Dynamics of plant nutrients and the symptom of their deficiency and excess.

Part 3: Micro elements
Mo, B, Cl

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Molybdenum deficiency

- Absorbed in its anion form.
- Susceptible in acidic soils.
- Yellow spots in citrus fruits.
- Deformed leaves of Brassicaceae crops.
- Deformed leaves of Fabacaceae crops.
- Yellow-green or pale orange colored spots in lower and medium position leaves.

Roles of molybdenum

- Constituting element of nitrogenase and nitrate reducing enzymes.
- More than 10 times larger amounts of molybdenum is contained in root nodules than in leaves and stems of legume and non-legume plants.
- Molybdenum deficiency causes nitrogen deficiency.
- Contribute in the utilization of nitrate nitrogen.

Molybdenum deficiency in tomato

Ambiguous chlorosis appears in the leaves of medium to lower position.

Boron deficiency

- Fixation and adsorption occur in soils with high pH.
- Hardly translocated in plants, and the deficiency occurs near the growing point.
- Occurs readily in fast growing and elongating tissues, such as flower stem, pollen tubes, tuberous roots, fruits, and the tips of stems.

B, Ca, Si contents in leaves

B, Ca, Si contents in the leaves of 108 kinds of plants grown on the same soil, features related to their classification.

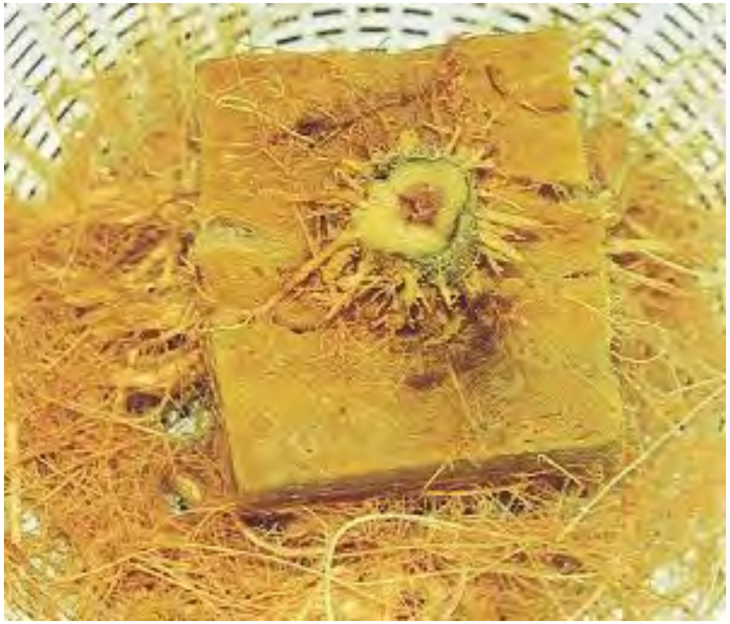
	B (ppm)	Ca (%)	Si (%)
Dicotyledoneae (66)	20.1	1.92	0.26
Monocotyledonae (42)	9.6	1.41	0.84
Gramineae (13 in above)	1.6	0.56	2.11
Lily family (10 in above)	10.1	2.30	0.19
Others (19 in above)	14.8	1.53	0.32

(Takahashi and Miyake, 1976)

Contents of boron in the crops

Crops	Parts	B (ppm) in the crops grown on normal soils	B (ppm) in the crops grown on deficient soils
Chinese cabbage	head	20.3	10.4
Rape seed	stem	8.3	5.0
Beer barley	grain	3.8	1.2
Rice	brown rice	0.8	No deficiency
	rice husks	2.6	observed
	leaves /stems	1.2	

Boron deficiency in tomato



Vascular bundle has been formed like cork (at the 6^{th} leaf stage, 6 weeks after B depletion).

Boron deficiency in corn

- Due to the inferior growth of pollen and pistil hair, seeds become sterile and unripe.

Boron deficiency in barley.

- Heading is uneven, heads are narrow, pale yellow colored, and delayed in maturing.

Chlorine deficiency

- Leaves on the tip of stem are withered and the growth is stopped. Roots become fat and short due to necrosis.
- Sugar beet, lettuce and cabbage are susceptible.
- Grains and legumes are non-susceptible.
- Growth of oil palm and coconuts are promoted by Cl.

