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EFFECT OF INOCULATION AND APPLIED NITROGEN ON YIELD, GROWTH AND NITROGEN FIXATION OF TWO PEANUT CULTIVARS

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ABSTRACT

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Applications of ammonium nitrate (108 kg/ha application) and commercial inoculum (11.2 kg/ha) were made to the peanut (*Arachis hypogaea* L.) cvs. 'Argentine' (spanish) and 'Florigiant' (virginia) in 1978 and 1979. Both cultivars nodulated abundantly, even in the absence of inoculation, but plants of the cv. Florigiant were generally larger, yielded more, had a higher harvest index, and showed greater nodulation and higher $N_2(C_2H_2)$ fixation values than those of cv. Argentine. Inoculation did not increase plant weight or yield, though N_2 fixation traits were improved in 1 year. Applications of nitrogen increased plant weight 49% in 1978 and 24% in 1979 and fruit yield by 37% in 1978 and 31% in 1979 but reduced harvest index from 37 to 34.9% in 1978 and reduced N_2-fixing traits in both years.

There is no evidence from this study to indicate any need for inoculation to peanuts in soils with high populations of the appropriate *Rhizobium*. However, the increase in plant weight and fruit yield with the application of nitrogen, although not economic, suggests that either the peanut-rhizobia symbiosis does not fix enough nitrogen for maximum yield or that fixed nitrogen is not utilized as efficiently as fertilizer nitrogen.

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) grown in soils previously cropped with this species rarely require inoculation (Thornton, 1963; Reid and Cox, 1973; Van der Merwe et al., 1974; Walker et al., 1976) or nitrogen fertilization (Schiffmann, 1961; Reid and Cox, 1973). However, Elkan et al. (1980) have demonstrated that single strain isolates of *Rhizobium*, applied at high rates, can increase nodulation and nitrogenase activity in soils which already con-

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tain large populations of rhizobia. The genotype of the peanut has been shown to influence response to both nitrogen fertilization and nitrogen fixation (Duggar, 1935a, b; Erdman, 1943; Chomchalow, 1971; Burton, 1975; Wynne et al., 1980).

Date (1976) described a trial using uninoculated, inoculated and nitrogen fertilization treatments to determine the need for inoculation and to estimate the effectiveness of the native rhizobia. This study applies this methodology to two genetically diverse peanut cultivars grown in soils containing native rhizobia.

MATERIALS AND METHODS

Experiments were conducted in 1978 and 1979 at the Central Crops Research Station, Clayton, NC using both a spanish ('Argentine') and a virginia ('Florigiant') cultivar. Standard cultural practices were employed both years. Plots consisted of two rows in 1978 and a single row in 1979. Each row contained 10 plants. Rows were 90.4 cm apart and plants within a row were 25.4 cm apart. Plants to be inoculated received 11.2 kg/ha Nitragin® granular peat-based peanut inoculant No. LX579 at planting. Plants in the nitrogen treatment received approximately 108 kg NH_4NO_3/ha, hand applied, of CF Industries® pelleted ammonium nitrate (34% nitrogen) at planting and equivalent amounts at monthly intervals thereafter.

The experimental site was a Plinthic Paleudult with clay present from 35 to 45 cm and plinthinite detected between 120 to 150 cm. Soil analysis indicated that macro- and micronutrients in the rooting zone were above the critical level required for peanut production.

The experimental design was a four-factor factorial arranged in a split-split-split plot with four replicates. Sampling dates were assigned to whole plots. Sampling began 4 weeks after emergence and continued at monthly intervals with the final sampling for N_2 fixation traits at 112 days after emergence in 1978 and 140 days after emergence in 1979. Peanut cultivars were assigned to subplots, nitrogen application to sub-subplots, and *Rhizobium* to sub-sub-subplots.

