VII^th Symposium of the International Society for Tropical Root Crops,
Gosier (Guadeloupe), 1-6 July 1985, Ed. INRA, Paris, 1988.

FERTILIZER N INDEPENDENT AND DEPENDENT SWEET POTATO CULTIVARS

(Variétés de Patate N dépendantes et indépendantes)

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SUMMARY

In 1983, 197 seeds from high yielding sweet potato cultivars developed at the International Institute of Tropical Agriculture (IITA) were propagated and evaluated for growth and yield. Vine cuttings of the 25 most adapted cultivars were transplanted into an unfertilized field in 1984. Total root weight ranged from 10 to 41 mt/ha, marketable root weight ranged from 1.2. to 24.7 mt/ha and foliage weight ranged from 3.1 to 30.8 mt/ha. Three cultivars from IITA (fertilizer N independent types (FNI)) - T2024, T2037 and T2041, and three USA grown cultivars - "Centennial", "Jewel" and "Rojo Blanco" (fertilizer N dependent types (FND)) were grown at 0,60 and 120 kg N/ha. The T2024, T2041 and "Centennial" cultivars produced 22, 23 and 20 mt/ha at 0 kg N/ha. Yields of 15 to 16 mt/ha were obtained from T2037, "Jewel", and "Rojo Blanco" at 0 kg N/ha. At 60 kg N/ha "Centennial", "Jewel", T2024 and T2041 produced 28, 22, 23 and 20 mt/ha, respectively ; yields of 14 mt/ha were obtained for both T2037 and "Rojo Blanco". Lower yields were produced for all cultivars except "Jewel" at 120 kg N/ha. In 1984 'Centennial" was inoculated with the N_2-fixing bacteria *Azospirillum* at 2, 4 and 6 weeks after transplanting. Inoculation increased total and marketable root yields by 12 and 17 per cent respectively.

RESUME

En 1983 des plantules issues de 197 variétés à haut rendement produites à l'IITA (Nigéria) ont été testées pour leur rendement et leur croissance. Les boutures des 25 variétés les plus adaptées furent transplantées dans un terrain non fertilisé en 1984. Le poids total de racine varie de 10 à 41 t/ha, celui des racines commercialisables de 1,2 à 24,7 et celui des feuillages de 6,8 à 66,1 t/ha. Trois cultivars de l'IITA (N indépendants), T2020, T2037 et, T2041, et trois des USA,

"Centennial", "Jewel", et "Rojo blanco" (N dépendants) purent cultivés avec 0,60 et 120 kg N/ha. Les cultivars T2024, T2021 et "Centennial" produisirent 22, 23 et 20 t/ha à 0 kg N/ha. Des rendements de 14 t/ha furent obtenus de T2037 et "Rojo Blanco". Des rendements inférieurs furent réalisés par tous les cultivars sauf "Jewel" à 120 kg N/NA. En 1983 et 1984 "Centennial" fut inoculé avec des bactéries N2 - fixatrices, Azospirillum, à 2, 4 et 6 semaines après transplantation. L'inoculation accrut les rendements en racines et en feuilles.

INTRODUCTION

Though numerous studies have indicated that N and K fertilizers significantly influence yield and quality of sweet potato (sweet potato is highly tolerant of low P levels), in most parts of the tropics sweet potatoes are seldom fertilized (HILL, 1985). For this reason, the sweet potato program at the International Institute of Tropical Agriculture (IITA) does not apply fertilizers in breeding line and cultivar field evaluations. On unfertilized experiment station fields at IITA in Nigeria, up to 50 t/ha in unfertilized fields have been reported (HAHN, et al, 1984). This yield is lower than the 85 t/ha reported on fertilized experiment station fields in the USA (COLLINS and WALTER, 1981) but is substantially greater than the 3.8 to 21.5 t/ha obtained on farmers fields throughout the world (FAO, 1980). The fact that high yielding varieties of sweet potato have been developed that grow on low organic matter soils and do not require application of N fertilizer, suggest the following : 1) existence of sweet potato genotypes efficient in foraging for soil N reserves (TSUNO, 1970), and/or 2) existence of mutually beneficial plant - N^2 - fixing microbial associations that provide N to the plant and/or enhance root growth (HILL and CROSSMAN, 1984 ; HILL et al., 1983 ; VAN BERKUM and BOOLHOOL, 1980 ; VOSE, 1983).

