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Effects of Uranium on Growth Performance in *Vigna unguiculata (L.)*

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ABSTRACT

The aim of this article is the determination of uranium concentration in shoots and roots of barley (Vigna Unguiculata.), grown on soils, together with its phytotoxic effect on the plant growth and development. The soils was contaminated with different doses (12.5µM to 200 µM) of uranyl nitrate. Vegetative as well as Fruiting stages indicated uranium phytotoxic effect on plant height, yield, and germination of seeds, shoot –root fresh weight as well as shoot-root dry weight. This effect was stronger on the plants grown at high concentration in comparison with those grown at lower concentration. Soil properties determined the tolerance and accumulation of U in plants.

INTRODUCTION

Plant physiologists have shown that uranium is a necessary nutrient for plant growth[1]. Uranium concentration in any plant exceeding 2ppm may be indicative of a geologically favourable situation for uranium deposit[2]. Uptake of radionuclides by plants depends on the plant species, the radionuclide and on substrate characteristics [3].The root uptake of nutrients and other mineral elements (as well as radionuclides) takes place via the soil solution. Uranium absorptivity of plants depends on the pH of the cell sap of the root hairs and it was concluded that uranium is absorbed easily by plants in which pH of the cell sap is less than 5.2, such as conifers and certain members of the rose family. Such plants absorb much calcium, sodium, sulphur and selenium but little potassium. Cannon has stated that U may be a micronutrient for higher plants[4] and radishes showed a response to soil U similar to nutrient elements[5]. Plants readily take up elements essential for plant growth when substrate concentrations are low (deficient)[6], whereas plant uptake of non-essential elements is generally constant in this substrate concentration range[7]. Keeping the above in view the effect of different concentrations of uranyl nitrate were studied on the growth performance of cow pea in soil.

MATERIALS AND METHODS

Certified seed of *Vigna Unguiculata* were obtained from Rajasthan State Seed Corporation, Udaipur. Five kilograms of soil was filled in earthern pots of 30 cm height and 25 cm diameter. For the preparation of uranium concentrations, uranyl nitrate were used. Five concentrations of uranium were prepared separately by taking corresponding amounts (Calculated on the basis of their molecular weights) of the chemical per Kg of air dried soil. Uranium in the form of uranyl nitrate was applied at doses of 12.5, 25, 50, 100, 200 µM of air dried soils. Pots without the added uranium constituted the control. Experiments were set during the month of November for cow pea. Fifteen seeds were sown equidistantly at 2 c.m. depth in each pot for both the crops. Watering was done on alternate days. After establishment seedlings were thinned to ten per pot for Cow Pea. Two sets in triplicate were prepared to record observations for each crop during two stages of their life span, i.e. vegetative and fruiting. Plants were harvested for both the stages of growth. Observations were noted for shoot and root length, fresh and dry weight.

RESULTS

Vigna Unguiculata

Shoot-Root Length: In Cow Pea, the lower concentration of uranium (12.5 µM) resulted in an increase in shoot and root length during vegetative and fruiting stages of growth. All higher concentrations (25µM-200µM) resulted in severe decrement during vegetative and fruiting stages of growth. Maximum increase in shoot root length, over the control, was observed at 12.5 µM addition of uranyl nitrate, which was 4.03%, 0.71% for vegetative stage and 6.45%, 10.32% for fruiting stage. 12.5 µM of uranyl nitrate concentration showed 1.42%, 8.85% and 3.48%, 0.82% increase during vegetative stage and fruiting stage of growth. At 200 µM concentration of uranyl nitrate, maximum reduction, over the control, in shoot and root length was 8.97%, 26.07% and 22.07%, 39.99%, respectively, during vegetative and fruiting stages.

Shoot-Root Fresh Weight: Lower levels of uranium were benefiticial in relation to fresh weight during vegetative and fruiting stages (12.5 µM). Maximum increase in shoot fresh weight was observed at 12.5 µM concentrations of uranyl nitrate which was 1.20% higher over the control. Maximum root fresh weight was also at similar concentration and was 48.04% higher, over the control during vegetative stage of growth. Maximum decrement of 35.93%, over the control, was observed for shoot fresh weight at 200 µM dose of uranyl nitrate during vegetative stage of growth.