Dynamics of plant nutrients and the symptom of their deficiency and excess.

Part 4: Useful elements and the tolerance of crops to acidity, salt, heavy metals, and nutrient deficiency

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Effect of silica on rice.

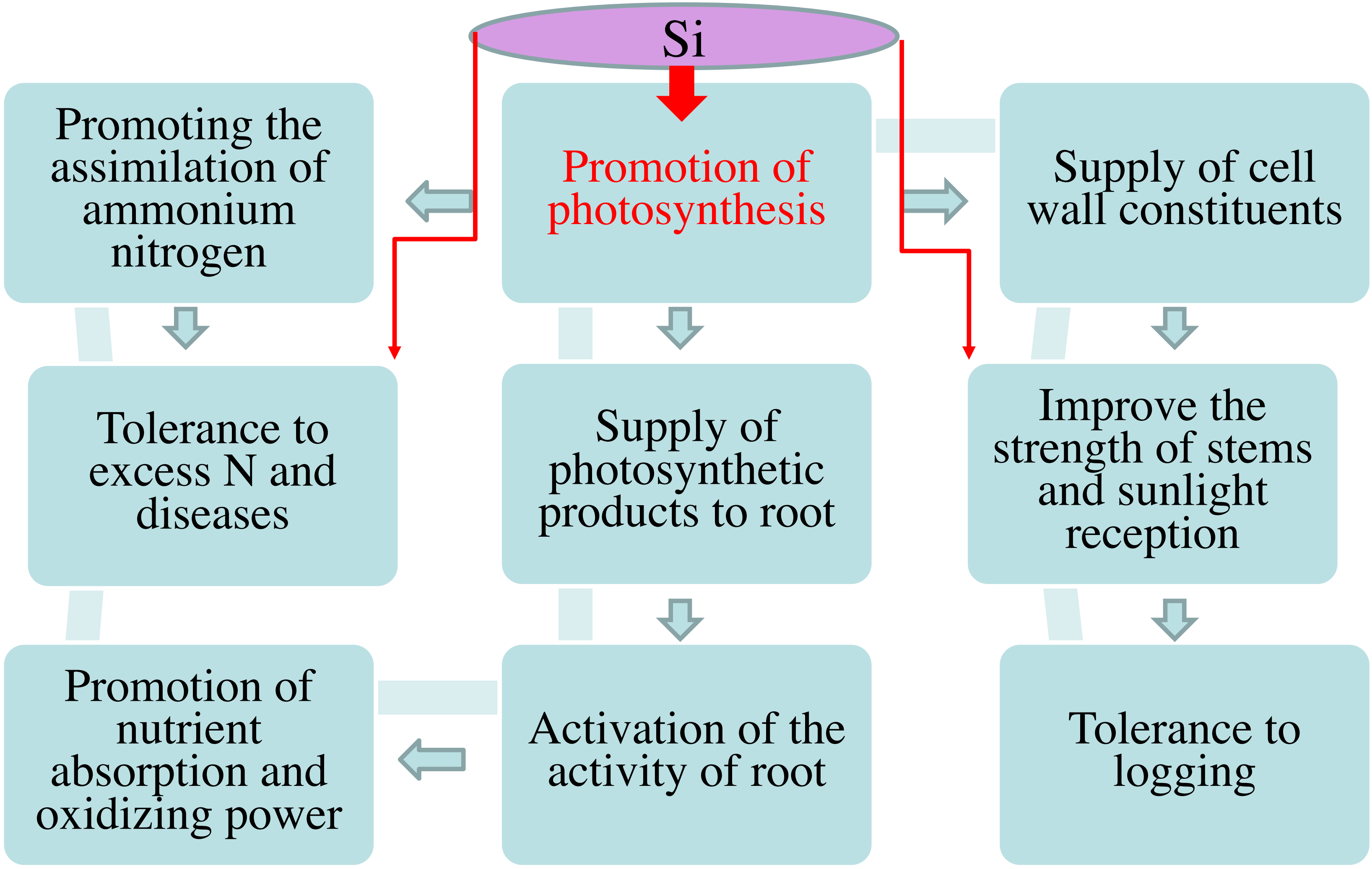
- Improve the shape of rice plant to receive sunlight. Prevent the bending of stems. Reduce the overlapping of leaves. Improve the light environment in the community.
- Improve the tolerance to disease and insect damage.
- Improve the tolerance to logging.

