

Effect of Silicon on the improvement of wheat germination in salt and drought conditions

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Summary. The effect of Silicon on germination in salt and drought conditions of durum wheat (was studied) in a completely randomised block experimental design with four replications for each stress level applied. Six NaCl concentrations (0, 25, 50, 100, 150 and 200mM) and four concentrations of Poly Ethylene Glycol 6000 (PEG) (0, 20, 40 and 60 g/l) were used to simulate salt and drought stress conditions with or without Silicon source in Ortho-Silicic Acid form $\text{Si}(\text{OH})_4$. The result obtained 10 days after seeding at 25°C, revealed a depressive effect of drought and salt on germination. Under salt and drought conditions, the presence of Silicon at 1mM concentration improved the germination responses. The differences due to Silicon presence were greater when drought stress was important. The presence of ortho - silicic acid also improved the germination rates in both stress conditions. This paper discusses the Silicon roles and the mechanisms involved in the seed germination in relation to salt and drought conditions. The effect of Silicon sources use on the improvement of germination and on the crop establishment in saline areas (where only saline water is available).

Key words: Wheat, Silicon, Salt, Drought, Germination

Effet du Silicium sur l'amélioration de la germination du blé dans des conditions de déficit hydrique et de salinité

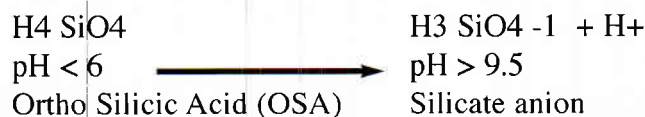
Résumé. L'effet du Silicium sur la germination du blé a été étudié en condition de déficit hydrique et de salinité. Le dispositif expérimental utilisé est un bloc aléatoire complet avec 4 répétitions (pour chaque stress appliqué) en présence et (ou) en absence de Silicium sous sa forme active qui est l'Acide Ortho-Silicique ($\text{Si}(\text{OH})_4$) à une concentration de 1mM. Six concentrations de Chlorure de Sodium NaCl ont été appliquées pour les conditions de stress salin à savoir: 0, 25, 50, 100, 150 et 200mM. Le stress hydrique a été simulé par l'application du Poly Ethylène Glycol (6000) à 4 concentrations qui sont 0, 20, 40 et 60g/l. Les résultats obtenus, 10 jours après germination à 25°C, ont montré un effet dépressif du stress sur la germination aussi bien en condition saline que de déficit hydrique. En présence du Silicium, les caractéristiques germinatives du blé se sont significativement améliorées particulièrement en concentrations élevées. La présente communication, en plus des résultats sur la germination mène une discussion sur les différents rôles du Silicium en conditions de stress, et l'intérêt des sources ou amendements silicatés dans l'installation des cultures au niveau des régions affectées par la salinité.

Mots clés : Blé, Salinité, Déficit hydrique, Silicium, Germination

Introduction

Germination is an important stage for crop establishment. In arid and semi arid area, this germination is widely affected by abiotic stresses mainly drought and salinity. In these situations, Silicon can contribute to the alleviation of the stress effect. Silicon is one of the most abundant elements in the crust of the earth but it is mostly inert and only a slight soluble mineral element. In nature, Silicon is always coupled to an oxygen molecule and thereby forms

SiO₂. It is considered as a functional nutrient (Mengel and Kirkby, 1982). In the biosphere Silicon exists mostly in three forms: amorphous (Si); silica gel and ortho silicic acid (OSA: Si (OH)₄). The OSA is a neutral, small molecule with low solubility (0.05 - 5 mg Si/L); its stability depends on pH, concentration and temperature.



OSA is also the most available form of (Si) to plants; it is the active form of (Si), (Iler, 1979; Lefaucheur, 1988).

The application of Si to salt affected soils has a high impact on plant productivity because Si optimises the use of the other nutrient. The optimisation of Si plant nutrition increases plant tolerance to salt toxicity. Bouzoubaâ demonstrated the effect of the presence of Silicon on water uptake and conservation in Wheat.

This study aims to show the effect of (Si) application in its active form Si (OH)₄ on wheat germination under saline and drought conditions.

