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INSTITUTION: Auburn University

PROJECT TITLE: Effects of Drought Stress on Symbiotic Nitrogen Fixation in Peanut

RES. AGR. NO.: APPA-RIA03-PID 415 BID 1317
PROJECT LEADER: Drs. Yucheng Feng and Charles Chen

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FINAL REPORT For Year 2:

Summary

Drought stress is one of the major environmental factors affecting peanut productivity and its effect can be economically devastating when occurring at critical growth stages. The objective of this study was to evaluate the effects of drought stress on symbiotic nitrogen fixation in various peanut genotypes. Three drought treatments (irrigated control, middle-season and late-season drought) were applied to three separate rainout shelters. Two parental lines (Tifrunner and C76-16) and 14 recombinant lines (seven drought susceptible and seven drought tolerant genotypes) were planted in rainout shelters using a randomized complete block design within each drought treatment. The ^{15}N natural abundance technique was used to evaluate differences in symbiotic nitrogen fixation among different genotypes under drought stress. Both drought treatments negatively affected symbiotic nitrogen fixation; the middle-season drought treatment showed a greater reduction in the amount of N fixed compared with the late-season drought treatment. Proportions of shoot N derived from the atmosphere varied among different genotypes. Under middle-season drought, shoot N derived from N_2 fixation for the drought tolerant lines was higher than those for the susceptible lines. The most drought tolerant line identified in our previous yield study had the highest N-fixing capacity under both drought treatments. There was no correlation between shoot N derived from N_2 fixation and total shoot N in the drought treatments although they were correlated in the irrigated treatment. Our results suggest that drought stress had a negative effect on symbiotic nitrogen fixation in peanut and the effect was more severe for mid-season drought.

Introduction

Peanut plants form symbiotic relationships with rhizobia, resulting in the fixation atmospheric nitrogen, thus reducing or eliminating the need for nitrogen fertilization. Symbiotic nitrogen fixation is affected by the rhizobial strain involved, the genotype of the host plant, and environmental conditions. Different nitrogen fixation capabilities have been observed in different peanut cultivars. Symbiotic nitrogen fixation is known to be sensitive to soil drying, which tends to occur in sandy soils where peanut is commonly grown. Maximizing symbiotic nitrogen fixation during the development of high-yielding peanut cultivars is critical for obtaining high yields without the application of expensive nitrogen fertilizers in peanut production. In Year 2 of this three-year project, we determined the effects of drought stress on symbiotic N_2 fixation in various peanut cultivars.

Materials and Methods

We have conducted the rainout shelter experiment to evaluate the effects of middle- and late-season drought on symbiotic N_2 fixation at the USDA National Peanut Lab in Dawson, GA. Three drought treatments (irrigated control, middle-season and late-season drought) were applied to three separate rainout shelters. Two parental cultivars (Tifrunner and C76-16), seven drought susceptible and seven drought tolerant peanut genotypes were planted. Middle- and late-season drought stress treatments were initiated 61 and 103 days after planting (DAP), respectively. Each drought treatment lasted for four weeks. Peanut plants were harvested at the end of each drought treatment and two weeks after each drought treatment ended. The two parental lines under irrigation were sampled five times during the season to determine the effect of growth stage on symbiotic N_2 fixation. Shoot samples were washed, oven-dried and weighed to obtain biomass data. The samples were then ground up and analyzed for total N and ^{15}N natural abundance. The proportion of shoot N derived from N_2 fixation was calculated using the 15N data.

Results

Drought stress negatively affected symbiotic N_2 fixation in peanut for both middle and late season drought treatments; the impact of middle-season drought was greater than that of late-season (Figure 1). The proportions of shoot N derived from N_2 fixation for individual genotypes also differed significantly (Figure 2). The drought resistant genotypes performed better in terms of N_2 fixation for the middle season drought than the late season drought. The most drought tolerant line (genotype 587) identified in our previous yield study had the highest N-fixing capacity under both drought treatments. For the middle season drought treatment, N_2 fixation did not recover after irrigation resumed except for genotype 506 (Figure 3a). For the late season drought treatment, N_2 fixation in four genotypes showed recovery effect, three of which were drought resistant genotypes (Figure 3b). The difference in N_2 fixation between middle and late season treatments may be explained by the difference in environmental conditions (Figure 4). During the late season drought treatment, the soil temperatures were lower and soil moisture levels were higher compared with the middle season drought treatment. There was no correlation between the proportion of shoot N derived from N_2 fixation and total shoot N in the drought treatments although they were correlated in the irrigated treatment. The effect of drought stress on shoot biomass varied among genotypes.

Under irrigated conditions, the drought tolerant cultivar C76-16 obtained less N from N_2 fixation than Tifrunner. C76-16 obtained a larger proportion of N from N_2 fixation than Tifrunner at the end of the mid-season drought treatment, but no significant difference was found at the end of late-season drought treatment.