Associative N_2 -fixation can be defined as N_2 - fixation by free-living bacteria under the direct influence of plants. Among the many N_2 -fixing bacterial - plant associations that have been described are the associations of *Azospirillum* spp. with grasses, cereal, crops, orchard crops and sweet potatoes (HILL, et al., 1983 ; HILL and BOHLOOL, 1980, VOSE, 1983). Though inoculation studies with *Azospirillum* have note given consistent results, a number of studies have reported increased crop yields and/or N uptake in response to inoculation (CROSMANN and HILL, 1984 ; KAPULNIK et al., 1983 ; VOSE, 1983).

The objectives of this study were to compare soil and fertilizer N use efficiency of sweet potato genotypes that were developed under N fertilizer independent (FNI) and N fertilizer dependent (FND) conditions, and to evaluate the response of sweet potato growth to inoculation with *Azospirillum*.

MATERIALS AND METHODS

Experiment 1. In the spring of 1983, 197 seeds from the highest yielding cultivars developed at IITA were planted in a greenhouse at the Tuskegee Institute Experiment Station and the seedlings were transplanted to an unfertilized field in July 1983. Vine cuttings and roots from the most vigorous plants were planted/bedded in the greenhouse and further vine cuttings were made during the winter of 1983-1984 to increase the quantity of planting material. In may 1984, vine cuttings from the 27 most adapted IITA cultivars were transplanted into 1.2 x 4.2 m rows of Norfolk sandy loam (Typic Paleudult) without fertilizer addition. In October 1984, the foliage and roots were harvested. Roots were graded and roots and foliage were weighed and analysed for crude protein content.

Experiment 2. On May 15, 1984 planting material selected in 1983 from three of the most vigorous IITA (fertilizer N independent (FNI) cultivars -T2024, T2037 and T2041, and three U.S. grown cultivars - "Centennial", "Jewel", and "Rojo Blanco" (fertilizer N dependent (FND) types) were transplanted to the field. Vine cuttings were transplanted into Norfolk sandy loam into rows 1.2 x 4.2 m. The experiment was a 6 x 3 factorial with a split plot design and three replications. Main plot treatments consisted of three rates of fertilizer N (0,60 and 120 kg N/ha) and the six cultivars were subplot treatments. Fertilizer N application was split for those plots receiving 120 kg N/ha with half applied at planting and the other half 6 weeks after planting. Phosphorous and K were applied according to soil test to all treatments and weeds were controlled by hand. At 9 weeks after transplanting, petioles of the fifth leaf from the growing tip were sampled and analysed for N content using the semi-microKjeldahl procedure. Roots and foliage were harvested on September 16, 1984. Roots were graded and samples of roots and foliage were analysed for N content.

Experiment 3. "Centennial" sweet potato slips were planted into 1.2 x 4.2 m rows of Norfolk sandy loam previously limed to pH 6.5 on May 18, 1984. The experiment was a complete randomized design with four replications. The treatments consisted of three N levels (0, 40 and 80 kg/ha) applied at planting with and without *Azospirillum* inoculant and 0 kg N/ha + the inoculant medium. The inoculant was applied to the "root sorption zone" of the plants at 2, 4 and 6 weeks after transplanting. Each inoculation consisted of the application of 5 ml of the bacterial suspension per plant at the rate of 10^8 - 10^{10} cells per ml. the inoculant used was *A. brasilense* (ATCC 35629) initially isolated from sweet potato roots (HILL et al., 1983) and used in previous inoculation studies (CROSSMAN and HILL, 1984). Roots and foliage were harvested on September 30, 1984. Roots were graded and root and foliage yields determined.