Shoot-Root Dry Weight: Effect of uranium on dry matter production was similar to that of fresh weight. An increase in shoot dry weight was observed at 12.5 µM concentration of uranyl nitrate which was 38.73%, 4.81%, 0.09%, 4.23%, over the control, during vegetative and fruiting stages respectively. The reduction, over the control, was maximum at 200 µM level of uranyl nitrate which was 26.12 %, 93.09% and 22.56%, 25.96% respectively for shoot and root dry weight during vegetative and fruiting stages of growth.

DISCUSSION

Results of present studies indicate that lower concentrations of uranium (12.5µM) were promotory for growth but higher concentrations were toxic for both the test crops. Richard *et al.*[8] suggested that plant uptake of the uranium was independent of soil concentration. Richard *et al.*[8] reported that concentrations of uranium in soils greater than 200ppm are toxic to some plants, and uptake of uranium from the soil by plants was in the range 10^{-1} - 10^{-2} µg g^{-1}. Uranium content of vegetables from the field ranges from 7.13 to 27.70 ng g^{-1} fresh weight while U level in the vegetables grown in pots with enhanced uranium level in soil and irrigation water ranges from 13.81 to 214.2 ng g^{-1} fresh weight. Soil analysis indicated large concentrations of As (500 $\mu g g^{-1}$dry soil) and Co (309$\mu g g^{-1}$drysoil) in addition to same U (43$\mu g g^{-1}$drysoil)[9].Green house conditions have been used for the study of uptake of uranium by Wheat and Tomato plants as affected by its concentration in soil and irrigation applied. Highest yield of wheat was obtained at 3.0 ppm of uranium in the soil.

In the present studies, the effect of uranium concentrations on root elongation reduction at least in part is due to elevated uranium concentration present in high treatment concentrations. Roots seem to be particularly affected both in length and biomass as they accumulated large amount of uranium in relatively shorter period of time than shoots. The overall decrease in different growth parameters under stress (high concentration of uranium can also be explained as follows. When a plant grows in normal soil, it maintains an ionic equilibrium between soil and its cells. But when the concentration of ions are excessively high in the outer atmosphere, in order to maintain a threshold level of element it has to expend energy to repel the excessive ions entering into the cell. The energy expended by the plant otherwise, would have been available for its healthy growth. This may lead to reduction in all the growth parameters[10-11]. The growth of whole plant and plant parts is frequently employed as an index to monitor the effect of stressful environment. Among plant parts, roots are the organs, which have the first and direct contact with noxious substance and show rapid and sensitive changes in their growth characteristics[12]. Plants require many essential elements for their growth which are mainly absorbed from the soil by the root system and transported to the upper parts of plant[13].

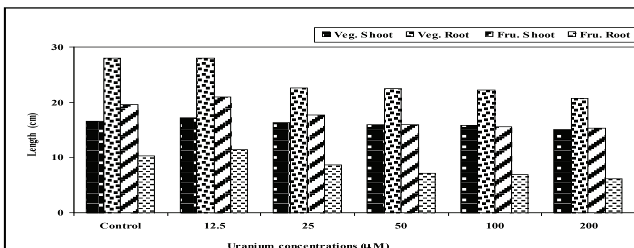

Fig. 5.1 : Effect of different concentrations of uranyl acetate on shoot-root length (cm) of *Hordeum vulgare* L. during different stages of growth.

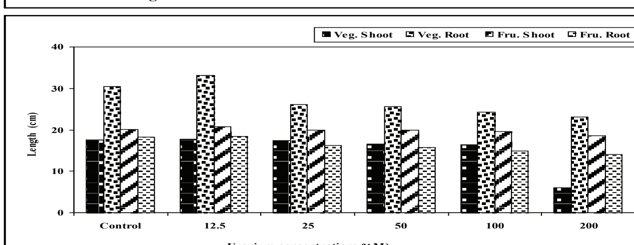

Fig. 5.2 : Effect of different concentrations of uranyl nitrate on shoot-root length (cm) of *Hordeum vulgare* L. during different stages of growth.

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Declaration: *We also declare that all ethical guidelines have been followed during this work and there is no conflict of interest among authors.*

CONFLICT OF INTEREST

It is hereby Declared that there is No Conflict of Interest to Disclose in The Research Paper Entitled **"Effects Of Uranium On Growth Performance In Vigna Unguiculata (L.)"**

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