Material and methods

- Plant material: bread wheat seeds cv Achtar;
- Treatments: two applied stresses with or without Silicon (1mM concentration of Ortho-Silicic-Acid (OSA);
- Drought conditions were simulated by four concentrations of PEG (6000) (the poly ethylene glycol), 0; 20; 40 and 60g/l;
- Salt conditions were simulated by six levels of NaCl: 0; 25; 50; 100; 150 and 200mM.
- All the experiments were conducted in Petri dishes with filter paper moistened by the applied solution;
- Experimental design is a completely randomized block design with four replications.

Results and discussion

Generally, all aspects of germination and seedling of wheat cv Achtar were affected by drought and saline treatments. Figure 1 (A, B, C and D) and Figure 2 (A, B, C and D) show significant depressive effect of drought and salt on wheat germination for all measured parameters. Germination percentage, root fresh weight, root dry weight and root length were significantly reduced by both drought and salt application as compared to the check or no stressed regimes. It is obvious that the highest reduction in growth parameters was associated with the highest concentration of PEG or NaCl applied (photo1). Concerning salt effect, Levitt (1980) reported that salt stress influenced plant germination and growth in two ways: firstly, there is an effect of plant water deficit due to the reduction in soil water potential, and secondly, the presence of salt can affect the uptake of other essential nutrients and also the sodium and chloride ions themselves may be phytotoxic. Wheat seedling seemed to be more tolerant to 20g/l of PEG (Fig. 1 A, B, C and D), and 50mM of NaCl (Fig 2. A, B, C, D and photo1: root length reduction of seedling wheat in salt conditions).

As shown in figure.1 and figure 2, both under salt and drought conditions, seeds subjected to

Silicon treatments showed higher germination percentage. The increase varied from 9.8% to 111% in drought conditions and from 2 to 200% in salt conditions for germination percentage (Fig 1. A; Fig 2.A), root fresh weight (Fig 1.B; Fig 2. B) root dry weight (figure 1 C; figure 2 C); or root length (figure 1 D; figure 2 D; photo2.)

The observed triple response of root fresh weight; root dry weight and root Silicon presence has been well characterized and widely discussed in Bouzoubaâ work (1991). This work described the Silicon uptake and accumulation by crops. Silicon accumulation in root of wheat seedling (plant 6 days aged) was demonstrated by several complementary techniques of micro-analyses methods. First, the detection of Silicon deposition by microprobe with selected energy (Photo.3); second, the relative measure of the importance of deposition by microprobe analyses with dispersed energy (photos 4 and 5) then the sub cellular detection by microscope observation (photo 6.). The importance of this research was the localization of Silicon barriers both at endodermis and epidermis root levels. Those barriers played mechanical and protective roles against external aggressions. They also played an important role in the filtration of water and mineral nutrient (Bouzoubaâ; 1991).

In addition to its importance in the improvement of root biomass and root length, Silicon also increases the self protection of plant against bacteria, fungi and diseases, as shown in photo 7. Water treatment samples were more and more colonised by fungi than the (Si) treated ones. The application of Si increased the resistance of root system against pathogens, and then improved the nutrients uptake by roots; this result was confirmed by Elawad et al. (1982).

Conclusion

- (Si) improves wheat germination percent both in drought and salt conditions;
- Salt and drought affect the root dry weight; but the presence of (Si) improves the root dry weight;
- Silicon improves the root growth as well in thickness as in length;
- Silicon plays a mechanical role by its accumulation in strategic places in the plant as epidermis both in leaves and roots, and endodermis in the root;
- Protective role: Si increases natural resistance of plant as it was confirmed by Tsyurupa (1964).

Silicon amendments must be integrated in all the agricultural practices particularly in arid and semi arid area where water resources are limited, and in saline area for their valorization because of the strong relationship that exists between this element and water improving by plants.

