porary trees before their removal.

Pruning results in long, vigorous shoots. In lateral-bearing cultivars, these shoots are capable of producing many nuts during the year after pruning. Our yield data indicate that biennial pruning takes advantage of this bearing habit by allowing maximum production in the year following nonpruning and renewal of fruitwood without sacrificing production in the year following pruning. Although nut quality was highest in the annually pruned treatment, biennial treatments had the highest production. Pruning weights from the biennially pruned trees averaged ≈9 kg more per tree in the year trees were pruned than the annually pruned trees, but the time involved to prune a hectare of trees was nearly the same (data not presented).

Pruning labor for biennially pruned treatments was half that of annual pruning, since it was done only every other year. The increased production, compared to no pruning, with the moderate reduction in nut quality and half the labor of annual pruning makes biennial pruning of mature lateral-bearing walnut trees. an attractive alternative to annual pruning, and a practice clearly better than continued nonpruning.

Alternate bearing is a concern with alternate-year pruning. In this experiment, we observed that pruning biennially following the years of low production reduced the alternate-bearing tendency, while pruning biennially following the years of high production accentuated it. Kuykendall (1973) and Worley (1984) have reported similar observations with pecan. Consequently, when considering a change to or initiating a biennial pruning program, one should also consider the previous cropping history of the walnut orchard.

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Sweetpotato Growth and Nitrogen Content Following Nitrogen Application and Inoculation with *Azospirillum*

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Abstract. **The influence of *Azospirillum* inoculation on sweetpotato *Ipomoea batatas* (L.) Lam.] was evaluated in combination with fertilizer N rates of 0, 40, and 80 kg·ha^{-1}. Plants were inoculated with 5 ml of the inoculant at 2, 4, and 6 weeks after transplanting. Inoculation increased total and marketable yield by 12% and 17%, respectively, in 1984 and 5% and 22%, respectively in 1985. Higher storage root yields were accompanied by lower foliage yields, which suggested the inoculant may enhance storage root growth at the expense of foliage growth on soils with low to moderate N levels (40 to 80 kg·ha^{-1}). Storage root N (1984 and 1985) and leaf N (1985) were higher for 40 kg N/ha with inoculation than with inoculation alone (treatments 4 vs. 2), which suggested that *Azospirillum* plus fertilizer N increased the N content of the plants.**

N-fixing bacteria are associated with roots of nonleguminous tropical and temperate plants. Nitrogen-15 incorporation and ^{15}N isotope dilution methods have demonstrated N incorporation into several grass and cereal crops (Dobereiner and Pedrosa, 1987). Inoculation of cereal and grass crops with the N-fixing bacteria *Azospirillum* results in increased plant growth, yield, and N concentration (Barber et al., 1979; Kapulnik et al., 1983; Millet et al., 1984), although results have been inconsistent (Dobereiner and Pedrosa, 1987). Crossman and Hill (1987) found that inoculation of sweetpotato with *Azospirillum* increased N content, storage root yield, and foliage weight, depending on cultivar and inoculant strain used. Results from several studies suggest that *Azospirillum* may enhance plant growth by contributing growth hormones, such as cytokinins or auxins (Bouton et al., 1979, 1985; Tien et al., 1979). Our objective was to determine the effects of *Azospirillum* inoculation and N rates on storage root yield, foliage weight, and N content of sweetpotatoes.

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Two experiments were conducted at the George Washington Carver Agricultural Experiment Station at Tuskegee Univ., Tuskegee, Ala., in 1984 and 1985. 'Centennial' sweetpotato slips were planted into Norfolk sandy loam (Typic Paleudult), previously limed to pH 6.5, using 0.3-m spacing within rows 1.2 m apart (≈ 29,000 plants/ha). A completely randomized design with six treatments and four replications was used. The treatments consisted of three N levels (0, 40, and 80 kg·ha^{-1}) applied at planting (one half at planting, with the remainder applied 6 weeks thereafter for the highest rate) and combined with *Azospirillum brasilense* inoculum, no inoculum, or with an autoclave medium. The inoculum was applied manually into the root sorption zone of the same plants at 2, 4, and 6 weeks after transplanting. Each inoculation consisted of the application of 5 ml of the bacterial suspension (TI-Sp-7, ATCC 35629) per plant at the rate of 10^{5} to 10^{10} cells/ml. Phosphorus and potassium were applied, based on soil tests, at 40 and 148 kg·ha^{-1}, respectively. Field plots were not irrigated either year, but 1985 was a relatively dry growing season compared with 1984 (453 mm vs. *559* mm).

