Nutrient recycling potential of *Tephrosia candida* in cropping systems of southeastern Nigeria

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**Abstract**

Improving fallow quality in cassava–fallow rotations in southeastern Nigeria through the use of leguminous cover crops has been shown to sustain the productivity of such systems. We studied the effects of age (1 or 2 years) of *Tephrosia candida* fallow on biomass and nutrient accumulation, on weed biomass and yield response of cassava/maize intercrop and on changes in soil chemical properties in a 3 yr field trial. Results were compared with those obtained in natural fallow. Total biomass and litter were three times higher in plots fallowed for 2 yr with *Tephrosia candida* than in those under natural fallow for the same period. Weed biomass was 205% lower in *T. candida* plots fallowed for 2 yr than in the natural fallow and was 174% smaller in *T. candida* plots fallow for 1 yr than in the natural fallow. Nutrient (nitrogen, phosphorus, calcium, magnesium and potassium) yields in leaves of *T. candida* fallow for 2 yr were on average 200–300% higher than in leaves of other fallows. The same trend was observed for cassava and maize yields. Soil chemical changes at soil depth 0 to 5 cm showed significant increases in N and C concentrations after 2 yr fallowing and a year of cropping, particularly in the planted fallow plots. Conversely, soil pH, available P and the exchangeable cations, especially Ca were lower, while Al was higher than the initial values, mainly in plots fallowed under *T. candida*, indicating a tendency of this fallow species to further exacerbate the soil acidification problem of the acid Ultisol at the study site in southeastern Nigeria.

**Introduction**

Soils of the humid tropics are highly weathered and acidic, with pH ranging from 3.5 to 6.0 and mineralogy dominated by low activity clays. The important characteristics of low activity clay soils are low cation exchange capacity (CEC), which is normally less than 8 cmol kg⁻¹ of soil, and low base saturation (Juo and Adams 1986). The soils have a low organic matter (0.5–3%) and consequently low nutrient reserve, an imbalanced nutrient elements composition and toxic levels of microelements. Therefore, loss of organic matter in these soils causes soil compaction, low water and nutrient retention, low infiltration rate and accelerated run-off and erosion, leading to loss of the natural resource base and decline in soil productivity (Hulugalle et al. 1998).

The dominant farming systems in the tropics for centuries have been based on bush or forest fallow. The potentials, problems and the structural framework for this land use system have been extensively discussed by Nye and Greenland (1960), Allan (1965) and Nair (1986). Over the years attempts have been made to use annual and perennial herbaceous legumes to enhance green manure input and thus recycle nutrients (Vine 1953; Webster and Wilson 1980).
However, most of the legumes were annuals and only suitable for use in relay fallowing (Ikpe et al. 2003), lasting for about six months.

Nye and Greenland (1960) and Jaiyebo and Moore (1964) reported that trees and shrubs, such as *Tephrosia candida* (Roxb.) D.C., which have deep roots, are more efficient agents of nutrient recycling than grasses or herbs. During the fallow period, plant nutrients are taken up by fallow vegetation, either trees or shrubs, from various soil depths. These nutrients are later released during litter and biomass decomposition for the improvement of soil organic matter and sustainable yields of food crops. This study thus evaluates the potentials of an indigenous, leguminous, perennial, fast growing tree, *Tephrosia candida*, for nutrient recycling. Yields of cassava and maize inter-crops as well as soil fertility changes in southeastern Nigeria were measured.

### Materials and methods

#### Site description

The experiment was conducted on farm on an acid Ultisol at Kpite, 50 km from Port Harcourt (4° 45' N, 7° 18' E) in southeastern Nigeria. Kpite lies in the high rainfall, humid forest of the Niger Delta region in southeastern Nigeria. The mean annual rainfall at the experimental site is 2400 mm in monomodal distribution, lasting from March to November. Temperatures are moderate. Relative humidity in the area remains high throughout the year, with mean values ranging from 78% in February to 89% in July and September. Monthly mean temperatures of the coolest (July and August) and hottest months (February to April) are 25 and 27 °C, respectively.

#### Field trial

The complete history of the field used for the trial is unknown. However, the field has been cropped for about 20 yr without fertilization. The experimental site was covered by a natural fallow regrowth dominated by grass species. The vegetation also included herbaceous legumes and non-leguminous species. The site was slashed in April 1993 and marked into plots.

The experimental design was a split plot fitted into a randomised complete block. The main treatment was fallow age (1 vs. 2 yr) and sub-treatment was fallow species (*Tephrosia candida* vs. natural bush regrowth). The treatments were replicated four times. At the peak of the rainy season *T. candida* seeds estimated to give 10,000 plants per hectare were broadcast uniformly on the plots. These plots were kept free from weed. At the end of the first year, plots designated for 1 yr fallow were cleared as *T. candida* shoots were cut back at the soil surface. Wood, leaves and twigs were chopped and distributed evenly on the plot to serve as mulch. The same procedure was applied to plots designated for 2 yr fallow. Cassava was planted at 1×1 m (10,000 plants ha⁻¹), and maize intercropped at 1×1 m as well (10,000 hills ha⁻¹ and 20,000 plants ha⁻¹). On each row, there was one cassava plant every metre, with one hill of maize plants at mid distance. Plots were hand weeded three times per year. Maize was harvested at 90 d maturity while cassava was allowed to grow for one year. The cassava (*Manihot esculenta* Crantz) variety used was var. TMS 9193, while maize (*Zea Mays* L.) was var. TZPB-SRW. One cassava cutting of about 25 cm was planted per hill, while two maize plants were left per hill.

#### Soil sampling and analytical methods

At the onset of the trial, prior to sowing seeds of *T. candida* and after 1 yr of cropping in the main plots (1 yr and 2 yr of fallowing) soil samples were taken. An auger was used at 0–5, 5–15 and 15–30 cm depths. The soil samples were air-dried in the laboratory and ground to passa 2 mm sieve prior to chemical analysis. Soil pH was determined on a 1:1 soil:H₂O solution with a glass electrode pH meter according to the procedure of Tel and Rao (1982). Organic carbon was determined using a modification of the method of Walkley and Black (1934). Total nitrogen was determined using a Technicon autoanalyzer (Technicon AAII) after digesting the sample with a mixture of concentrated orthophosphoric and sulphuric acid in a Tecator Digester. Available phosphorus in soil was determined by the Bray-1 method (Bray and Kurtz 1945) using the Technicon autoanalyzer. Exchangeable cations were extracted with 1 N NH₄OAC + 0.01 M EDTA at 20:50 fresh soil:extractant ratio. The concentrations of calcium and magnesium in the extracts were determined with an Atomic Absorption Spectrophotometer (AAS), while the concentrations of potassium and sodium were measured with a flame photometer. The effective cation exchange capacity (ECEC) was calculated by the sum of exchangeable

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