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Research Article

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Arsenic Distribution in Green Bean Yield Irrigated by Waste Water

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Abstract

The objective of the study is to investigate the effect of different arsenic concentrations on some physiological parameters of bean (*Phaseolus vulgaris*) seedlings, grown in sand with nutrient solution in a climatic box was treated with 0, 5, 10, 15 and 20 ppm Arsenic in the form sodium arsenate Na_3AsO_4 (pH 5.5). After 3 months of As treatment, the various growth parameters as well as changes in leaf gas-exchange, water potential, chlorophyll and protein contents, peroxidase activity and lipid peroxidation in roots was recorded. Results clearly show that with increase in arsenic concentration growth activities of bean plant suppress.

Keywords: Arsenic concentrations; Physiological parameters; *Phaseolus vulgaris*

Introduction

Arsenic has been found to be largely immobile in agricultural soils [1] which could be caused by a variety of factors. MacLean et al. worked on arsenic in orchard and potato soils and plant tissues they found an increased as content in soil showed an increase in arsenic content in potato leaf and peel, but not in the pulp [2]. This indicates that the contamination came from direct soil and dust contact and not as uptake by the plant. Veneman et al. worked on arsenic and lead distribution in soil [3]. He studied that arsenic slowly leached through the soil while lead is quite immobile. Miteve and Peycheva grew tomato and green bean plants in pots containing 1 kg soil, contaminated with as (50 mg/kg) concentration in soluble form [4]. They found that as induced peroxidase synthesis in green bean plants. Ministry of environment in Ontario provided fact that green beans are good indicators of arsenic in soil, since bean plants are particularly sensitive to arsenic [5]. If green beans grow well in a garden, it is unlikely that the uptake of arsenic into other vegetables will be high enough to pose a health risk. Another study confirmed that increased as was present in food items when in direct contact with contaminated soils [6]. Arsenic and phosphorus behave similarly in the soil and in cell reactions [7]. Vela and Heitkemper studied total arsenic in infant food product [8]. They found that inorganic arsenic was present in freeze-dried green beans. Stoeva et al. applied 0, 2, 5 mg (As) dm^{-3} as Sodium Arsenate (pH 5.5) [9]. After 5 days of As treatment, they found changes in leaf gas-exchange, water potential, chlorophyll and protein contents, peroxidase activity and lipid peroxidation in roots of green bean plant. Miteva et al. worked on Arsenic as a factor affecting virus infection in tomato plants i.e. changes in plant growth, peroxidase activity and chloroplast pigments [10]. He found that at 25 ppm concentration arsenic effects more adversely than higher dose. Ruiz-Chancho et al. worked on arsenic speciation in plants growing in arsenic-contaminated sites [11]. They found arsenic concentration in plant samples from the contaminated sites ranged from 1.14 to 98.5 mg/kg (dry mass) and plant growing in non-contaminated sites contain less amount of arsenic. Farooqi et al. studied that amount of arsenic in soil surface samples was 10.2 mg/kg, with highest concentration 35 mg/kg [12]. McBride grew green beans, lettuce, carrot and tomatoes on soil containing a range of total as (6.9-211 mg/kg) concentrations [13]. He found that arsenic concentration highest in lettuce and green beans. Chandra et al. worked on Arsenic in Food chain and Community Health Risk, by studying arsenic accumulation in different vegetables, they found that tuberous vegetables accumulated higher amount of arsenic than leafy vegetables [14]. Pooja and Bhatnagar worked on effect of enhanced level of as in soil on green bean plant tissues [15]. They found that at high concentration (30 mg as kg^{-1} soil), loss of structural organization and disintegration of cytoplasm were observed.

