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SULPHATE ACQUISITION BY SUNFLOWER FROM ROOT MEDIUM WITH VARIABLE pH

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Abstract

A controlled conditions study on sunflower grown in root medium with a pH range of 4.5 to 8.5 revealed a consistent growth improvement with the rise in root medium pH. Similarly, the sulphate concentration of root and shoot consistently increased with the increase in root medium pH. The same trend was observed in the total sulphate uptake by sunflower shoot. A significant positive correlation between biomass accumulation and sulphate uptake by sunflower shoot indicated the distinct role of sulphur in optimum growth of this non conventional oil seed crop of Pakistan.

Introduction

The activity of a particular nutrient may be dependent on the specific pH of the system in plant tissues. Sulphur owing to its peculiar status in the nutrient chart, plays a dominant role in protein synthesis. Mostly plant metabolism and physiology are dependent on S-containing compounds as methionine and cysteine are integral part of structure and function of many enzymes (Torchinsky, 1981). The synthesis of a particular amino acid is dependent on a specific pH. Therefore, pH plays a significant role in the growth of a particular plant. In some oil seed crops it has been observed that sulphur commands a great physiological significance during the early stages of plant growth (Onkar, 1984). Among the oil seed crops, sunflower requires relatively higher amounts of sulphur for oil production (Nabi *et al.*, 1989).

To meet the requirements of edible oil, sunflower is being introduced in Pakistan agriculture. Sulphur application with NPK has been found important in increasing crop yields of oil seed (Salim & Rahmatullah, 1986, Rahmatullah & Salim, 1987). Sunflower needs to be assessed in variable conditions to standardize its characteristics for growth. Among these characteristics, pH is an important parameter. Most of the Pakistan soils are alkaline in nature but in some climatic conditions due to high organic matter and rainfall the pH may decrease. The presence of high amounts of salts in soil due to saline-sodic conditions increases the soil pH considerably. Application of sulphur to soil has acidic effect in the root zone. It has been observed that sulphur is absorbed in the form of sulphate ion from the roots (Bardsley, 1960). The present report describes the effect of different pH of root medium on the absorption of sulphate ion by roots at the early growth stage of sunflower under controlled conditions.

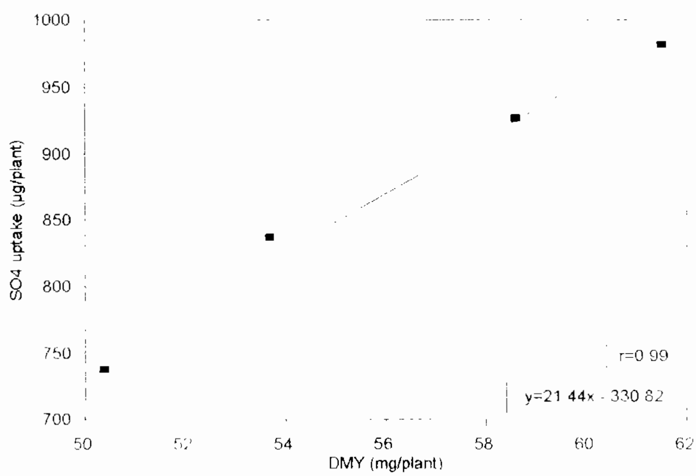

Fig. 1. The influence of SO_4 uptake on shoot dry matter accumulation in sunflower during the initial 48 hours of growth.

Materials and Methods

Sunflower (*Helianthus annuus* L.) NK 265 was grown in aerated modified nutrient solution (Hoagland & Arnon, 1950) in controlled climate chamber having 16 hours light with illumination of 450 μmol m^{-2} s^{-1} at shoot level and a temperature of 29$\pm$2°C. All the pots were supplied with 0.5 mM $CaSO_4 \cdot 2H_2O$ as sulphate source, pH was adjusted at 4.5, 6.5, 7.5 and 8.5 with either dilute KOH or HCl. The pots were arranged in randomized block design. Ten day old seedlings grown in nutrient solution without sulphate ion were transferred to these pots. At 0,6,24 and 48 h interval the plants were harvested, the roots washed with distilled water and the shoot and root portions oven dried at 70$\pm$2°C. After recording the dry weight, these parts were digested in boiling 1N HNO_3 and 0.5N $HClO_4$ mixture (Salim, 1989). Sulphate was determined in the digest as suggested by Verma *et al.*, (1977). The data were analyzed statistically (Kwanchai & Arturo, 1976).

Results and Discussion

Since the study was conducted for short period, different effects of variable pH on sunflower growth were not observed. Dry matter yield (DMY) of shoot was linearly correlated (r=0.99) with the sulphate uptake (Fig.1). In the shoots, sulphate accumulation started when DMY was greater than 15.5 mg/plant. Similarly, in the root, DMY and sulphate uptake relationship was linearly correlated (r=0.95; Fig.2) and sulphate uptake started when the DMY was greater than 7.0 mg/plant. Therefore, for sulphate uptake to play a significant role, the shoot growth was required to be twice that of the root. Increase in DMY in shoot was more dependent on sulphate uptake as

