Seasonal pattern of nitrogen mineralization and soil moisture beneath *Faidherbia albida* (syn *Acacia albida*) in central Malawi

C. RHOADES  
*Institute of Ecology, University of Georgia, Athens, GA 30602-2202, USA*

**Key words:** *Faidherbia albida* parcland, soil nitrogen mineralization, soil moisture

**Abstract.** On fertile alluvial soils on the lakeshore plain of Malawi, maize (*Zea mays* L.) yields beneath canopies of large *Faidherbia albida* (syn *Acacia albida*) trees greatly exceed those found beyond tree canopies, yet there is little difference in soil nutrients or organic matter. To investigate the possibility that soil nutrient dynamics contribute to increased maize yields, this study focused on the impact of *Faidherbia albida* on nitrogen mineralization and soil moisture from the time of crop planting until harvest. Both large and small trees were studied to consider whether tree effects change as trees mature.

During the first month of the rainy season, a seven-fold difference in net N mineralization was recorded beneath large tree canopies compared to rates measured in open sites. The initial pulse beneath the trees was 60 µg N g⁻¹ in the top 15 cm of soil. During the rest of the cropping cycle, N availability was 1.5 to 3 times higher beneath tree canopies than in open sites. The total production of N for the 4-month study period was 112 µg N g⁻¹ below tree canopies compared to 42 µg N g⁻¹ beyond the canopies. Soil moisture in the 0–15 cm soil layer was higher under the influence of the tree canopies. The canopy versus open site difference grew from 4% at the beginning of the season to 50% at the end of the cropping season.

Both N mineralization and soil moisture were decreased below young trees. Hence, the impact of *F. albida* on these soil properties changes with tree age and size. While maize yields were not depressed beneath young *F. albida*, it is important to realize that the full benefits of this traditional agroforestry system may require decades to develop.

**Introduction**

A goal of agroforestry research is the design of land use management systems that sustain or improve farm productivity. For over a decade, agroforestry research has focused on intensively-managed land use management systems such as alley cropping. As researchers encounter constraints in transferring agroforestry practices from the controlled conditions on experimental stations to rural farmland, researchers have begun to acknowledge and investigate indigenous land use systems. In Malawi for example, the national agroforestry research program has expanded beyond typical on-station and on-farm alley cropping research to identify and study indigenous tree-cropping practices [Maghembe and Seyani, 1991; Bunderson et al., 1995]. Rural surveys identified nearly 150 tree species retained within cropland for a variety of purposes [Maghembe and Seyani, 1991]. More than 25 of these were identified by farmers as important soil improvers.
In Malawi, as in much of semi-arid Africa, *Faidherbia albida* is one of the most highly regarded soil-improving tree species in a variety of cropping systems [Charreau and Vidal, 1965; Radwanski and Wickens, 1967; Felker, 1978; Miehe, 1989; Poschen, 1989; Kamara and Haque, 1992]. In Malawi, the tree grows on alluvial soils on the lakeshore plain and on upland sites in the central region [Brown and Young, 1962]. Though farmers maintain and manage tree stocking levels, *F. albida* is rarely planted. Farmers protect naturally regenerating *F. albida* sprouts during tillage operations. Sprouts of other most woody species are removed from croplands, so *F. albida* becomes the dominant species in areas where farming has continued for long periods of time.

Bunderson and coworkers [Bunderson et al., 1995] measured the effect of *F. albida* on maize production over several seasons at a variety of locations in Malawi. They found that maize yields were 100 to 400% higher beneath canopies of large *F. albida* trees, compared to yields in open areas. Results were consistent in 3 different regions, with greatest maize responses occurring on fertile, alluvial soils near Lake Malawi where maize increased from under 1 t ha$^{-1}$ to over 2 t ha$^{-1}$. Maximum grain yields occurred 6 to 10 m from the tree trunk. The Malawian results agree with other studies where increased crop yields were measured for millet, groundnuts, and sorghum [Dancette and Poulain, 1969; Poschen, 1989; Depommier et al., 1992].

The positive effect of *F. albida* on crop production is commonly attributed to the tree's combined impact on soil fertility, soil physical conditions, microbial populations and microenvironmental conditions [Jung, 1970; Radwanski and Wickens, 1967; Charreau and Nicou, 1971; Jama and Getahun, 1991]. Increased soil fertility beneath *F. albida* and other parcland tree species derives from both litterfall and accumulations of animal dung [Bernard-Reversat, 1982; Belsky et al., 1989; Kessler and Breman, 1991]. At several sites in Malawi, carbon and total nitrogen range from 3 to 30% and from 5 to 29% higher beneath *F. albida* canopies [Bunderson et al., 1995]. Exchangeable K, Ca, Mg were also higher beneath tree crowns. In an Ethiopian vertisol, Kamara and Haque [1992] found higher N, P, and K beneath *F. albida*, but no differences in exchangeable Ca, Na, Mg or soil pH. In Sudan, organic carbon increased by 3 to 70% and total nitrogen increased by 50 to 90% beneath *F. albida* [Radwanski and Wickens, 1967]. Felker [1978] documented increases of 50 to 100% for soil organic matter beneath *F. albida*. On the lakeshore plain of Malawi, no significant differences in soil nutrient pools were found beneath either large or small trees (Table 1). The high natural fertility of the alluvial soils along with soil mixing during tillage activities may mask nutrient enrichment associated with the trees.

*Faidherbia albida's* unique canopy phenology influences microenvironmental conditions beneath tree canopies. Leaves are shed at the beginning of the rainy season and maintained during the dry season. Thin shade is cast beneath *F. albida* crowns during the cropping season as compared to dense