

Nutritional components and nitrogen fixation in seabuckthorn (*Hippophae rhamnoides* L.)

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Tohoku University Africa Program



東北大学

- ◆ **Title:** Collaborative research initiative between Tohoku University and Africa to promote the use of underutilized plant resources
- ◆ **Purpose:** The lack of the micronutrient in Africa is serious with the dissatisfaction of the main nutrient. Some underutilized plants are rich in vitamins and stress-tolerant. This project promotes the research and personal exchange for searching and introducing valuable underutilized plants.
- ◆ **Future:** Developing to governmental program



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◆ Plan

- 1) Examination of the possibility of the cultivation in Africa of underutilized plant species proposed by Tohoku University
- 2) Research promotion for use of underutilized plant resources proposed by African nations (e.g. Evaluation of their potential, Development of novel functional components)
- 3) Personal exchanges for 1) and 2)
- 4) Construction of research promotion network for use of underutilized plant resource

◆ **Potential research group:** Global Horticulture Initiative, ICUC, Others

Background

- ◆ Seabuckthorn (*Hippophae rhamnoides* L.) is a small fruit tree in the family Elaeagnaceae that originated in central Asia.
- ◆ Fruit is rich in vitamin.
- ◆ Actinorhizal plant.
- ◆ There are three spp.:
 - ssp. *mongolica* (Central Asia)
 - ssp. *rhamnoides* (Europe)
 - ssp. *sinensis* (China)



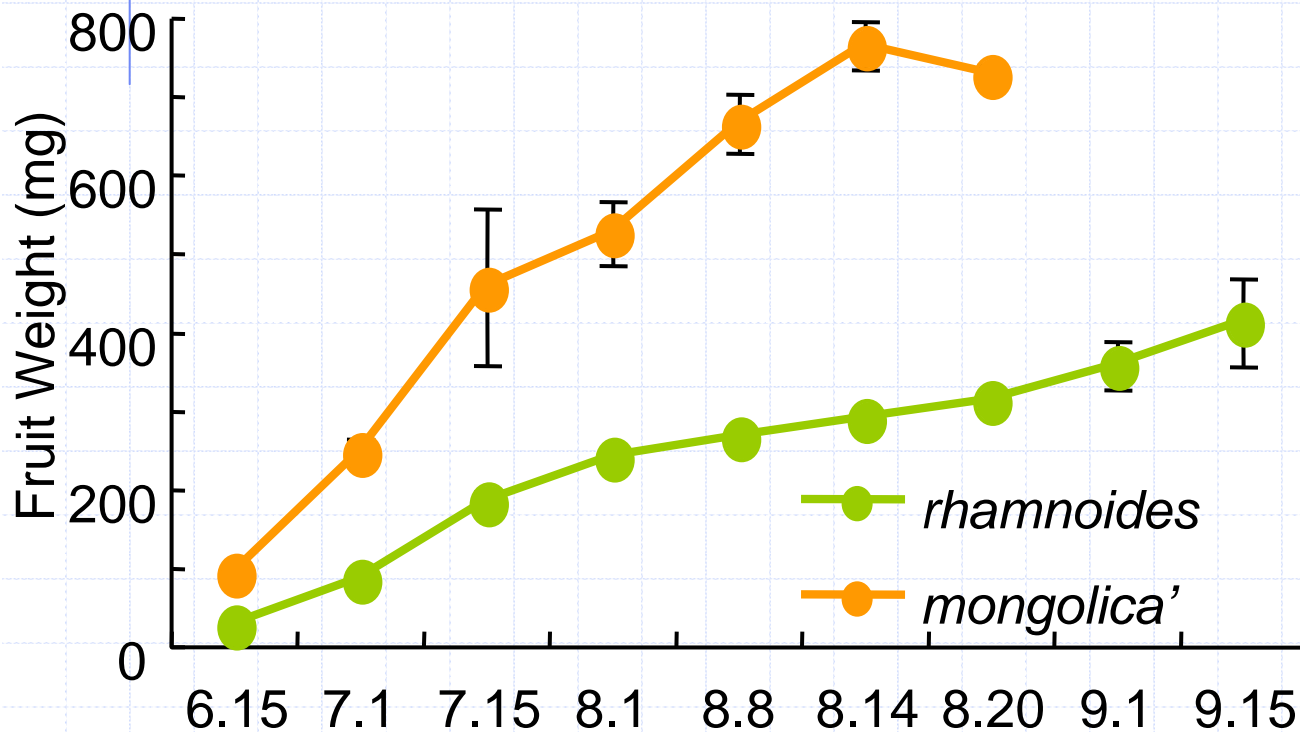
Purpose

- ◆ The physiological study of small fruit trees like seabuckthorn is insufficient.
- ◆ To evaluate the nutritional components of the fruit, nitrogen fixation, and abiotic stress tolerance of seabuckthorn as an example of underutilized plants that could be useful for food security and sustainable production.