Effects of silicate application on the growth of rice (Norin 22) by hydroponic culture in a 1/5000 a Wagner pot.

SiO_2 in the culture solution	Above ground dry matter	Grain yield	SiO_2 in leaf and stem	Absorbed amount of SiO_2
(ppm)	(g/plant)	(g/plant)	(%)	(g/plant)
0	17.4 (100)	2.9 (100)	0.07	0.01
5	19.6 (113)	3.7 (128)	0.62	0.13
20	21.1 (121)	4.5 (155)	2.00	0.39
60	22.6 (130)	6.3 (217)	5.19	0.98
100	24.6 (143)	8.6 (297)	8.01	1.52

(Takahashi, 1961)

Effects of silicate on the growth of rice



Silicate deficiency in rice (Rice blast).

Rice blast disease in the field.

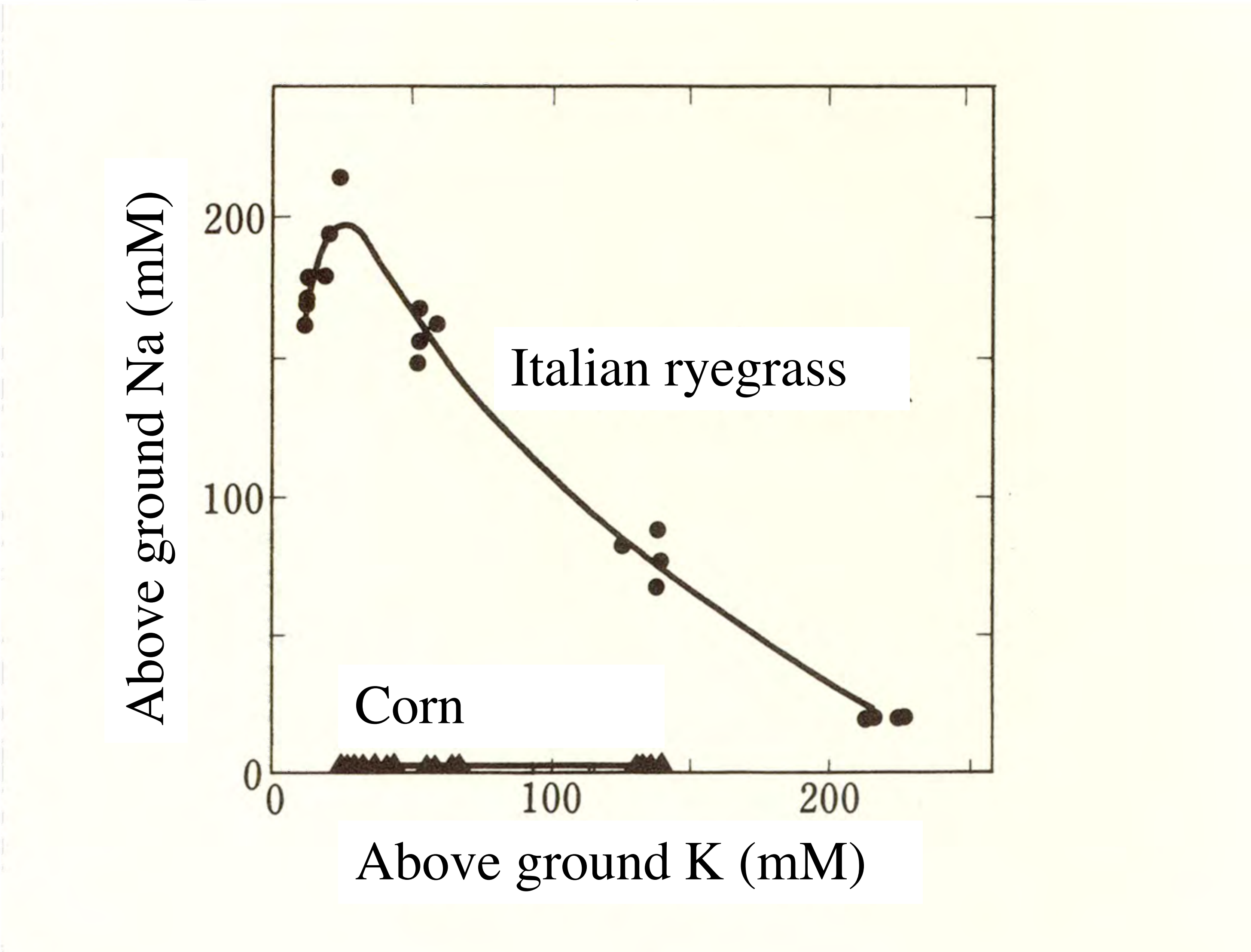
Effect of sodium on the growth of plants

