Distribution of implanted ions in seeds and roots of mung bean*

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Abstract Doses of 1×10^{16}, and $2\times10^{16}cm^{-2}$ and 1×10^{16}, 2×10^{16}, 3×10^{16} and $3.6\times10^{16}cm^{-2}$ for iron and cppper ions are implanted in dry seeds of mung bean, respectively. The results show that the accumulated-copper and -iron ion amounts in the seeds and roots vary with different doses of ion beam, and the fresh and dry weights of the roots decrease progressively with increasing iron and copper doses, except the treatment of 1×10^{16} Cu^+ ions/cm^2, and the accumulated-copper and -iron ion amounts in the seeds of the different test groups can be correlated with the ion distribution in the roots.
Keywords *Phaseolus radiatus* (L.), Copper ion, Iron ion, Ion beam irradiation, Ion distribution

1 Introduction

Ion irradiation as a new mutagenic source has been, for recent years, applied to the mutagenic breeding of rice, cotton, barley, ray, maize, wheat, soybean, pansy and petunia, and a considerable headway was got. Compared with other radioactive rays, the ion beam irradiation possesses lower damage, higher mutagenic frequency and wider mutagenic spectrum. By a novel ion implantation direct gene transfer technique the foreign gene can be introduced into plant cells. Besides, we found that the toxic effects on the nucleoli in the root tip cells of *P. radiatus* induced by Al^{3+} ions could be, to a certain extent, eased by N^+ and Cu^+ ions beam irradiation.[1] The effects of ion beam irradiation on crop breeding have been extensively studied, but little is known about the distribution changes of the irradiated-ions in the seeds and seedlings. The aim of the present investigation was to understand the distribution changes of the copper and iron ions in the dry seeds after the treatment with ion irradiation, and in the roots after the seed germination and growth.

2 Materials and methods

Healthy, equal-sized and plump bean were chosen from a population of the common bean *P. radiatus* L. ($2n$=22). By a MEVVA Metal and Air Double-Source Separating Injection Machine, Cu^+ and Fe^+ ions at the energy of 50 keV were, respectively, injected to the embryos of the dry seeds. The doses are 1×10^{16}, 2×10^{16}, 3×10^{16}, $3.6\times10^{16}cm^{-2}$ for Cu^+ and 1×10^{16}, $2\times10^{16}cm^{-2}$ for Fe^+. The injected-seeds and control were soaked in distilled water for 10 h, respectively. They were allowed to germinate and produce roots on wet filter paper with distilled water in Petri dishes at 24°C for 96 h, and protected from direct sunlight. The distilled water was changed every 24 h.

After 4 d of the culture, the samples (20 roots and 20 dry seeds per treatment as a group) were dried for 8 h at 65°C, and dried again for 2 h at 105°C in oven. The fresh and dry weights were also measured. The elements Cu and Fe were determined by a 180~80 polarized Zeeman atomic absorption spectrophotometer after dry-ashhing. All the treatments mentioned above were repeated three times.

3 Results

3.1 Effects of copper and iron ion beam irradiation on root growth

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As shown in Table 1, the fresh and dry weights decrease progressively with increasing Fe and Cu doses, except the treatment 1×10^{16} Cu^+/cm^2. For dry matter, all the treatment groups are more or less the same as the control, except 1×10^{16} Cu^+/cm^2. The treatments 3×10^{16} and 3.6×10^{16} Cu^+/cm^2 were not determined because the seeds could hardly germinate and produce roots during the whole treatment period.

3.2 Distribution changes of irradiated-ions in seeds and roots

As can be seen from Fig.1 the amounts of the irradiated-ions both in seeds and in roots increase progressively with increasing iron dose. The similar distribution trend is also found in the groups with copper ion irradiation (see Fig.2). The accumulated-copper and iron ion amounts in the seeds of the different groups can be correlated with the distribution amounts in the roots.

Table 1 Changes in fresh and dry weights of the roots (20 roots)

Elements	Treatment	Fresh weight/g	Dry weight/g	Dry matter/%
Fe	Control	6.786	0.394	5.81
	1×10^{16}	6.032	0.358	5.95
	2×10^{16}	4.584	0.268	5.85
Cu	Control	6.786	0.394	5.81
	1×10^{16}	6.511	0.406	6.23
	2×10^{16}	6.153	0.337	5.48