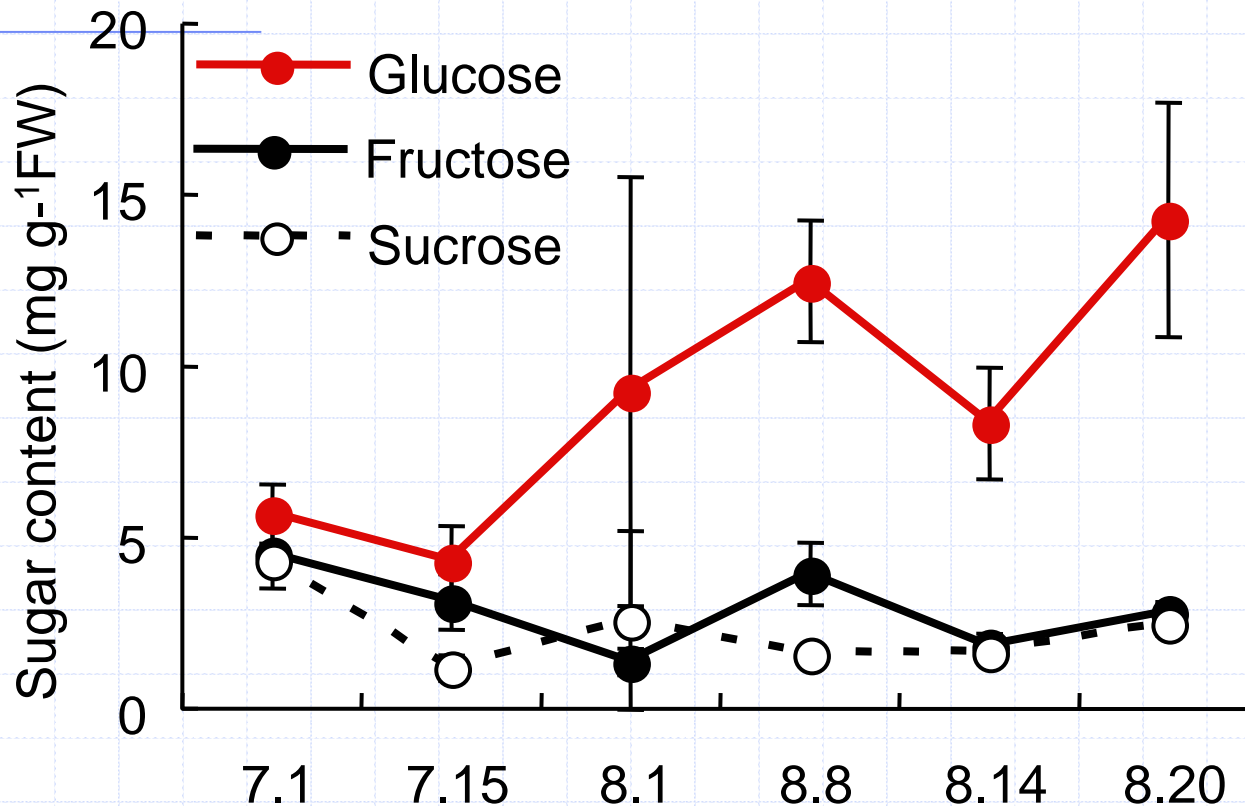
Changes in fruit size in seabuckthorn fruit