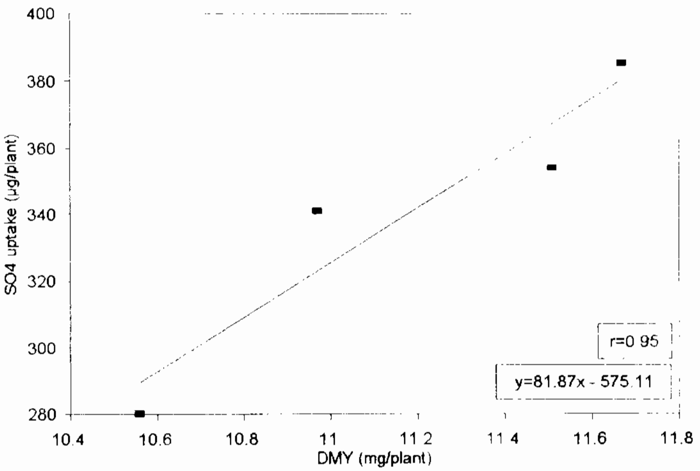

Fig.2. The influence of SO_4 uptake on root dry matter accumulation in sunflower during the initial 48 hours of growth.

compared to that of root. Burgos *et al.*, (1993) signified proton extrusion for the growth, but here a wide range of pH was maintained and the influx of SO_4 was related to the metabolic activities of glutathione and cysteine in the shoot. The transport of SO_4 ion was rapid and in favour of mass accumulation of shoot.

Although the growth of shoot and root is a function of time (Fig.3), but the increase in DMY in the shoot was more prominent. There was comparatively five times increase in DMY in shoot per unit increase in time period. The shoot growth of sunflower was sensitive to the increasing pH levels during sulphate uptake. Its uptake

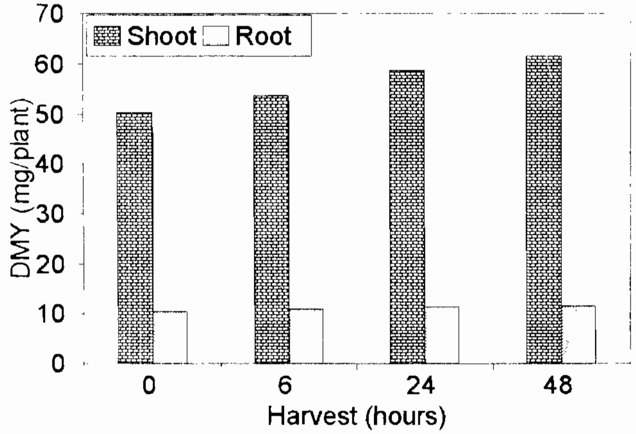

Fig.3. Dry matter yield of sunflower shoot and root as a function of harvest time when sulphur was applied to the root medium.

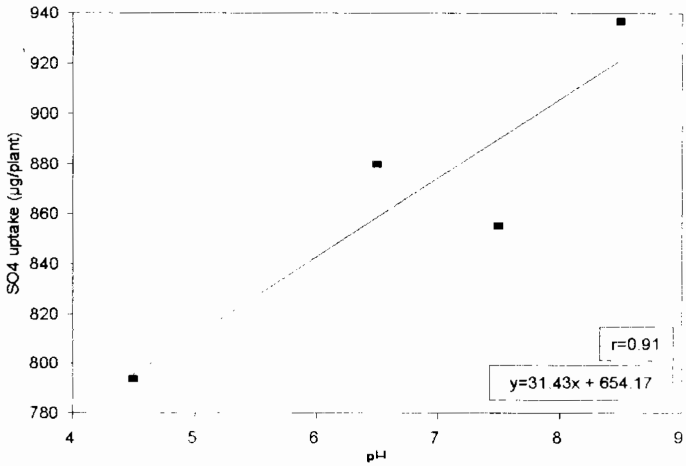

Fig.4. Relationship between SO_4 uptake by sunflower shoot and pH of the root medium.

was in a very good relationship (r = 0.91) with pH (Fig.4). Per unit increase of pH above 4.5 played a significant role for sulphate uptake in the shoot. With the increase in reduced condition, the proton extrusion from roots favoured the entry of other cat ions. It is synergistic with the phenomenon "the increasing soil $CaCO_3$ level increased root DW in sunflower" (Fuleky & Hussain, 1988). More effort was exerted by the top of the sunflower in this pH range to acquire sulphate ions from the nutrient solution through the roots (r^2=0.82).

Comparing the sulphate concentration in shoot to that of root at the early growth of the sunflower, it was observed that per unit increase in pH above 4.5 favoured sulphate

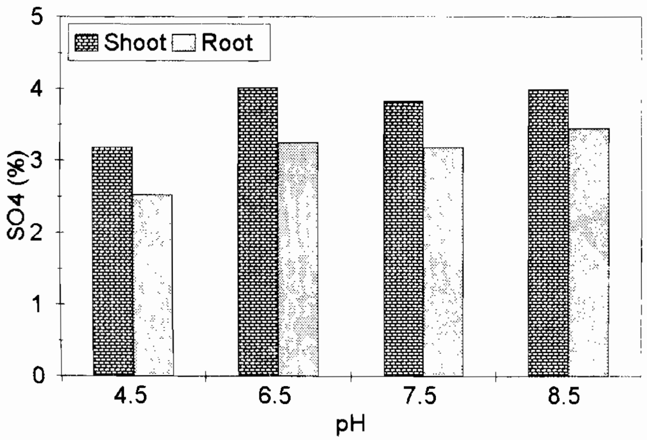

Fig.5 Sulphate accumulation by sunflower shoot and root at different pH values of the root medium

concentration in shoot than the root (Fig.5). There are reports where root growth and function can be directly affected at pH 5 and below depending on species (Alan, 1989). The root growth relationship was positive at all pH levels examined. The shoot response was rapid to sulphate concentration. The entry of sulphate ion through root was carried out with the elevated pH of the medium under the influence of the shoot system as per unit of time period during the early growth of sunflower when sulphate ion was applied in the form of $CaSO_4.2H_2O$ as a source.

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