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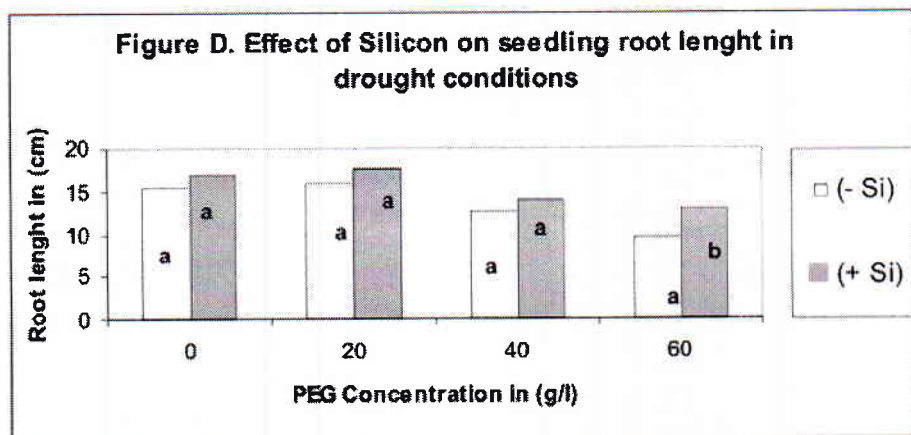
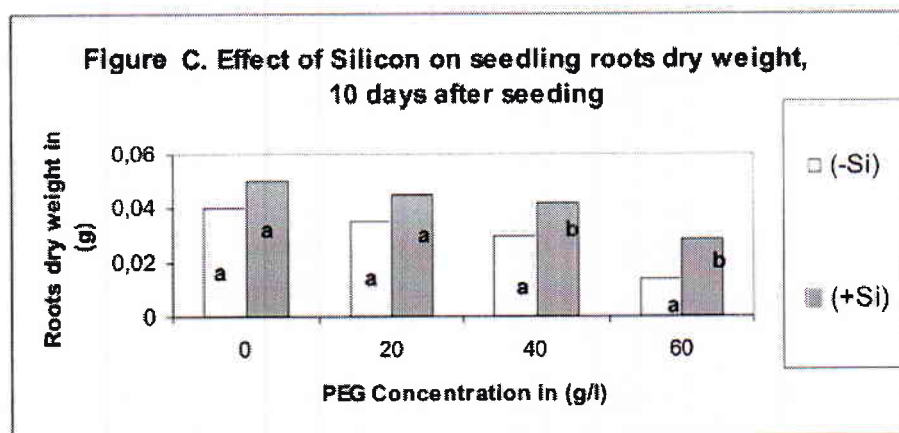
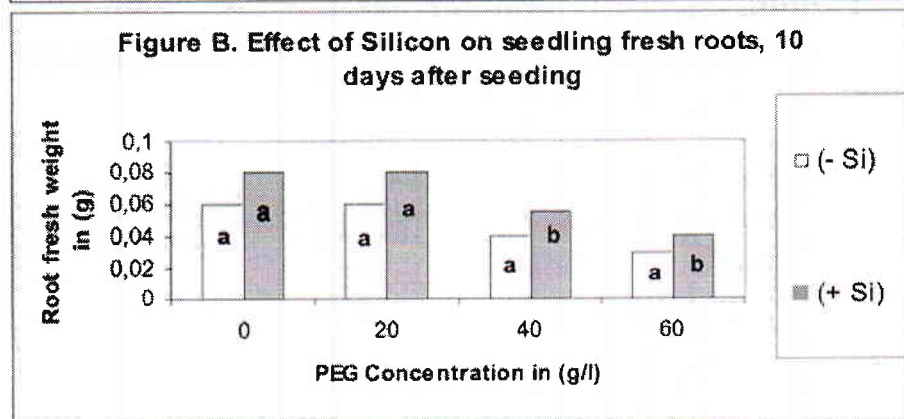
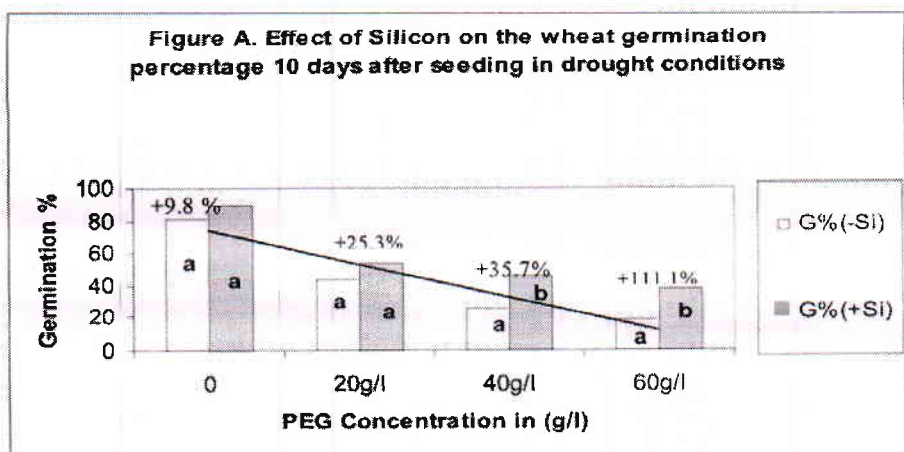