ssp. mongolica

ssp. rhamnoides

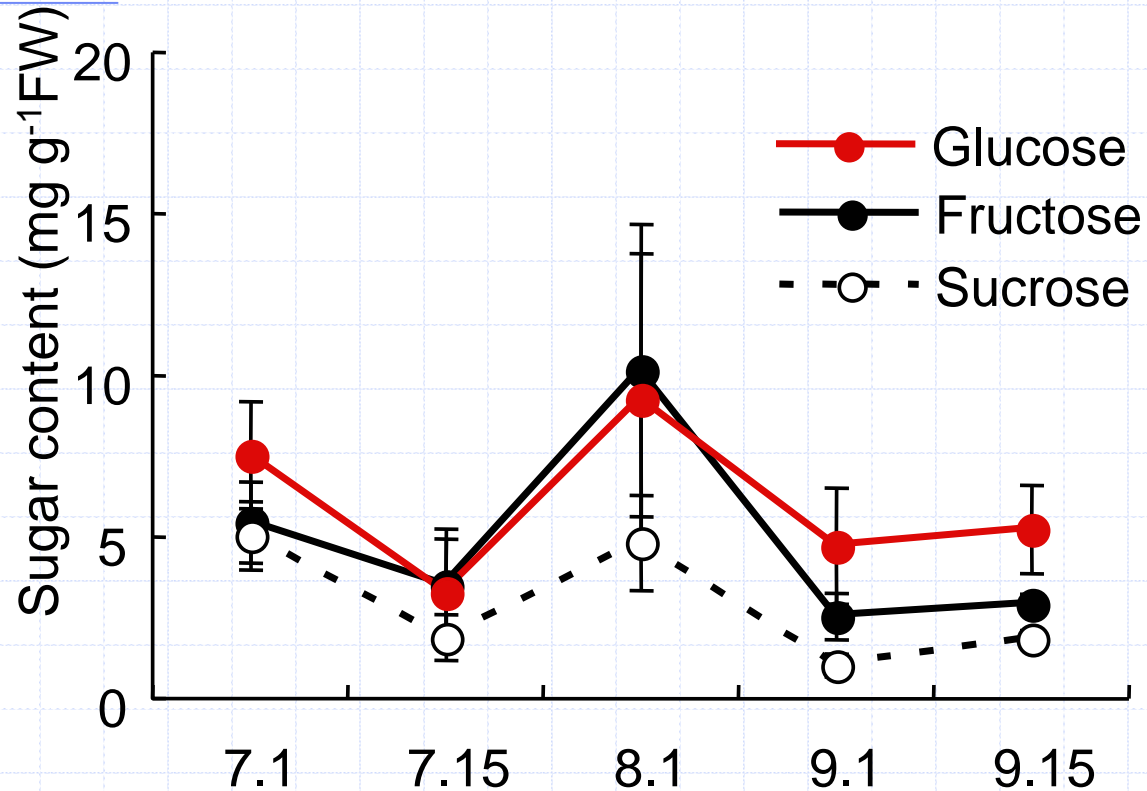


Changes in sugar content in seabuckthorn (ssp. *mongolica*) fruit



Glucose content increased rapidly during the month before the harvest, in contrast to the fructose and sucrose contents.

Changes in sugar content in seabuckthorn (ssp. *rhamnoides*) fruit



The contents of the three sugars did not increase during fruit growth.

Sugar composition in seabuckthorn fruits and leaves

LEAF:

Photosynthate is translocated to fruit as **sucrose**.

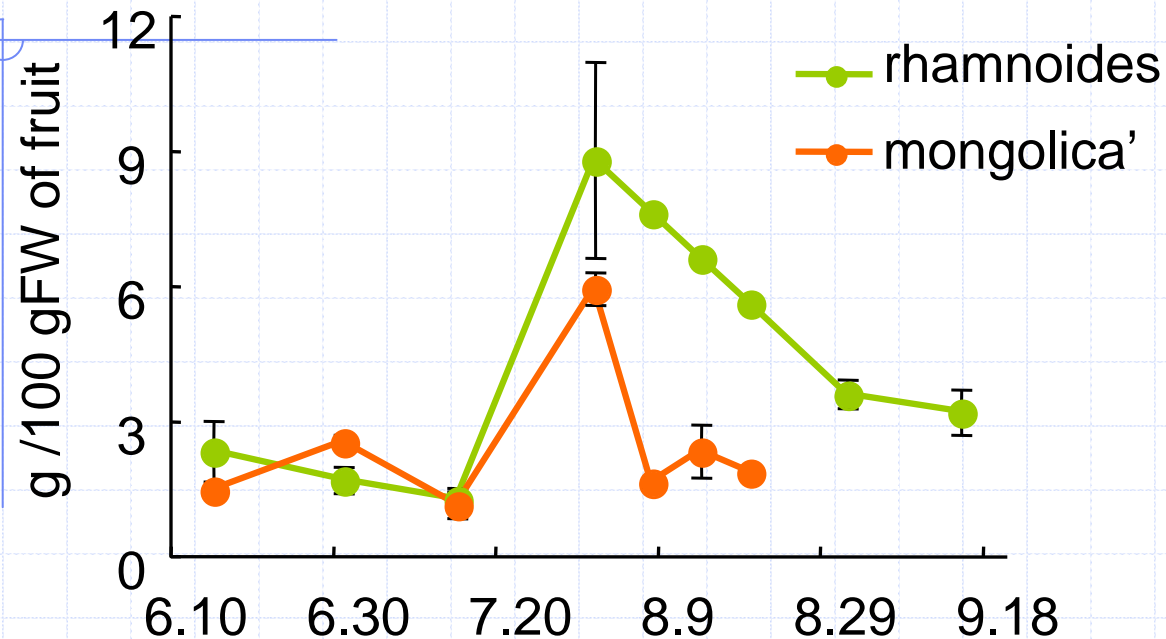
FRUIT	Glc	Fru	Suc	Total
	mg g ⁻¹ FW			
spp. <i>mongolica</i>	12.5	3.9	1.6	18.0
spp. <i>ramnoides</i>	5.2	2.9	1.9	10.0

