The effect of applied N on total root N, non-protein N/total N ratio, and yield of sweet potato roots, 1977, means of 4 replicates.[z]

N treatment (kg/ha)	Total root N (% dry wt)	Non-protein N. total N	Yield (Mt/ha)
O	1.12	0.39	14.6
56	1.32	0.38	11.5
112	1.46	0.41	11.5

[z]Correlation coefficient (r = 0.724) between N treatment and root N significant at 1%. Correlation between N treatment and NPN and N treatment and yield are not significant.

$$\% \text{ root N} = 0.0030 \text{ applied N} + 1.1312.$$

There was no significant effect due to S and no S × N interaction. Application of N had no effect on the non-protein N/total N ratio or yield.

Wilson (16) has reported that too much N inhibits root thickening, causing a decrease in root yield but increases the growth of foliage. The amounts of N used in this study cannot be compared to the study by Wilson because in that study N application was reported as ppm N in a nutrient solution added to a sand culture. This effect of N on root growth may explain the variability and absence of response noted in this study and by other workers in North Carolina (8).

Data for 1978 was consistent with the data of 1977. Application of N caused a significant linear increase (r = 0.724***) in total root N (Table 2). The increase was expressed as:

$$\% \text{ root N} = 0.00417 \text{ applied N} + 0.7912.$$

Application of N had no effect upon the non-protein N/total N ratio or on yield. Application of S had no effect, and there was no N × S interaction.

Increasing rates of K resulted in a significant linear increase (r = 0.874***) in yield expressed as:

$$\text{yield} = 0.0423 \text{ applied K} + 11{,}047.$$

Application of K did not affect % total root N or the non-protein N/total N ratio (Table 3).

In both years of the study, N application was the only factor investigated which influenced the total N content of sweet potato roots. The correlation coefficient (0.724) between the 1978 N application rates and percent total N suggests that about 55% of the observed variance could be accounted for by N application. The increased percent total N in the roots indicated some increased nutritional value because total N and protein N increased together. Application of K did not alter nutritional value as judged by non-protein N, but, due to higher yields, an increase in the quantity of nitrogenous material was harvested.

Undefined condition relating to location, year, and environmental variables apparently affected total N and the non-protein N/total N ratio in the roots (Tables 1 and 2). A search for these variables may be useful because control could result in a significant increase in nutritional value of sweet potatoes. Estimated nutritional value based on crude protein (total N × 6.25) content would lead to over-estimation, since the non-protein N fraction contains small amounts of the essential amino acids. Thus, either the non-protein N must be measured or a procedure must be devised which quantifies true protein content.

Table 2. Effect of applied N on total root N, non-protein N/total N, and yield of sweet potato roots, Sampson and Johnston Counties, 1978; means of 2 plantings, 2 levels of S, and 3 replicates of each planting and treatment.[z]

N treatment (kg/ha)	Total root N (% dry wt)	Non-protein N/ total N	Yield (Mt/ha)
0	0.80	0.24	17.8
51	0.98	0.25	18.8
101	1.23	0.25	19.7

[z]Correlation coefficient ($r = 0.724$) between N treatment and root N significant at 0.1%. Correlations between N treatment and NPN/N and N treatment and yield are not significant.

Table 3. Effect of applied potassium (K) on total nitrogen (N), non-protein N/total N ratios and yield, Sampson County, 1978; means of 3 replicates.[z]

K treatment (kg/ha)	Total root N (% dry wt)	Non-protein N/ total N	Yield (Mt/ha)
0	1.52	0.24	19.1
56	1.54	0.26	30.2
112	1.35	0.23	29.6
168	1.37	0.25	34.3
223	1.42	0.23	39.4
280	1.44	0.22	45.1

[z]Treatments included 90 kg/ha nitrogen. Correlation coefficient ($r = 0.874$) between K treatment and yield significant at 0.1%. Correlations between K treatment and root N and K treatment and NPN/N are not significant.

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