Figure 1. Effect of Silicon on the alleviation of drought stress in wheat germination

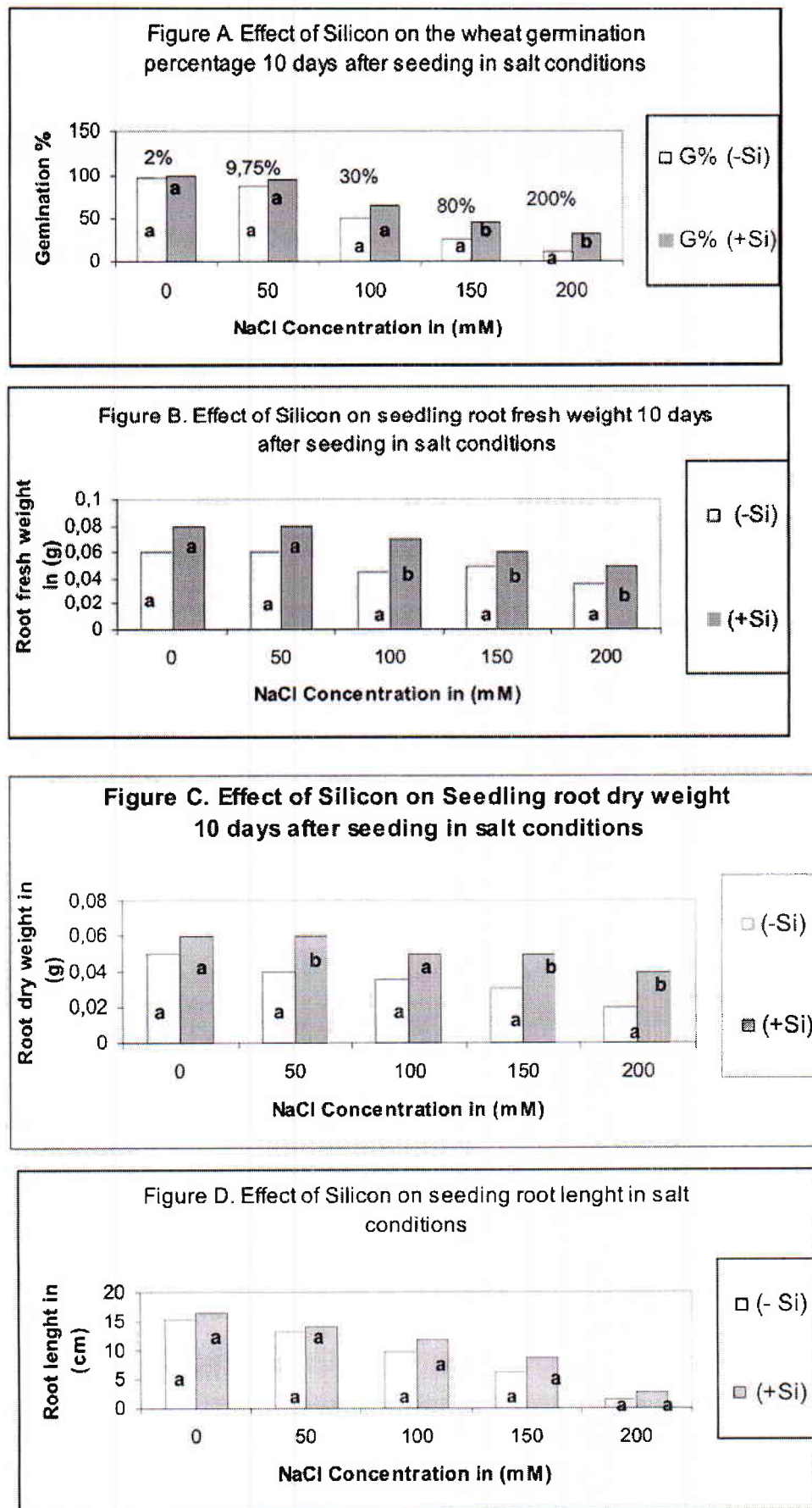


Figure 2. Effect of Silicon on the alleviation of salt stress in wheat germination