The bacterial suspension was prepared by incubating a loopful of the bacteria in 20 ml of a semisolid malate medium for 48 hr at 30C. The chemical composition of the semisolid malate medium was similar to that of van Berkum (1980), and the pH of the medium was adjusted to 6.8 with NaOH. The inoculum was prepared by quantitatively transferring the entire 20 ml into the required

Table 1. Means and contrasts of total and marketable yields ($t \cdot ha^{-1}$) foliage fresh weight ($t \cdot ha^{-1}$), and N concentration (%) in leaves and roots of 'Centennial' sweetpotato in response to fertilizer N rates ($kg \cdot ha^{-1}$) and inoculation with *A. brasilense.*

Treatment no.	N rate	Inoculation	Root yield Total 1984	Root yield Total 1985	Root yield Marketable 1984	Root yield Marketable 1985	Foliage fresh wt 1984	Foliage fresh wt 1985	N concn Leaves At 9 wks 1984	N concn Leaves At 9 wks 1985	N concn Leaves At harvest 1984	N concn Leaves At harvest 1985	N concn Roots 1984	N concn Roots 1985
1	0	No[z]	24.8	17.4	19.1	10.2	12.3	20.0	2.88	2.56	2.16	2.55	0.60	0.66
2	0	Yes	34.1	22.2	28.1	17.0	10.9	14.9	3.45	3.04	2.20	2.53	0.60	0.61
3	40	No	29.2	20.1	23.9	13.1	19.4	18.2	2.61	3.33	2.34	3.29	0.64	0.90
4	40	Yes	30.8	16.7	25.4	10.8	14.1	13.9	3.83	2.94	2.94	2.92	0.84	0.95
5	80	No	28.1	20.1	22.1	13.9	14.3	25.3	3.52	3.39	2.41	3.15	0.63	1.21
6	80	Yes	33.0	19.0	28.6	13.5	17.4	29.3	2.37	2.81	2.32	4.10	0.62	1.00
Treatment contrasts														
1 vs. 2			0.01	0.10	0.03	0.17	---	---	---	---	---	---	---	---
4 vs. 2			---	---	---	---	---	---	---	---	0.01	---	0.06	0.05
6 vs. 2			---	---	---	---	---	0.02	0.02	---	---	0.05	---	0.02
3 vs. 2			---	---	---	---	0.03	---	0.07	---	---	---	---	0.09
5 vs. 2			0.08	---	---	---	0.09	0.07	---	---	---	---	---	0.002
4 vs. 3			---	---	---	---	---	---	0.01	---	0.04	---	---	---
6 vs. 5			---	---	---	---	0.02	---	---	---	---	---	---	---
Inoculation			32.6	19.3	27.4	13.8	16.8	19.4	3.22	2.93	2.49	3.18	0.69	0.85
Noninoculation			29.2	18.4	23.5	11.3	20.6	19.9	3.14	3.24	2.32	3.23	0.63	0.96
P > F			0.09	NS	0.01	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]Autoclave medium.

amount of inoculant needed, based on 5 ml/plant, then incubated for 48 hr at 30C. The inoculum was continuously stirred to provide proper aeration for growth.

Leaf samples were selected from all plots each year. Each sample consisted of the fifth fully opened leaf from the end of the vine of four plants at 9 weeks after transplanting and at harvest. Storage root samples (25 g) were randomly selected at harvest. These samples were cleaned, dried, ground, and analyzed for total N, including nitrate and nitrite, using a modified semimicro version of the method of Bremmer (1965).

Storage root yield and foliage weight data were obtained from roots and foliage harvested 120 days after transplanting. Storage roots were graded according to the guidelines of the National Sweet Potato Collaborators Group into marketable (U.S. No. 1, canners, and jumbos) and nonmarketable (culls and cracks), and root and foliage yields were determined. All data were subjected to analysis of variance, and mean separation was determined using orthogonal contrasts (Steel and Torrie, 1980).

Plants receiving inoculum only produced higher total and marketable root yields than the controls in 1984 and showed a similar trend in 1985 (treatment 1 vs. 2; Table 1). Differences in storage root yields were similar in both years for the inoculated and noninoculated treatments (treatment 3 vs. 2), when the latter was supplemented with 40 kg N/ha, but foliage yield was significantly lower in 1984, for the inoculant alone. There were trends for a higher total root yield in 1984 and lower foliage yields in 1984 and 1985 for inoculation alone compared to 80 kg N/ha (treatment 5 vs. 2). In 1984 and 1985, the soil $NH_4 + NO_3$-N levels were 26 and 35 $\mu g \cdot g^{-1}$, respectively, at transplanting, suggesting a relatively low to moderate N index (Mascianica et al., 1985). These results suggest that *Azospirillum* inoculation alone enhanced sweetpotato storage root growth, but did not enhance foliage growth when applied to soils with low to moderately high available N levels.

At harvest, the storage root N in 1984 and 1985 and leaf N in 1984 were higher for 40 kg N/ha with inoculation than for inoculation alone (treatment 4 vs. 2; Table 1). For the same treatments, differences in storage root yield and vine weight were not significant, indicating the fertilizer N with inoculant increased N uptake but did not influence yield or weight of roots or foliage, when compared to inoculant without fertilizer N. Other contrasts for N concentration did not show consistent differences for the two years of this study. These results suggest that the inoculation with *Azospirillum* contributes to sweetpotato root growth by mechanisms other than supplying N; stimulation of growth by growth hormones, as noted earlier, may be one such mechanism.

Inconsistent responses to inoculation with *Azospirillum* have been observed for several grass and cereal crops and have been attributed to inadequate methods for strain selection or higher indigenous *Azospirillum* populations in soil (Dobereiner and Pedrosa, 1987). Previous work by Crossman and Hill (1987) showed that sweetpotato plants receiving inoculation of two *Azospirillum* strains (ATCC 35629 and ATCC 35630) produced higher storage root yields than the single ATCC 35629 strain used in this study.

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