Table 1. Root yields and foliage weight of the 27 highest yielding sweet potato cultivars propagated from seeds developed at the International Institute of Tropical Agriculture

Cultivar	Marketable Yield	Nonmarketable Yield	Total Yield	Foliage Fresh Weight	Protein in Roots
	mt/ha				%
T 2044	24.8	2.7	27.5	16.4	10.7
T 2074	24.7	4.6	29.3	12.3	9.7
T 2075	23.3	6.5	29.9	11.2	7.6
T 2091	20.8	14.5	35.3	12.0	8.1
T 2032	20.4	20.8	41.3	30.8	8.1
T 2098	18.7	4.5	23.2	11.5	7.4
T 2097	17.8	6.9	24.8	9.9	7.7
T 2046	16.0	6.4	22.4	13.1	6.4
T 2025	15.6	1.5	17.1	11.7	6.8
T 2083	14.3	7.1	21.4	3.1	7.9
T 2010	14.3	5.3	19.6	7.9	8.0
T 2043	11.3	3.5	14.8	8.4	13.6
T 2079	8.7	2.0	10.7	20.1	7.4
T 2174	8.5	7.8	16.4	21.2	6.7
T 2042	6.3	1.6	7.9	8.8	10.0
T 2171	5.6	5.0	10.7	8.3	7.0
T 2026	5.0	21.8	26.9	5.1	9.7
T 2166	4.6	19.3	24.0	6.0	7.4
T 2080	4.4	6.0	10.4	10.7	6.5
T 2076	4.2	12.3	16.6	7.9	7.4
T 2172	3.8	15.8	19.7	10.1	8.2
T 2077	3.1	3.4	6.5	5.9	8.7
T 2066	2.1	1.9	4.1	13.3	10.2
T 2057	1.8	3.5	5.3	14.8	8.3
T 2071	1.1	16.1	17.2	5.9	8.7
T 2059	0.9	22.2	23.1	17.1	8.6
T 2078	0.6	1.3	2.0	8.6	9.3

RESULTS AND DISCUSSION

The 27 cultivars evaluated in experiment 1 had marketable root yields, non marketable root yields, total root yields and foliage weights ranging from 1 to 25, 1 to 22, 2 to 41 and 3 to 31 mt/ha, respectively (Table 1). Highest marketable root yields were obtained from T2044 and T2074 and highest total root yields were obtained from T2032 and T2041. There was an inverse relationship between total and marketable root yields for the top five yielding cultivars. The highest biomass (roots + foliage) produced was 72 mt/ha for T2032. The percent protein in the roots and foliage ranged from 6 to 14 per cent and 13 to 22 per cent, respectively. Among to the top yielding cultivars, T2044 and T2074 had the highest root protein contents. Significant correlations were found between marketable yield and foliage protein content (Table 2). The results verify that high sweet potato root and foliage yields can be obtained from the IITA developed cultivars without fertilizer inputs, and also show that relatively high protein contents can be obtained in the high yielding varieties.

In experiment 2 the FNI cultivars T2041 and T2024 produced the highest yields at 0 kg N/ha ; the FND cultivar "Centennial" produced the highest yield at 60 kg N/ha ; and the FND cultivars "Centennial" and "Jewel" produced highest root yields at 120 kg N/ha (Table 3). At all three N levels T2037 and "Rojo Blanco" produced lower root yields than the other cultivars. At 0 kg N/ha the FNI cultivars as a group tended to outyield the FND cultivars ; at 60 kg N/ha there was little difference between the FNI and FND yields, and at 120 kg N/ha, though differencees were not significant, the FND cultivars had a 27.6 per cent greater yield than the FNI cultivars. Comparison of marketable and total root yields and foliage weight for the six cultivars is shown in Table 4. There was an inverse relationship between foliage weight and root yields (marketable and total) for the FNI cultivars, but not for the FND cultivars. The petiole N content (data not shown) was also inversely related to root yields (marketable and total) for the FNI but not the FND cultivars.

Root and foliage yields for the N rate plus inoculant treatments of experiment 3 are shown in Table 5. Though total and marketable root yields were not significantly different for the inoculant vs inoculant treatments at each N rate, there was an overall tendency for marketable ($P > 0.10$) and total ($P > 0.09$) root yields to be higher for the inoculated treatments as a group than the noninoculated treatments as a group. The 0 kg N/ha plus inoculant treatment produced significantly higher marketable and total root yields than the 0 kg N/ha plus the medium used for bacterial growth. This showed that increases in yield were due to the presence of the bacteria in the medium and not the medium itself. Foliage yields for inoculated treatments were significantly lower at 0 kg N/ha and tended to be lower at 40 kg N/ha than treat-

Table 2. Correlation coefficients of root yields, foliage weight, percent protein in roots and foliage and percent dry matter of the 27 highest yielding sweet potato cultivars propagated from seeds developed at the International Institute of Tropical Agriculture

	Marketable Yield	Total Yield	Foliage Weight	Protein In Roots	Protein In Foliage	Dry Matter
Marketable Yield	---	0.72***	0.28	-0.03	-0.36**	-0.28
Total Yield		----	0.31*	-0.11	-0.20	-0.27
Foliage Weight			-----	-0.15	-0.10	-0.28
% Protein in Roots				----	-0.21	-0.10
% Protein in Foliage					-----	0.05
% Dry Matter						----

* Significant at the 10% level.