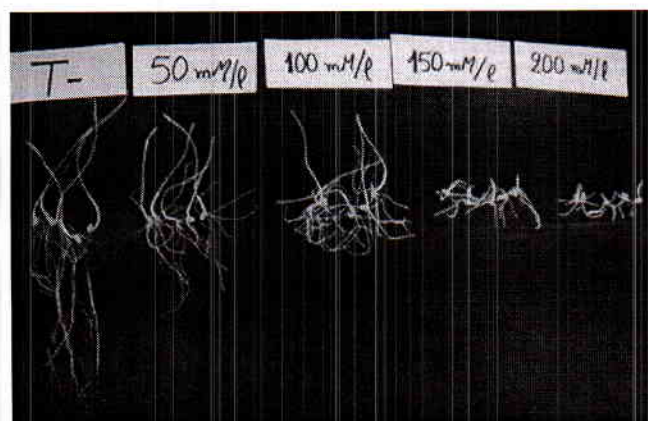


Photo 1 : Length root reduction of seedling wheat in salt conditions

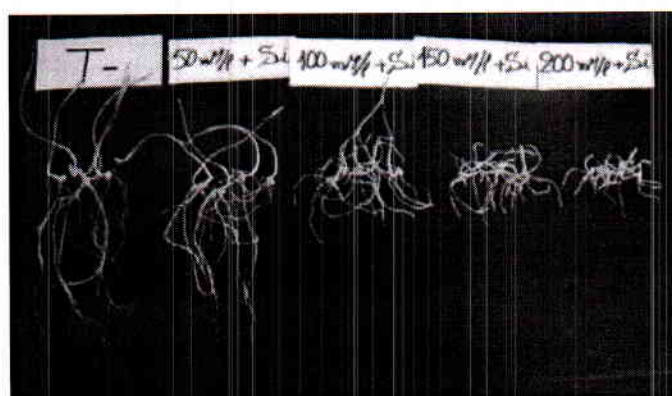


Photo 2 : Alleviation of salt effect on wheat seedling root length in presence of Si (OH₄).

