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EFFECTS OF ALUMINIUM ON GERMINATION AND GROWTH OF TWO DIFFERENT WHEAT CULTIVARS

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The effects of aluminium on seed germination, shoot, root and dry weight of two wheat cultivars were studied. The seed germination of *Triticum aestivum* cv. 'Faisalabad 85' and *Triticum aestivum* cv. 'Blue Silver' was significantly ($p < 0.05$) affected by different concentration of aluminium as compared to the control. The increase in concentration of aluminium at 10 ppm suppressed the root and shoot length in *T. aestivum* cv. 'Faisalabad 85', whereas the reduction in shoot length was observed for *T. aestivum* cv. 'Blue Silver' at 15 ppm. A significant ($p < 0.05$) reduction in dry weight of 'Blue Silver' was observed at 25 ppm aluminium.

Key words: aluminium, germination, seedling growth, wheat

INTRODUCTION

Pollution by toxic element is a worldwide problem. These toxic pollutants are discharge in the air by man-made activities (Nriagu and Pacyna 1988). Once released into the environment they are not broken down into harmless components. Mineral nutrients are important for the normal growth of plants. Presence of unbalanced nutrients in soil can cause disturbance in the uptake of certain element, which are necessary for the plant growth. There have been several investigations of aluminium toxicity and tolerance of forest tree species (Humphreys and Truman 1964, McCormick and Steiner 1978, Matsumoto and Hirasawa 1979, Steiner *et al.* 1980, 1984, Schier 1985, Goransson and Eldhuset 1987, Taylor 1989). Godbold *et al.* (1988) had found root elongation in *Picea abies* decreased by 63–73% at aluminium concentrations of 0.8 and 1.2 mM. Reductions in growth and root length elongation of different *Pinus* species occurred at aluminium concentration of 3 mM (McCormick and Steiner 1978). The phytotoxicity of a wide variety of metals has been well established in the literature (Taylor *et al.* 1991). Aluminium generally has toxic effects on plant growth (Alam 1981) and has produced adverse effects on the protoplasm of the cells (Clarkson 1967). It has been observed to cause precipitation of phosphate inside cell walls thus reducing the transport of phosphorus from the root to the shoot and causing phosphorus deficiency (Alam 1981).

Wheat (*Triticum aestivum* L.) is recognised as the most ancient crop. The Egyptians and Mesopotamian grew wheat and today at least half of the world's cultivated land is producing cereal grains. Wheat is classified into market classes by the colour and composition of the grain and plant growing habitats. Wheat has a relatively broad adaptation, is well adapted to harsh climates, and will grow well where rice and corn cannot grow. Early growth is favoured by cool and moist conditions, with warmer and drier weather towards crop maturity. Because of its importance as a basic food staple for much of the world's population, extensive breeding programs have been undertaken in practically every wheat growing country in the world. Breeders continue to introduce new cultivars that are more resistant to diseases, insects, drought and lodging (Hartmann *et al.* 1988) and pollution. The concentration of the toxic elements in the environment is increasing through human activities and is affecting the plant growth. The present study was undertaken with a view to find out the toxic effect of aluminium on seed germination and seedling growth of two wheat cultivars.

MATERIAL AND METHODS

The healthy seeds of *Triticum aestivum* L. cv. 'Faisalabad 85' and *T. aestivum* L. cv. 'Blue Silver' were obtained from Pakistan Agriculture Research Council (PARC). The seeds were surface sterilised with dilute bleaching powder (1%) for three minutes to prevent any fungal contamination. The Petri dishes and filter papers were also sterilised in autoclave to reduce the chances of fungal contamination. Thereafter, the seeds were washed with distilled water and transferred to medium sized Petri dishes (90 × 20 mm) and placed on filter paper at room temperature (32±2 °C). The seeds were treated with different concentrations of aluminium phosphate, 5, 10, 15, 20 and 25 ppm, respectively. In control no treatment was given except distilled water. All the treatments were replicated three times. After six days, the seed germination percentage, and maximum root and shoot length were noted. Seedling dry weight was determined by drying the plant materials in an oven at 80 °C for 24 hours. Data obtained were statistically analysed by variance analysis and Duncan's multiple range test.