Taken together, our results suggest that drought stress had a negative effect on symbiotic nitrogen fixation in peanut and the effect was more severe for mid-season drought.

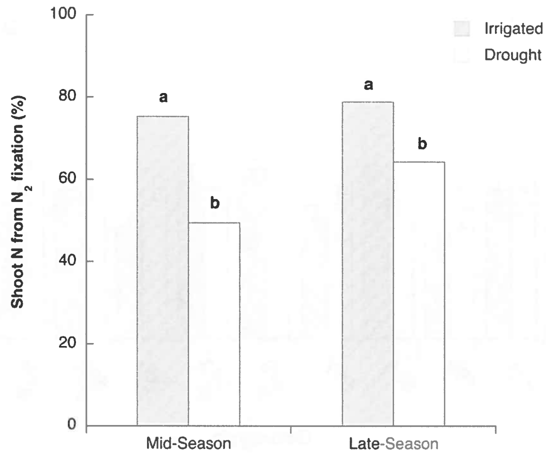


Figure 1. Average response of peanut genotypes to drought stress as indicated by symbiotic nitrogen fixation.

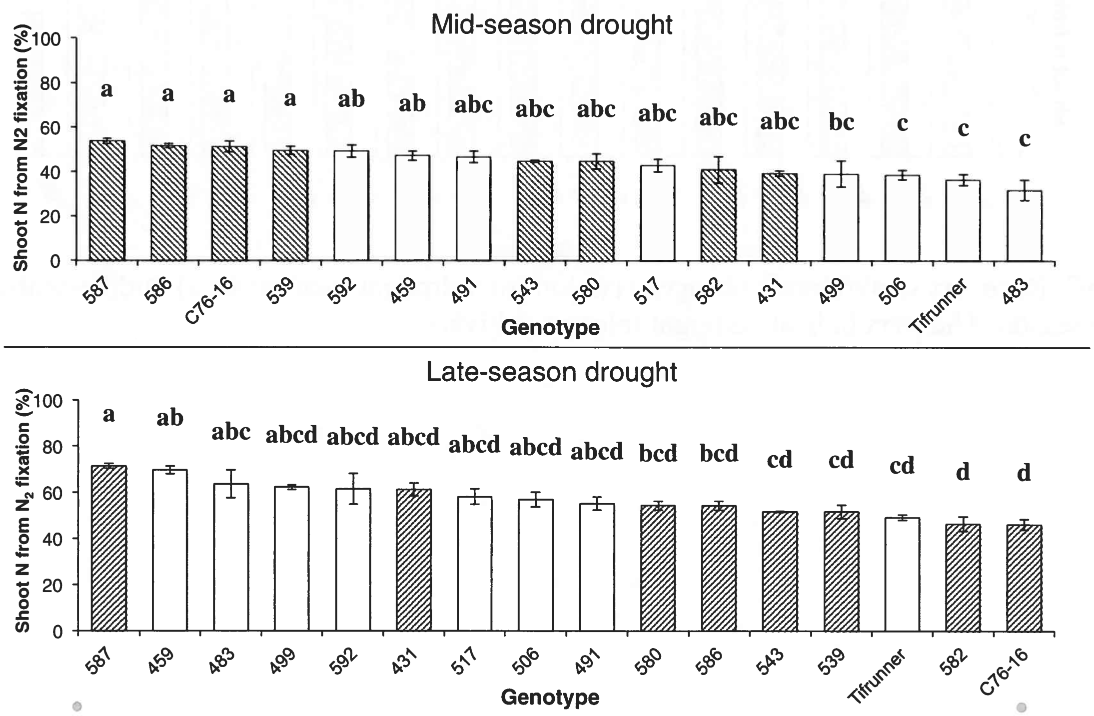
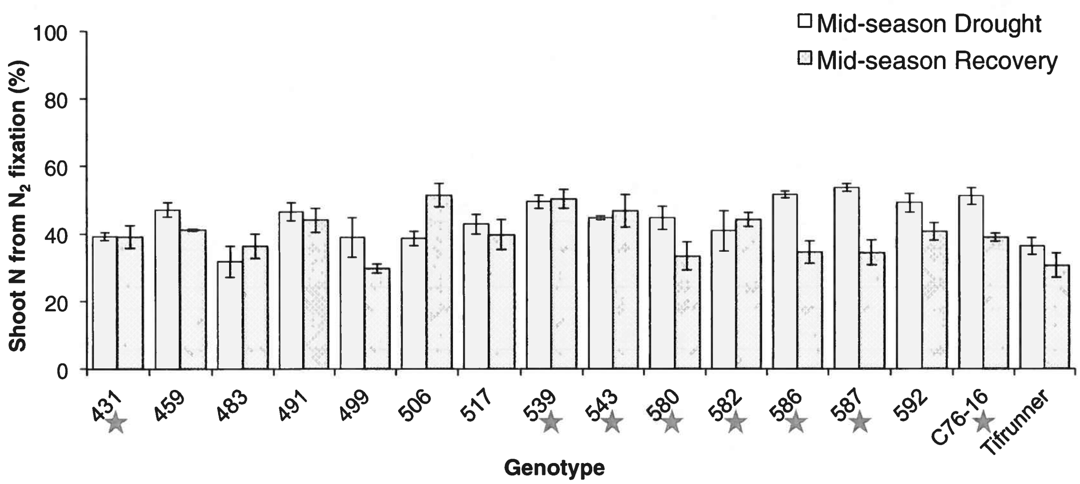