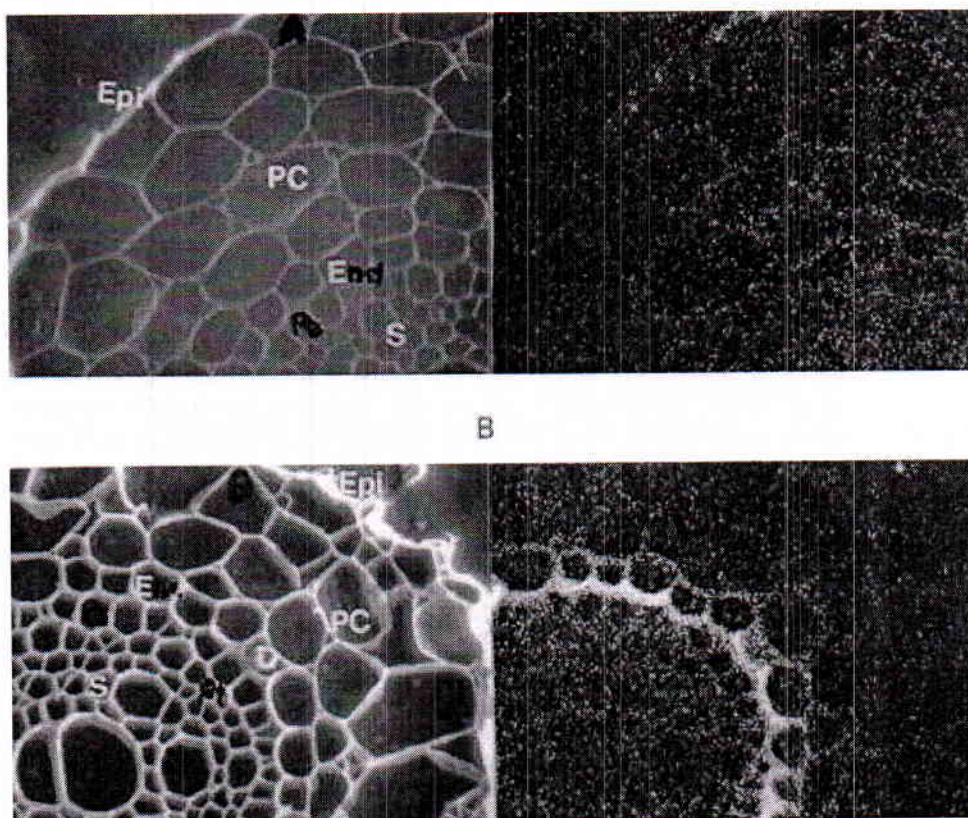


Photo 3 : Electronically microprobe analyses of Silicon accumulation in the endodermis of wheat, (at 6 days of age).
A: in the control; B: in the Silicon treated sample.

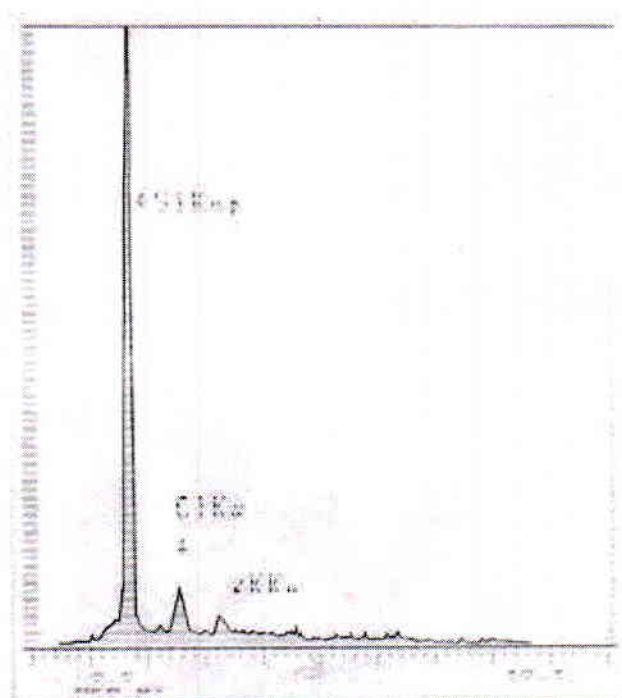


Photo 4 : Localization of Silica gel accumulation by electronic microprobe with dispersed energy at the endodermis cell of wheat seedling root, (at 6 days of age).

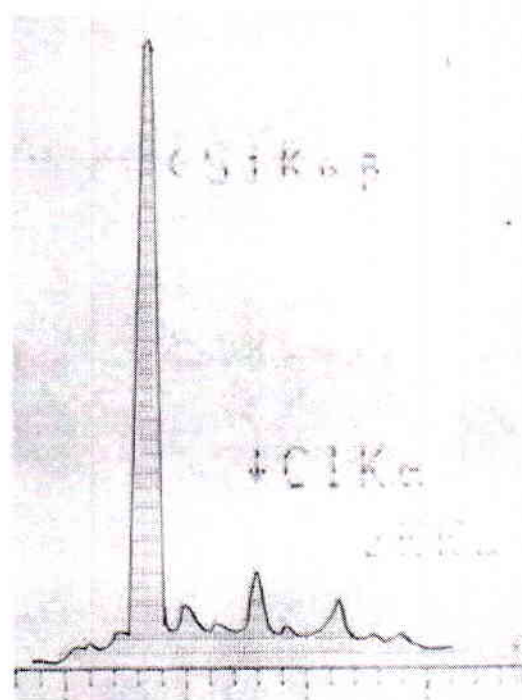


Photo 5 : Localization of Silica gel accumulation by electronic microprobe with dispersed energy at the epidermis cell of wheat seedling root, (at 6 days of age).