RESULTS

The results are presented in Figures 1–2 and Table 1. The response of *T. aestivum* cv. 'Faisalabad 85' and *T. aestivum* cv. 'Blue Silver' to aluminium tox-

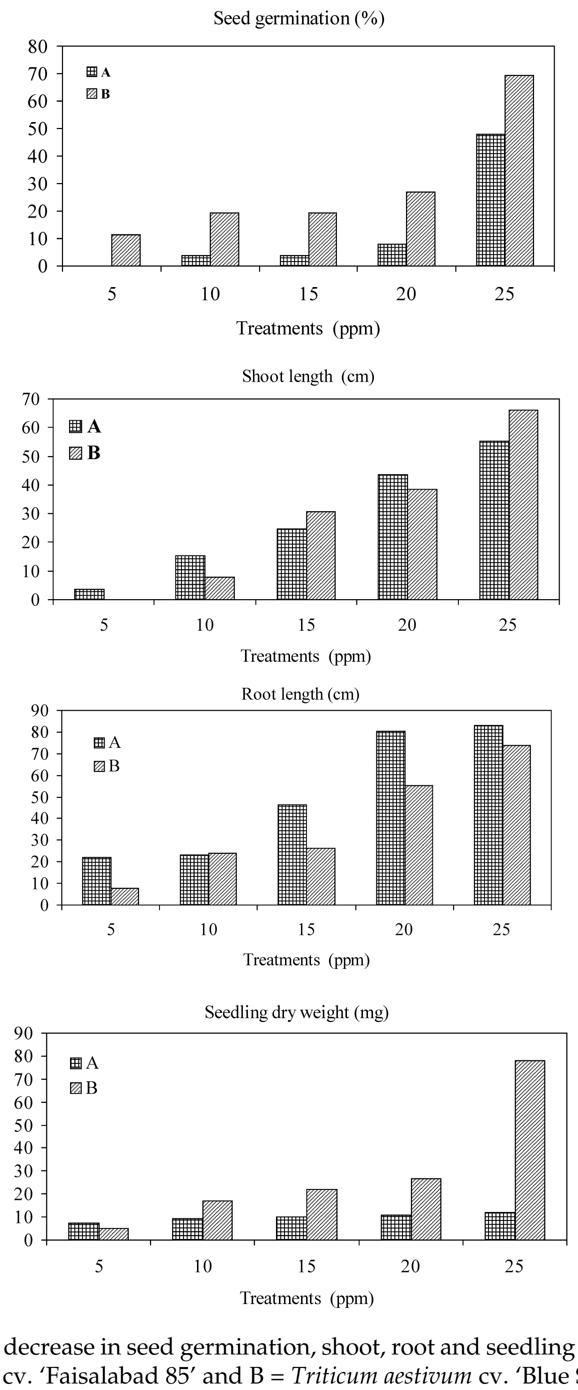

Fig. 1. Percentage decrease in seed germination, shoot, root and seedling dry weight of A = *Triticum aestivum* cv. 'Faisalabad 85' and B = *Triticum aestivum* cv. 'Blue Silver' at different treatments of aluminium as compared to the control

Table 1
Effects of aluminium on seed germination and seedling growth of two wheat cultivars

Treatment	Seed germination (%)		Root length (cm)		Shoot length (cm)		Seedling dry weight (mg)	
	+	++	+	++	+	++	+	++
0 ppm	83.3a	86.6a	8.2a	3.8a	8.5a	6.5a	37.00a	41.00a
5	83.3a	76.6ab	6.4b	3.5ab	8.2ab	6.5a	34.30a	39.00a
10	80.0a	70.0ab	6.3b	2.9ab	7.5ab	6.0a	33.60a	34.00a
15	80.0a	70.0ab	4.4c	2.8ab	6.4bc	4.5ab	33.30a	32.00a
20	76.6a	63.3b	1.6d	1.7ab	4.8cd	4.0ab	33.00a	30.00a
25	43.3b	26.6c	1.4d	1.0b	3.8d	2.2b	32.60a	09.00b
L.S.D	28.43	16.77	1.85	2.8	1.81	2.9	18.00	11.00

Numbers followed by the same letters in the same column are not significantly different, according to Duncan's multiple range test. Symbols used: + *Triticum aestivum* cv. 'Faisalabad 85', ++ *Triticum aestivum* cv. 'Blue silver'. Least significance difference (L.S.D) values at $p < 0.05$ level

icity in terms of seed germination, maximum shoot, root length and dry weight were found different as compared to the control. Results of the study indicated that the inhibitory effect of aluminium treatment appeared as the aluminium concentration increased, but the actual response depends on the plant cultivars. A significant ($p < 0.05$) reduction in seed germination of *T. aestivum* cv. 'Blue Silver' was observed at 20 ppm aluminium treatment as compared to the control (Table 1). Similarly, significant ($p < 0.05$) reduction in seed germination of *T. aestivum* cv. 'Faisalabad 85' was observed at 25 ppm aluminium treatment as compared to the control (Table 1). A significant ($p < 0.05$) reduction in maximum shoot length of *T. aestivum* cv. 'Faisalabad 85' was found at 15 ppm concentration of aluminium. *T. aestivum* cv. 'Blue Silver' showed high seed germination, shoot, root length and dry weight in control but toxicity of aluminium at 25 ppm concentration significantly ($p < 0.05$) reduced the maximum shoot and maximum root length in cv. 'Blue Silver'. A non-significant effect on dry weight production was observed in *T. aestivum* cv. 'Faisalabad 85', while *T. aestivum* cv. 'Blue Silver' showed a significant ($p < 0.05$) reduction at 25 ppm aluminium treatment.