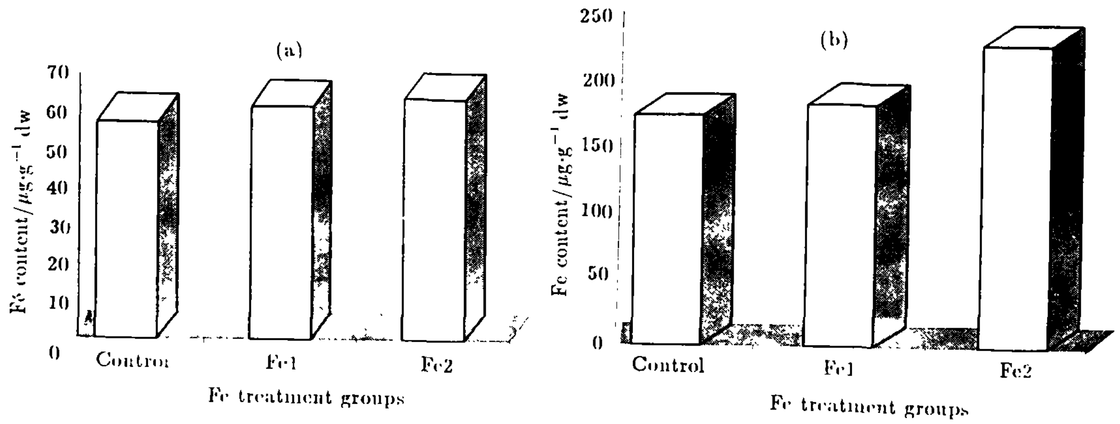

Fig.1 Iron ion amounts in the roots (a) and the seeds (b) after treatment with different doses

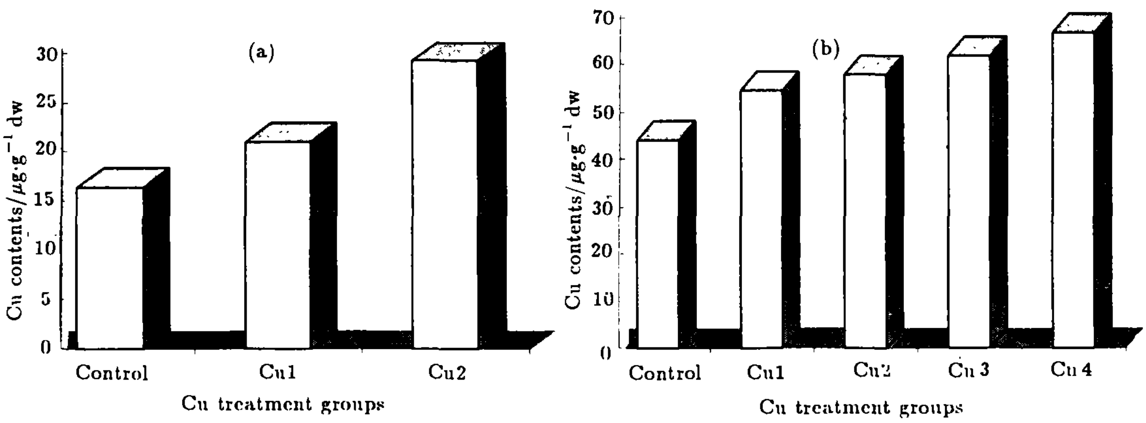

Fig.2 Copper ion amounts in the roots (a) and the seeds (b) after treatment with the different doses

In all treatment groups, the ion amount in the seeds is about twice or three times of that in the roots. It means that about 30% ions were transferred from the seeds into the roots during the whole treatment period, except the treatment 2×10^{16} Cu^+/cm^2 (about 50%).

4 Discussion

Lu *et al.*[2] stated that in meioses ion irradiation could induce univalent, trivalent and tetravalent in maize, lagging chromosomes in soybean and micronucleoli in rice. Zhu *et al.*[3] thought that nitrogen ion beam irradiation could induce chromosome translocation in rye, and that the chromosomal structure variation results from N^+ ion channel in the cells. However, no reports on distribution changes of the ions in seeds after ion irradiation treatments and the ions transferred to roots from the seeds have been published.

Copper is an essential element for plants, playing an irreplaceable role in the function of a large number of enzymes which catalyse oxidation reactions in a variety of metabolic pathways. Cu can also be considered as a toxic element whose deleterious effects usually arise from high concentrations.[4,5] The phenomena of the treatment 1×10^{16} $Cu^+\cdot cm^{-2}$ may be explained by the fact that the root growth is promoted with adding the appropriate amount of Cu ions and then accelerating electron flow, catalysing redox reaction in mitochondria, cell wall and in the cytoplasm of the plant cells.[6] And groups of the treatments 3×10^{16} and 3.6×10^{16} $Cu^+\cdot cm^{-2}$ are seriously inhibited, which results from the excessive doses of copper ions in the seeds, leading to the disturbance of mitosis[7], inhibition of root elongation and damage to root cell membranes.[8] Fernandes and Henriques[9] stated that most of the toxic effects of Cu ions are due to its potent inhibitory effects on a wide range of enzymes, possibly by irreversible binding of Cu^{2+} to SH groups that are essential for enzyme activity. In addition, some physical factors such as higher temperature during the ion beam irradiation may also cause the seeds to fail to germinate or produce roots. Therefore, it is very important to further and deeply study the biological effects of some ion concentration in the cells, which is of the significant importance in expounding the functions of nuclei, nucleoli and so on.

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