** Significant at the 6% level.

*** Significant at the 1% level.

Table 3. Yield of FNI and FND* sweet potato in response to fertilizer N rate.

Cultivars	N rate (kg N/ha)		
	0	60	120
	----------t/ha----------		
T2024	22.5^{ab}**	23.2^{ab}	16.7^{ab}
T2037	15.4^{b}	14.2^{b}	9.4^{b}
T2041	22.9^{a}	24.4^{ab}	21.5^{ab}
Centennial	19.9^{abc}	28.1^{a}	23.2^{a}
Jewel	16.5^{abc}	22.1^{ab}	22.5^{a}
Rojo Blanco	15.0^{c}	14.0^{b}	14.0^{ab}
NFI	20.3	20.6	15.6
NFD	17.2	21.4	19.9
P > F	0.10	N.S.	N.S.

* FNI = Fertilizer nitrogen independent
FND = Fertilizer nitrogen dependent

** Figures with the same letter in the same column are not significantly different at the 5% level by the Duncans Multiple Range Test.

ments without inoculation. At 80 kg N/ha differences in foliage were not notable for the inoculated and non inoculated treatments. The soil $NH_4^+ + NO_3$ - N level was 26 ug g^{-1} at transplanting, suggesting a relatively low residual N index (MASCIANICA et al., 1985). Thus the high root and foliage yields in the control plots (0 kg N/ha without inoculant) suggests that "Centennial" is a good forager for nutrients (TSUNO, 1970), and/or can promote endogenous microbial - plant root associations that enhance root growth and N uptake (HILL and CROSSMAN, 1984 ; VOSE, 1983). The lower foliage yield and higher root yield in response to the inoculant treatment at 0 and 40 kg N/ha N suggest that the *Azospirillum* inoculant enhances sweet potato storage root growth at the expense of foliage growth when applied with low to moderate N fertilizer levels to soils with relatively low residual N index.

Table 4. Root and Foliage Yield and N concentration in Petiole of FNl and FND* Sweet Potato Genotypes

	Total Yield	Marketable Yield	Foliage Weight
	----------(mt/ha)----------		
T2037	13.00 b**	8.75[b]	24.8[a]
T2041	22.92[a]	17.15[a]	17.6[b]
T2024	20.78[a]	13.34[ab]	20.0[ab]
Rojo Blanco	14.34[b]	11.32[ab]	17.6[ab]
Jewel	20.39[a]	15.29[a]	20.0[ab]
Centennial	23.74[a]	16.08[a]	16.8[ab]

* FNI = Fertilizer nitrogen independent

FND = Fertilizer nitrogen dependent

** Figures with same letter in the same column are not significantly different at 5% level by the Duncans Multiple Range Test.

Table 5. Total and marketable root yields and foliage weights of 'Centennial' sweet potato in response to fertilizer N rate and inoculation with *Azospirillum brasilense*

Treatments	Total Yield	Marketable Yield	Foliage Fresh Weight
	(mt/ha)		
0 kg N/ha + medium	24.8	19.1	14.4
0 kg N/ha + inoculant	34.1	28.1	13.2
0 kg N/ha	30.2	24.6	22.0
40 kg N/ha + inoculant	30.8	25.4	16.8
40 kg N/ha	29.2	23.9	23.2
80 kg N/ha + inoculant	33.0	28.6	20.8
80 kg N/ha	28.0	22.1	16.8
LSD (.05)	7.0	8.1	4.4
LSD (.10)	5.8	6.7	3.6
With inoculant	32.6	27.4	16.8
Without inoculant	29.2	23.5	20.6
P > F	0.09	0.10	0.14

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