- Substitution for potassium

  Effective in barley, rice, Italian ryegrass, tomato and cotton.

- Not effective in corn, potato, and soy bean.

Na and K concentrations in the above ground part of Italian ryegrass and corn.



Low pH tolerance of crops

- Tolerant

corn, rice, wheat, rye, barley, sorghum, soy bean, kidney bean, adzuki bean, broad bean, red pepper, beefsteak plant, lettuce, asparagus, meadow fescue, Reed canary grass, timothy, tall fescue, Alsic clover

- Medium tolerant

oat, barnyard grass, green peas, white radish, potherb mustard, komatsuna, rutabaga, Chinese cabbage, egg plant, carrot, sponge gourd, cucumber, onion, parsley, alfalfa, Italian ryegrass, orchard grass, white clover, Crimson clover

Low pH tolerance of crops (continued)

- Intolerant

cabbage, mustard, turnip, tomato, garland chrysanthemum, burdock, celery, sugar beet, spinach

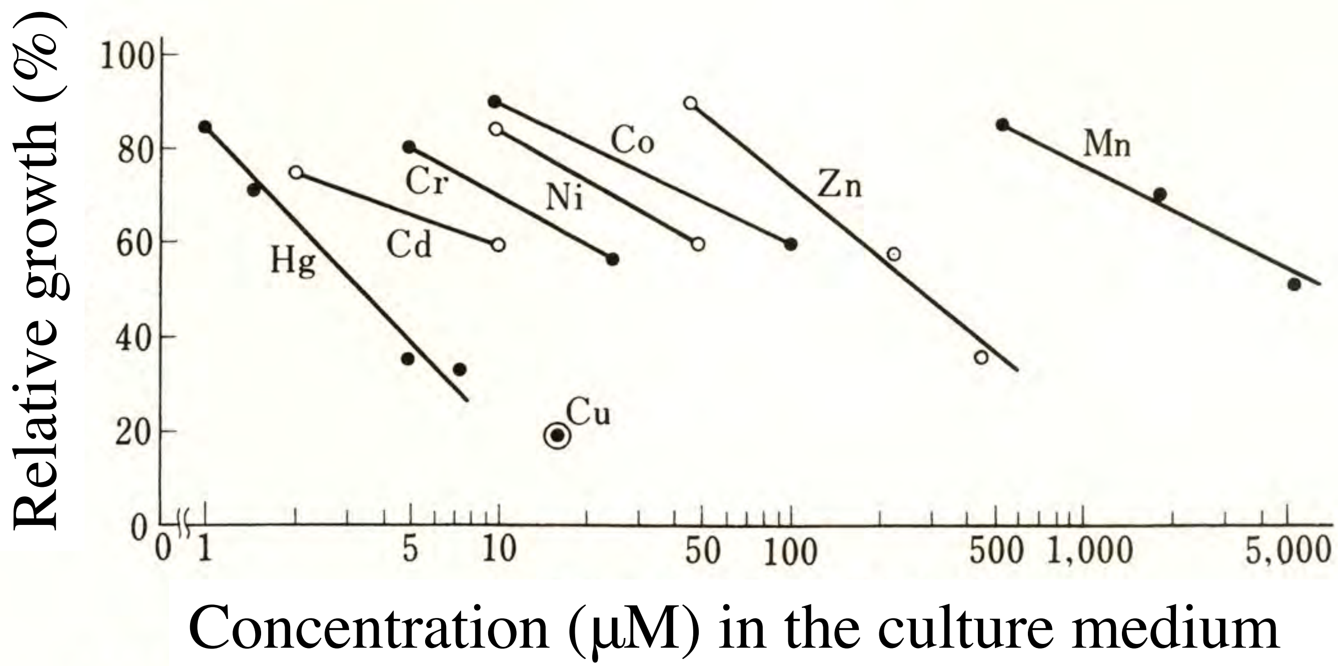
The lowest concentration of Al causing the decrease in dry matter weight of crops.