Figure 2. Effect of middle and late season drought on individual peanut genotypes. The filled columns indicate drought resistant cultivars.

a)



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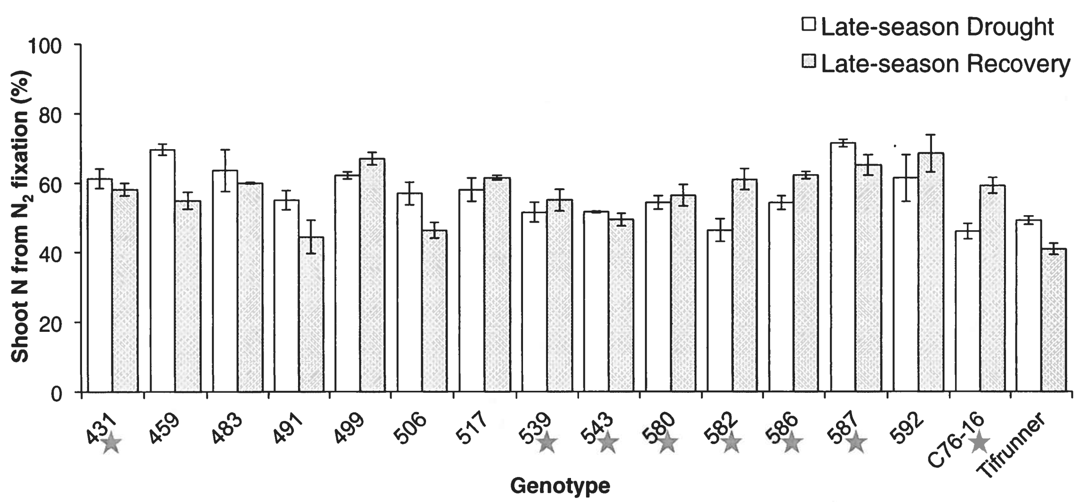

Figure 3. Recovery of symbiotic nitrogen fixation from drought treatments: a) middle-season and b) late season. The stars indicate drought tolerant cultivars.

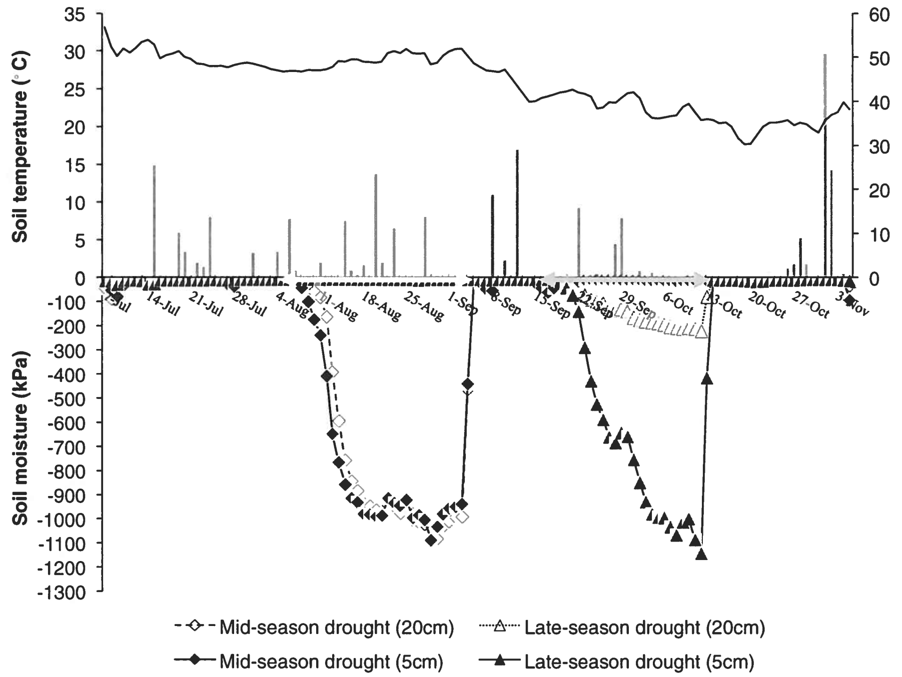

Figure 4. Precipitation and soil moisture (at 5 and 20 cm) and temperature (at 20 cm) during the study period in 2015.