Two 2-plant samples were dug by hand from each plot at monthly intervals to determine the nitrogen fixation traits. N_2-fixed (μM C_2H_4/h per plant) was measured for the root system of the two plants using an acetylene reduction methodology modified slightly from that of Isleib et al. (1980). In addition to N_2 fixed, nodule number and mass (g), and specific activity (μM C_2H_4/g nodule/h) were measured for each plant.

Five plants were randomly selected from each plot at final harvest for the growth traits. Plants and fruit were dried in a forced air dryer at approximately 70°C and then weighed. Traits measured were plant weight (g) and fruit yield (g per plant). Harvest index was computed as the ratio of fruit yield to entire plant weight × 100.

TABLE I

Means over cultivars for nitrogen-fixation traits for five sampling dates during growing season

Sampling date (days after emergence)	Nodule number		Nodule mass		$N_2(C_2H_2)$ fixed (μM C_2H_4/h per plant)		Specific activity (μM C_2H_4/g/h per plant)	
	1978	1979	1978	1979	1978	1979	1978	1979
28	50.1b	17.6c	0.7b	1.2c	1.4c	0.4d	27.9a	2.8e
56	215.1b	37.5c	5.3b	2.0c	9.5c	3.1c	15.6b	13.9b
84	1153.5a	128.6b	28.7a	4.7b	58.8a	5.9b	21.9ab	10.5c
112	988.1a	290.2a	25.7a	8.1a	34.7b	13.4a	14.7b	17.0a
140	—	199.7b	—	6.0b	—	5.1bc	—	7.6d

Means within years followed by the same letter are not significantly different at the 5% level of probability using the *F*-protected LSD test.

RESULTS AND DISCUSSION

During the 1978 growing season, nodulation (nodule mass and number) $N_2(C_2H_2)$ fixed and specific activity increased until a peak was reached at 84 days after emergence or at early fruit fill (Table I). All traits measured decreased on the final sampling date. In 1979, when nodulation and $N_2(C_2H_2)$ fixation were low, these traits continued to increase until 112 days after emergence or approximately early fruit fill. All nitrogen-fixing traits decreased on the final sampling date. This variation is probably due to environmental differences or possibly to location within the field.

As in previous studies (Wynne et al., 1980), the virginia cultivar Florigiant was significantly ($P > 0.05$) better in nodulation, $N_2(C_2H_2)$ fixed, specific activity and growth (plant weight, fruit yield and harvest index) except for plant weight in 1979 than the spanish cultivar Argentine (Table II). Differences in $N_2(C_2H_2)$ fixed between the cultivars were evident early in the growing season and continued until harvest (Fig. 1).

Application of nitrogen fertilizer decreased all nitrogen-fixation traits by approximately 50% in each growing season (Table II). The decrease was not the same for both cultivars as indicated by a significant ($P > 0.01$) cultivar × nitrogen interaction for specific activity in 1978, nodule mass in 1978 and 1979, and for $N_2(C_2H_2)$ fixed in 1979. Reductions were always greater for the spanish cultivar, Argentine. Reduction in nodulation and nitrogen fixed with the addition of nitrogen fertilizer is consistent with the results found for other grain legumes (Allos and Bartholomew, 1955). Plant weight and fruit yield were significantly ($P > 0.01$) increased by the application of nitrogen (Table II), but harvest index was significantly decreased during 1978 though not in 1979.

Inoculation had no effect on plant weight, fruit yield and harvest index in either growing season (Table II), but caused a significant ($P > 0.01$) increase in nodule number, $N_2(C_2H_2)$ fixed and specific activity in 1979. No significant inoculum effects were observed in 1978 except for an unexplained reduction in the number of nodules. A differential response to inoculum for the 2 years indicates that the effect of commercial peanut *Rhizobium* is dependent upon environmental factors.