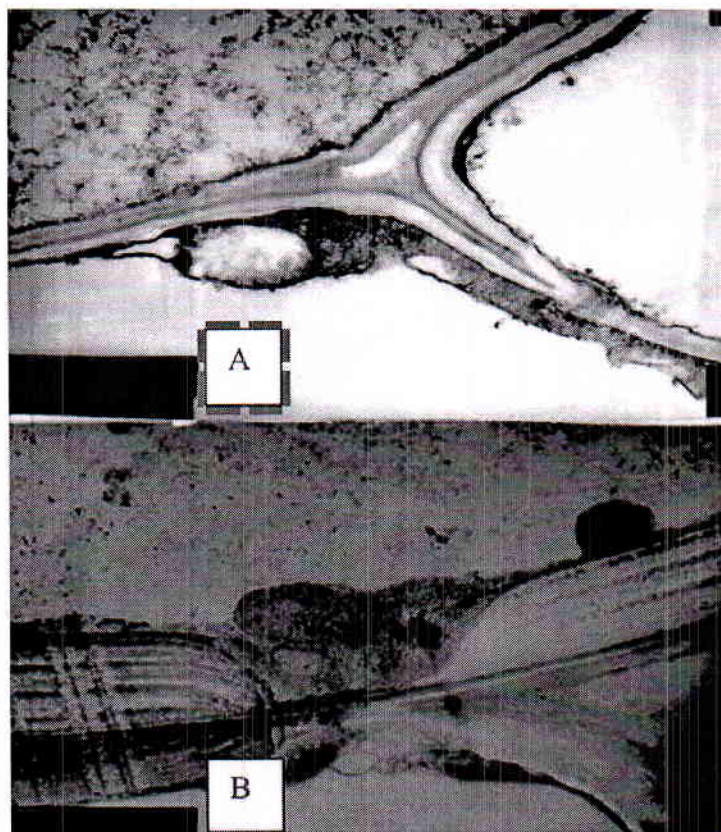


Photo 6. Localization of Silicon on the inner tangential wall of cell endodermis in wheat, (at 6 days of age) by electronic microscope in a control A; and a treated sample B.

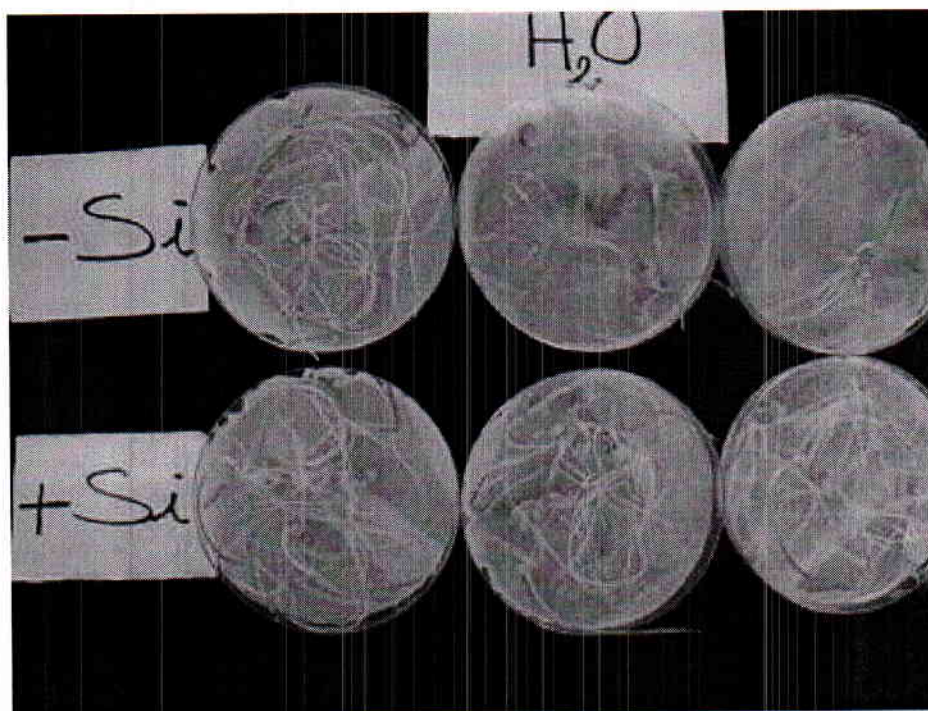


Photo 7. The beneficial effect of Silicon on root system protection against pathogens.