crops	ppm	crops	ppm	crops	ppm
alfalfa	0.5	corn	2.3	kidney bean	10
barley	0.5	carrot	3.6	cucumber	10
lettuce	0.7	wheat	6.0	cabbage	10
tomato	0.8	soy bean	6.0	oat	30
red pepper	1.5	radish	7.2	rice	90
buck wheat	1.5	turnip	7.2	Dry-land rice	20
sugar beet	1.8				

Intolerant　　Medium tolerant　　Tolerant to Al

Heavy metal concentration and plant growth.

(Tanaka and Tadano, 1975, 1978, 1980)

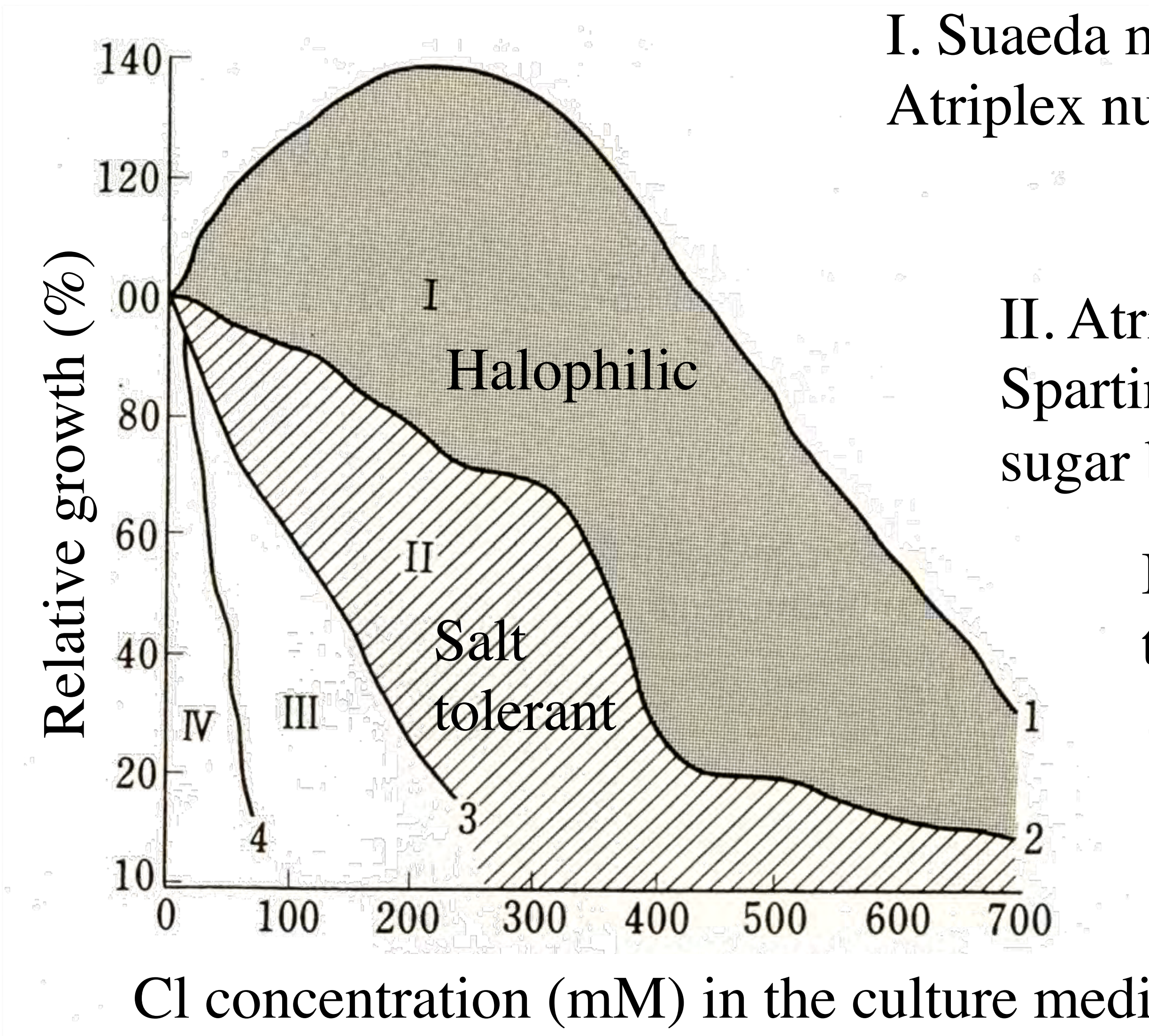


Control for relative growth: Hg, Cd, Cr, Ni, Co; Null treatment, Cu; 0.16 μM, Zn; 4.6 μM, Mn; 18 μM

Average of 16 – 19 crops.

Period of treatment: Cu; 24 days, Mn; 14 days, other elements; 18 – 19 days.

Salt tolerance of various plants



I. Suaeda maritima, Atriplex numularia

II. Atriplex hastata, Spartina townsendii, sugar beet

III. Cotton, barley, tomato, soy bean

IV. Avocado, mandarin orange

Organic compounds accumulated in plant cells under high salt concentration

Compounds	Distribution in various plants
D-sorbitol	Plantaginaceae, Rosaceae
D-mannitol	Rubiaceae
D-pinitol	Fabaceae, Rhizophoraceae, Caryophyllaceae
Inositol	Solanaceae
Glycine betaine	Chenopodiaceae, Amaranthaceae, Asteraceae, Poaceae
B-alanine betaine	Plumbaginaceae, Asteraceae, Poaceae