Plant weight and fruit yield were not increased by inoculation in the presence of native soil rhizobia infective for peanut, a finding similar to those of earlier investigations (Thornton, 1963; Reid and Cox, 1973; Van der Merwe et al., 1974; Walker et al., 1976). The increase in nitrogen fixation in one season without a subsequent increase in plant weight or yield suggests that researchers should be cautious in equating increases in biological nitrogen fixation with yield increases in grain legumes.

While the N levels applied in this trial were above those commercially recommended, the increase in plant weight and yield with the application of nitrogen indicates that shortage of nitrogen may be limiting productivity even though there is no response from inoculation. This clearly demonstrates that

TABLE II

Cultivar, nitrogen and inoculum means over all treatments for nitrogen fixation and growth traits

Treatment	Nodule number		Nodule mass (mg per plant)		$N_2(C_2H_2)$ fixed (μM C_2H_4/h per plant)		Specific activity (μM C_2H_4/g/h per plant)		Plant weight (g per plant)		Fruit yield (g per plant)		Harvest index (%)	
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
Cultivar:														
Argentine	429.5b	68.4b	9.7b	2.6b	19.2b	3.0b	22.0a	8.5b	200.6b	195.2a	66.7b	73.7b	33.0b	38.7b
Florigiant	773.9a	201.0a	20.5a	6.2a	33.0a	8.2a	18.1b	12.2a	355.3a	243.6a	136.0a	116.1a	38.9a	47.8a
Nitrogen:														
None	746.8a	179.3a	19.4a	6.0a	36.2a	7.9a	24.3a	12.0a	223.6b	196.2b	85.4b	85.7b	37.0a	43.3a
Applied	456.6b	90.1b	10.8b	2.8b	16.0b	3.2b	15.7b	8.7b	332.3a	242.6a	117.4a	104.1a	34.9b	43.0a
Inoculum:														
None	643.7a	93.7b	15.2a	4.0a	25.7a	4.4b	19.8a	9.0b	283.2a	211.4a	103.4a	89.1a	35.6a	42.8a
Applied	559.7b	175.7a	15.0a	4.8a	26.5a	6.8a	20.2a	11.8a	272.7a	227.4a	99.4a	100.7a	36.2a	43.4a

Means within years followed by the same letter are not significantly different at the 5% level of probability using the *F*-protected LSD test.

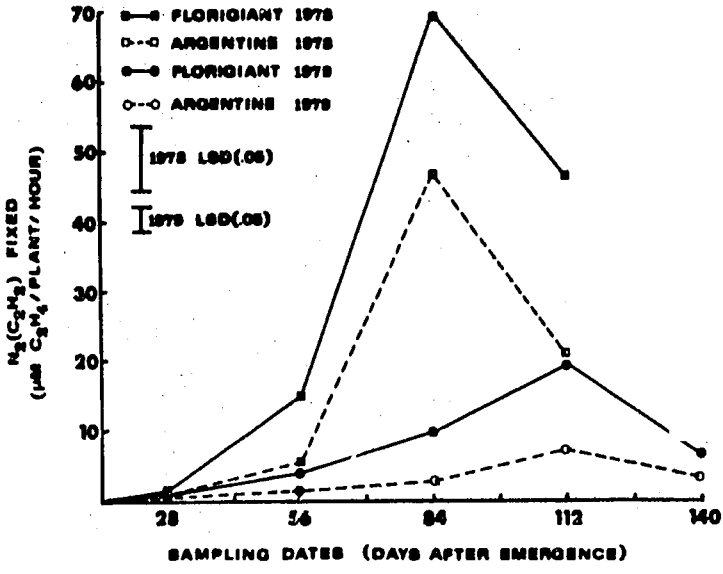

Fig. 1. Comparison of $N_2(C_2H_2)$ fixation for Florigiant and Argentine over sampling dates.

increases in productivity could occur from increased efficiency of the peanut-rhizobia symbiosis. From previous studies we concluded that approximately 25% of the variability in yield of peanuts can be accounted for by variation in nitrogen fixation (Wynne et al., 1982). Increases in the efficiency of symbiosis could lead to substantial increases in peanut yields. The greater response to nitrogen by the spanish cultivar which was lower in nitrogen-fixing capacity suggests that greater yield increases could occur for spanish cultivars with increased nitrogen fixation.

