学位論文の要旨

Abstract of Thesis

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学位論文題目　Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Reevaluation of Ionic Stress on Plant Growth and Grain Yield of Cereals under Salinity Conditions
（塩条件におけるイネ科作物の生育および収量に及ぼすイオンストレスの再評価）

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The rapidly increasing of world population requires 1.7 times or more increases in the production of cereal crops such as rice, wheat and barley until 2050. However, these crop cultivations are facing many difficulties of abiotic stresses as drought, salinity, and flood. Salinity is one of the most serious environmental stresses severely limiting crop growth and grain productivity. Salt-affected land occupies about 19.5% of irrigated agricultural land. It has been generally considered that the toxicity of sodium (Na^+) rather than chloride (Cl^-) results salinity damages in many species. Therefore, most research on salinity tolerance for the growth and yield of cereals focuses on the toxicity of Na^+ rather than Cl^-; the information on the negative effects of Cl^- on cereals is still limited. In this thesis, four experiments were carried out to reevaluate and clarify the ionic effect of Na^+ and Cl^- on plant growth, grain yield and yield components in rice, wheat and barley under salinity conditions.

In chapter 1, to know the difference in the long-term effects of Na^+ and Cl^- on the whole plant dry weight and grain productivities, three rice varieties differing in salinity tolerance were grown in pots and irrigated by NaCl and KCl solutions of the same molar concentration. The whole plant dry weight and grain yield in all varieties decreased to the same extent by NaCl and KCl treatments at the full heading and maturity stages compared to the control. In the most cases, the Cl^- content in plants in the NaCl and KCl treatment groups was similar, although Na^+ content in shoots of all varieties at all stages under NaCl treatment were significantly higher than that under KCl treatment. There was a negative significant correlation between the relative dry weight or grain yield (treated / control) and the Cl^- content in plant. From these results, it was suggested that plant dry weight and grain yield under long-term salinity conditions were reduced by Cl^- toxicity rather than Na^+ toxicity.

In chapter 2, the experiment was conducted to confirm the Cl^- toxicity in plant growth, yield and yield components in rice under several salinity treatments. Same three rice varieties in chapter 1 were grown under the different iso-osmotic salinity conditions including NaCl, KCl, Na_2SO_4 and $MgCl_2$. The results showed that reduction of whole plant dry weight and grain yield was the lowest at Na_2SO_4 and the highest at KCl or NaCl conditions. There was no correlation between plant dry weight or grain weight and Na^+ content in shoot, while a negative correlation was

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observed between Cl^- content in shoot and the plant dry weight or grain yield. The decreases of panicle number also related to not Na^+ but Cl^- content in shoot. These results suggested that the decreases of grain yield and panicle number were mainly caused by an increase in Cl^- accumulation. However, the decrease of grain number per panicle, percentage of ripened grain and 1000 grain weight were not clearly correlated with Na^+ and Cl^-. It implied that other factors such as osmotic stress were related to these decreases rather than ionic stress. It was concluded that the plant growth, grain productivity and panicle number in rice under long-term saline conditions were reduced by Cl^- toxicity rather than Na^+ toxicity.

In chapter 3, the experiment aims to evaluate the effects of ionic stress on wheat and barley at seedling stage under salt treatments. Ten varieties of wheat and barley were grown in hydroponic culture containing NaCl or KCl. The varietal difference in the dead percentage (dry weight of dead tissues / total dry weight) was observed in both species, dead percentage in KCl treatment was higher than that in NaCl. The dead percentage in both species was correlated with not Na^+ but Cl^- content in shoot, and hence it implied that the increasing of dead percentage was mainly caused by Cl^- accumulation. Thus, it was considered that the toxic ion of dead percentage increasing by salinity was not Na^+ but Cl^- in wheat and barley at seedling stage under short-term saline conditions.

In chapter 4, to clarify the effects of ionic stress on plant growth and grain productivity in wheat and barley under long-term saline conditions, 4 varieties of wheat and barley were planted in pots filled with vermiculate. Three concentration levels of NaCl and KCl solution were irrigated until maturity stage, and plant dry-weight and grain yield at maturity stage were measured. Cl^- content in shoot negatively correlated with plant dry-weight and grain yield in both species. A positive correlation between Cl^- content in shoot and dead percentage at full heading stage was observed, although there was no correlation between the Na^+ content in shoot and the dead percentage. Sensitive varieties showed higher value of Cl^- content in shoot than tolerance varieties. From the results, it was strongly suggested that Cl^- but not Na^+ was the toxic ion of plant growth and grain yield in wheat and barley under long-term salinity conditions.

Form these results, it was concluded that the toxic ion of plant growth and grain yield under salinity stress was Cl^- rather than Na^+ in rice, wheat and barley under long-term saline conditions. In addition, the increase of dead percentage of wheat and barley at seedling stage was mainly due to Cl^- toxicity under short-term saline conditions.