Effect of P and Fe applications to cowpea in three soil types

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Summary Cowpea (Vigna unguiculata L.) was grown using 3 soil types (designated Black, Red and Calcareous) at 4 rates of P (0, 40, 80 and 160 kg/ha) and 4 rates of Fe (0, 2, 4, and 8 kg/ha). Sampling was done fortnightly (starting at 4 weeks after planting) for measurements of leaf area, plant height, leaf dry weight and leaf concentrations of P and Fe.

Cowpea plants on P₀ treatment were stunted, irrespective of soil type. The P requirement for good growth on the Black soil was only a quarter that on the other two soils.

Different P:Fe ratios (24:1, 17:1 and 12:1) were required for best cowpea growth on the Black, Red and Calcareous soils respectively.

Significant (P = 0.05) increases in growth were obtained with the addition of P while addition of Fe did not lead to any such significant increases in growth on any of the 3 soils.

Highest leaf P was obtained in plants grown on the Black soil while the lowest was in plants on the Calcareous soil.

Introduction

Yearly applications of P fertilizers to leguminous crops may cause mineral imbalance involving Fe in some soils.

Absorption and translocation of most mineral elements are known to be controlled by the iron-phosphate (FePO₄) balance in the plant concerned¹³,¹⁶. Iron-phosphorus interaction in both the growth medium and within the plant has been reported in many crop species¹,²,⁶. Similarly, addition of P to plants grown on Saline soils has led to an increase in dry weight, leaf area, stomatal frequency and yield of peanut plants¹⁷.

Excess P in the soil has been observed to encourage Fe deficiency in plants⁶,¹⁸, although Zn and Mn¹⁷ have also been known to cause Fe deficiency in plants.

Plants showing Fe chlorosis induced by high levels of P show a normal concentration of Fe in the tissues but the ratio of P:Fe is larger in chlorotic plants²,⁶,¹¹,¹⁹. In cowpea however, the higher P:Fe ratio of chlorotic plants was associated mainly with lower Fe content of the plant and not to the P content¹⁶. Consequently, application of relatively large quantities of P can be particularly conducive to Fe stress and Fe chlorosis since
high P levels frequently interfere with Fe utilization by plants. Reports by Ajakaiye 1979 from autoradiographic work with $^{55}$Fe suggested that high P in the growth medium of sorghum and millet, (a) interfered with uptake and translocation of sufficient Fe from the growth medium, (b) caused inactivation or precipitation of Fe in the veins of chlorotic plants and, (c) prevented Fe from being translocated to the mesophyll.

Although iron-phosphorus interaction in both the growth medium and within the plant has been reported in cowpea (Vigna sinensis L.) information is however scanty on the response of cowpea to P and Fe on different soil types. In Northern Nigeria, the main crops include groundnuts (Arachis hypogaea L.) and cowpea and to which only P fertilizers are applied. It is important that cowpea response to P in relation to Fe on the predominant soil types be evaluated.

Studies were therefore undertaken to evaluate the response of cowpea to P and Fe on three soil-types designated ‘Black’, ‘Red’ and ‘Calcereous’. The evaluation was in terms of 1, growth, 2, best phosphorus-iron combination for cowpea growth and 3, tissue compositions of P and Fe of cowpea.

Materials and methods

The study was conducted in a glass house in the Botanical Garden of the Ahmadu Bello University Zaria, Nigeria.

Three types of soils designated black, red and calcereous were collected from different parts of Zaria and mixed with an equivalent of 20 kg N/ha of nitrochalk. Each soil type was then divided into four and each portion was mixed thoroughly with single superphosphate at the rate of 0, 40, 80 and 160 kg/ha. The four portions of soil were labelled P0, P1, P2, and P3 respectively.

A uniform weight (4 kg) of the soil was introduced into each of the plastic pots in which the cowpea plants were raised. Two weeks after sowing, an equivalent of 0, 2, 4 and 8 kg/ha Fe in form of EDTA was added in solution form. These Fe treatments were also labelled F0, F1, F2, and F3 respectively. Treatments were replicated three times. The P and Fe treatments were variously combined to give 16 combinations which were completely randomized. De-ionized water was used for watering the plants throughout the period of growth. Samples were taken fortnightly for growth analysis by measuring leaf area, plant height and leaf dry weight, starting four to ten weeks after planting.

Leaf area was measured using leaf area model L3000. Leaf dry weight was taken after drying the leaves at 70°C to constant weight.

Mineral elements were analysed by the method of Jackson 1972 and read in Perkin-Elmer Atomic Absorption Spectrophotometer, model 306. Phosphorus was analysed colorimetrically using Jackson’s vanadomolybdophosphoric yellow colour method.

Results

Growth

Significant differences were observed in the growth of cowpea plants on the soils used in terms of plant height, leaf area and leaf dry weight on per plant basis.