Nitrogen was applied on a monthly basis during this study. Additional studies are needed to determine if there is a critical stage of plant development when nitrogen is required to increase yield. Application of nitrogen at various growth stages of the peanut would indicate where efforts are needed to increase biological nitrogen fixation to maximize productivity.

REFERENCES

Allos, H.F. and Bartholomew, W.V., 1955. Effect of available nitrogen on symbiotic fixation. Proc. Soil Sci. Soc. Am., 19: 182–184.

Burton, J.C., 1975. Pragmatic aspects of the *Rhizobium* leguminous plant association. In: W.E. Newton and C.J. Nyman (Editors), Proc. First Int. Symp. Nitrogen Fixation, 1, pp. 429–446.

Chomchalow, S., 1971. The effectiveness of introduced *Rhizobium* strains on 'Rayong' peanut. Thai J. Agric. Sci., 4: 85–94.

Date, R.A., 1976. Principles of *Rhizobium* strain selection. In: P.S. Nutman (Editor), Symbiotic Nitrogen Fixation in Plants. Cambridge Univ. Press, Cambridge, pp. 137–150.

Duggar, J.F., 1935a. The nodulation and other adaptations of certain summer legumes. J. Am. Soc. Agron., 27: 32—37.

Duggar, J.F., 1935b. Nodulation of peanut plants as affected by variety, shelling of seed and disinfection of seed. J. Am. Soc. Agron., 27: 286—288.

Elkan, G.H., Wynne, J.C., Schneeweis, T.J. and Isleib, T.G., 1980. Nodulation and nitrogen fixation of peanuts inoculated with single strain isolates of *Rhizobium*. Peanut Sci. 7: 95—97.

Erdman, L.W., 1943. New developments in legume inoculation. Soil Sci. Soc. Am. Proc., 8: 213—216.

Isleib, T.G., Wynne, J.C., Elkan, G.H. and Schneeweis, T.J., 1980. Quantitative genetic aspects of nitrogen fixation in peanuts. Peanut Sci., 7: 101—105.

Reid, P.H. and Cox, F.R., 1973. Soil properties, mineral nutrition and fertilizer practices. In: Peanuts — Culture and Uses. Am. Peanut Res. Educ. Assoc., Stillwater, OK, pp. 271—297.

Schiffmann, J., 1961. Field experiments on inoculation of peanuts in northern Negro soils. Isr. J. Agric. Res., 11: 151—158.

Thornton, J., 1963. Some observation on groundnut nodulation in Gambia. Oleagineux, 18: 781—783.

Van der Merwe, S.P., Strijdom, B.W. and Uys, C.J., 1974. Groundnut response to seed inoculation under extensive agricultural practices in South African soils. Phytophylactica, 6: 295—302.

Walker, M.E., Minton, N.A. and Dowler, C.C., 1976. Effects of herbicides, a nematicide and *Rhizobium* inoculant on yield, chemical composition and nodulation of Starr peanuts (*Arachis hypogaea* L.). Peanut Sci., 3: 49—51.

Wynne, J.C., Elkan, G.H. and Schneeweis, T.J., 1980. Increasing nitrogen fixation of the groundnut by strain and host selection. In: Proc. Int. Workshop Groundnuts. ICRISAT Andhra Pradesh, India, pp. 95—109.

Wynne, J.C., Ball, S.T., Elkan, G.H., Isleib, T.G. and Schneeweis, T.J., 1982. Host and host plant factors affecting nitrogen fixation of the peanut. In: P.H. Graham and H.C. Harris (Editors), Biological Nitrogen Fixation Technology for Tropical Agriculture. CIAT, Cali, Colombia, pp. 67—75.

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