Tolerance of various crops to the low level of trace elements (1)

Crops	Fe	Mn	Zn	Cu	B	Mo
Rice	Weak	Strong	W-M	Strong	Strong	Strong
Wheat	Strong	Weak	M-S	Weak	Strong	Strong
Barley	-	Med.	M-S	W-M	Strong	Strong
Oat	-	Med.	Strong	W-M	Strong	Strong
Corn	Med.	Med.	Weak	Med.	Strong	Strong
Soy bean	Weak	W-M	W-M	Strong	M-S	Med.
Kidney bean	-	-	Weak	Strong	Med.	Strong

Tolerance of various crops to the low level of trace elements (2)

Crops	Fe	Mn	Zn	Cu	B	Mo
Green pea	-	-	Strong	Strong	Strong	M-S
Beet	Weak	W-M	Med.	W-M	Weak	W-M
Spinach	Weak	Weak	-	Weak	Med.	Weak
Radish	-	Weak	-	Med.	Weak	Med.
Chinese cabbage	-	Weak	Med.	Strong	Strong	-
Cabbage	Med.	Med.	Weak	M-S	W-M	W-M
Potato	-	-	Med.	M-S	Strong	M-S

Tolerance of various crops to the low level of trace elements (3)

Crops	Fe	Mn	Zn	Cu	B	Mo
Tomato	Weak	Med.	Med	Med.	W-M	W-M
Egg plant	-	-	Strong	-	Weak	-
Cucumber	-	-	Med.	Med.	Strong	-
Lettuce	-	-	-	W-M	W-M	Week
Onion	-	Weak	W-M	Weak	Med.	-
Carrot	-	Med.	Strong	Weak	W-M	M-S

(Andersson, 1956 : Berger, 1949 : Gartrell, 1981 : Gilbert, 1952 : Johnson et al, 1952 : Lucas et al, 1972 : Minami et al, 1972 : Tanaka et al, 1975, 1978 : Viets et al, 1954 : Yamauchi, 1976)