Materials and Methods

This experiment was conducted in pots under greenhouse condition in the Main Campus, University of Veterinary and Animal Sciences, Lahore, Pakistan. Bean plants (*Phaseolus vulgaris*) were grown in a moderately rich soil with a slightly acidic pH of about 5.5. Because they are legumes, they can fix their own nitrogen and don't need supplemental fertilizer, but still we amend the soil with organic matter. They were grown in a climatic box under irradiance of 200 μmol (PAR) m^{-2} s^{-1}, 14 hrs photoperiod, day/night temperature of 24 ± 2/18 ± 2°C, and relative air humidity of about 70%. Fifteen days after emergence the plants were treated with As in the form of Na_3AsO_4 in concentrations 0 (control), 5, 10, 15 and 20 ppm. T_0 was under control condition while T_1 T_2 T_3 T_4 were provided with 5 ppm, 10 ppm, 15 ppm, 20 ppm, of arsenic concentration respectively. There were three replicates of this arsenic application on green beans. The fresh mass of the shoots and roots was measured after 5 days of as treatment. Plant material was rinsed in deionized water and blotted. The dry masses were measured by drying the shoots and roots at 75°C to constant mass. The leaf area was measured with a leaf area meter. The net photosynthesis rate (PN), transpiration rate (E), and stomatal conductance of the intact leaves were measured with a portable infrared gas analyzer. The measurements were made under irradiance of 800 μmol (PAR) m^{-2} s^{-1}, temperature of 26 ± 2°C, an external CO_2 concentration of 400 μmol mol^{-1}, and relative air humidity of 70%. The water potential (Ψ) in leaves was measured with pressure chamber. Chlorophyll (Chl) and carotenoids (Car) was extracted with 80% acetone and the pigments determined spectrophotometrically at wavelengths 663 nm (Chl a), 645 nm (Chl b) and 470 nm (Car). For the measurement of lipid peroxidation, the thiobarbituric acid (TBA) test, which determines malondialdehyde

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Arsenic concentration (ppm)	Shoot length (cm)	Root length (cm)	Leaf area (cm^2)	Photo synthesis rate (mg dm^{-3})	Total chlorophyll/ carotenoids	Lipid per oxidation (nmol g^{-1})	Peroxidase activity (POD) (g^{-1} min^{-1})
0	32	19	71.5	5.5	71.5	11.35	5.5
5	28	17.5	73	3.8	73	13.80	3.8
10	24	14	79	3.1	79	17.46	3.1
15	19	10	85	2.7	85	21.39	2.7
20	15	07	96.3	2.01	96.3	25.34	2.01

Table 1: Effect of arsenic (As) at different concentration on different physiological parameters of green bean plants.

(MDA) content, was applied. The amount of MDA-TBA complex (red pigment) was measured by means of its specific absorbance at 532 nm. Non-specific absorbance at 600 nm was also subtracted. The data will be calculated using the coefficient of absorbance of 155 mM^{-1} cm^{-1}. Each plant extract will be assayed twice. Data collected will be analyzed statistically by ANOVA method.

Results and Discussion

An experiment was conducted on green bean plant in Department of Environmental Sciences, University of Veterinary and Animal Sciences, Lahore, Pakistan. Following results were recorded (Table 1):

Shoot length (cm)

Results indicated that maximum shoot length about 32 cm was observed in controlled condition when no arsenic was applied. While at highest concentration of about 20 ppm minimum shoot length was observed i.e. 15 cm.

Root length (cm)

Results indicated that maximum root length about 19 cm was observed in controlled condition when no arsenic was applied. While at highest concentration of about 20 ppm minimum root length was observed i.e. 7 cm.

Leaf area (cm^2)

Results indicated that reduction of leaf area was also more considerable in higher arsenic concentration at T_5=20 ppm. Leaf area reduced to 96.3 cm^2 while at lower concentration lesser changes were observed.

Photosynthesis rate

The Photosynthesis rate (P_N) decreased to 2.01 mg/dm^3 in the as treated plants at a concentration of 20 ppm while maximum photosynthesis rate was observed at control condition.

Stoeva et al. applied 0, 2, 5 mg (As) dm^{-3} as Sodium Arsenate (pH 5.5). After 5 days of as treatment, they found changes in leaf gas-exchange, water potential, chlorophyll and protein contents in green bean plant [9].

Total chlorophyll and carotenoids

There was a considerable decrease of Chl and carotenoid (Car) contents about 3.07 mg/dm^3 at control condition i.e. T_5 20 ppm and 2.59 mg/dm^3 at higher concentration. It was established that Car content decreased to a lesser extent than Chl content.

Lipid peroxidation

Results indicated that maximum lipid peroxidation 25.34 nmol g^{-1} was observed at higher concentration (T_5=20 ppm) while minimum lipid peroxidation was observed at control condition.

Peroxidase activity (POD)

Results indicate that peroxidase activity increases with increase in arsenic concentration. At higher concentration of about 20 ppm maximum POD activity of about 410 g^{-1} min^{-1} was observed while it's lesser under control conditions.

Miteve and Peycheva grew tomato and green bean plants in pots containing 1 kg soil, contaminated with as (50 mg/kg) concentration in soluble form. They found that as induced peroxidase synthesis in green bean plants [4].

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