DISCUSSION

Mineral nutrients are very important for the normal growth of plants. Plants require elements for growth, but excessive amount can leads to toxicity. The seed germination of both wheat cultivars was found significantly affected by the aluminium treatment. Aluminium treatment up to 15 ppm did not produce any significant reduction in seed germination of both wheat cultivars. The toxicity of aluminium to seed germination was found in both wheat cultivars at 20 ppm and 25 ppm treatment, respectively. Kalimuthu and Siva (1990) found reduction in seed germination in *Zea mays* (maize) treated with heavy metal treatment (lead acetate and mercuric chloride 20, 50, 100 and 200 (µg/ml)). The shoot length of both wheat cultivars showed gradual decrease with the increase in concentration of aluminium (Fig. 2). Reduction in root and shoot length in both wheat cultivars might be due to accumulation of aluminium. Its toxic effects generally result in an abnormal root development with short and thick roots (Alam 1981). Schier (1985) found that root-growth disturbances and damage might be a result of disturbed meristematic growth patterns. Excessive amount of toxic element usually caused reduction in plant growth (Prodgers and Inskeep 1991). Exposure to aluminium also results in the reduction of free magnesium and calcium in plant tissue. It has been shown in different conifer species that magnesium levels are reduced below that level critical for tissue survival in plants exposed to aluminium (Godbold *et al.* 1988), while calcium uptake was reduced by as much as 90%. It appears that aluminium probably acts on a number of critical physiological processes such as reduced percentage of seed germination, root and shoot growth. The dry matter yield of barley tops and roots decreased at high aluminium-treated plants while the roots were short, thick and spotted brown in colour (Alam 1981). Aluminium produced a significant effect on biomass production of cv. 'Blue Silver', however, non-significant reduction in seedling dry weight of *T. aestivum* cv. 'Faisalabad 85' was observed, which might be due to its tolerance to aluminium. The growth rate of root, shoot and formation of lateral root were found to be retarded with the increase concentration of heavy metals

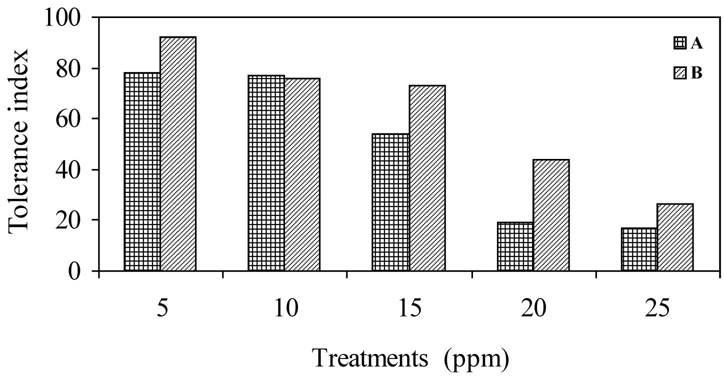

Fig. 2. Indices of tolerance for A = *Triticum aestivum* cv. 'Faisalabad 85' and B = *Triticum aestivum* cv. 'Blue Silver' at different treatments of aluminium

(mercuric chloride, cadmium acetate and zinc sulphate) in ground nut and gingerly (Renjini and Janardhanan 1989). Plant responses to metals are dose dependent. Toxicity appears to be the results of several interactions, and there is clearly no census on the mechanism of aluminium toxicity in higher plants. Aluminium toxicity has become important due to its constant increase in the environment. Plants can be used to get initial information on the status of chemical elements in the environment (Goodman and Roberts 1971). The results of this study showed that plant species differ in their sensitivity to aluminium. *T. aestivum* cv. 'Faisalabad 85' was found resistant to aluminium toxicity as compared to *T. aestivum* cv. 'Blue Silver' (Fig. 2). There is a need to carry out further monitoring of the toxic materials and their impact on plant growth. The chemical analysis of plant material will be helpful in providing the first indications of the absorbency of aluminium and translocation in different parts of the plants.

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