LEAF	Glc	Fru	Suc
	mg g ⁻¹ FW		
spp. <i>mongolica</i>	6.6	26.5	64.3
spp. <i>ramnoides</i>	7.3	18.5	63.3

FRUIT: The difference between two spp. is due to the different levels of glucose accumulation.

Flavor could be improved by enhancing the accumulation of sweeter sugars (Fru and Suc).

Changes in titrable acid in seabuckthorn fruit

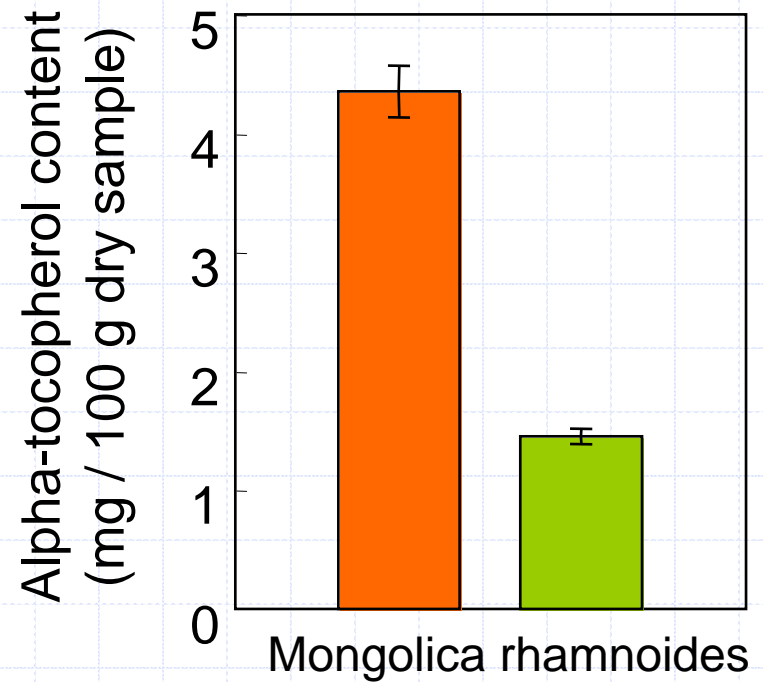
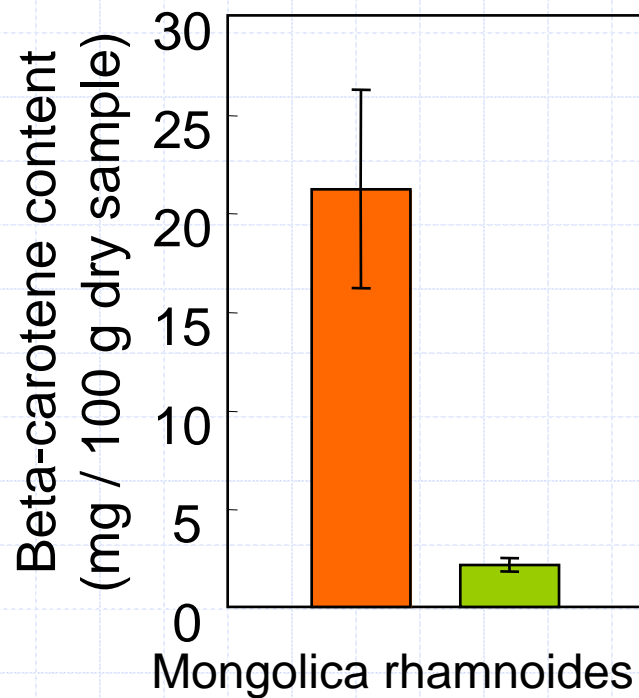


The titrable acid increased transiently during fruit growth and then **decreased** during ripening.

High sugar/acid ratio in spp. *mongolica* fruit is a beneficial characteristic.

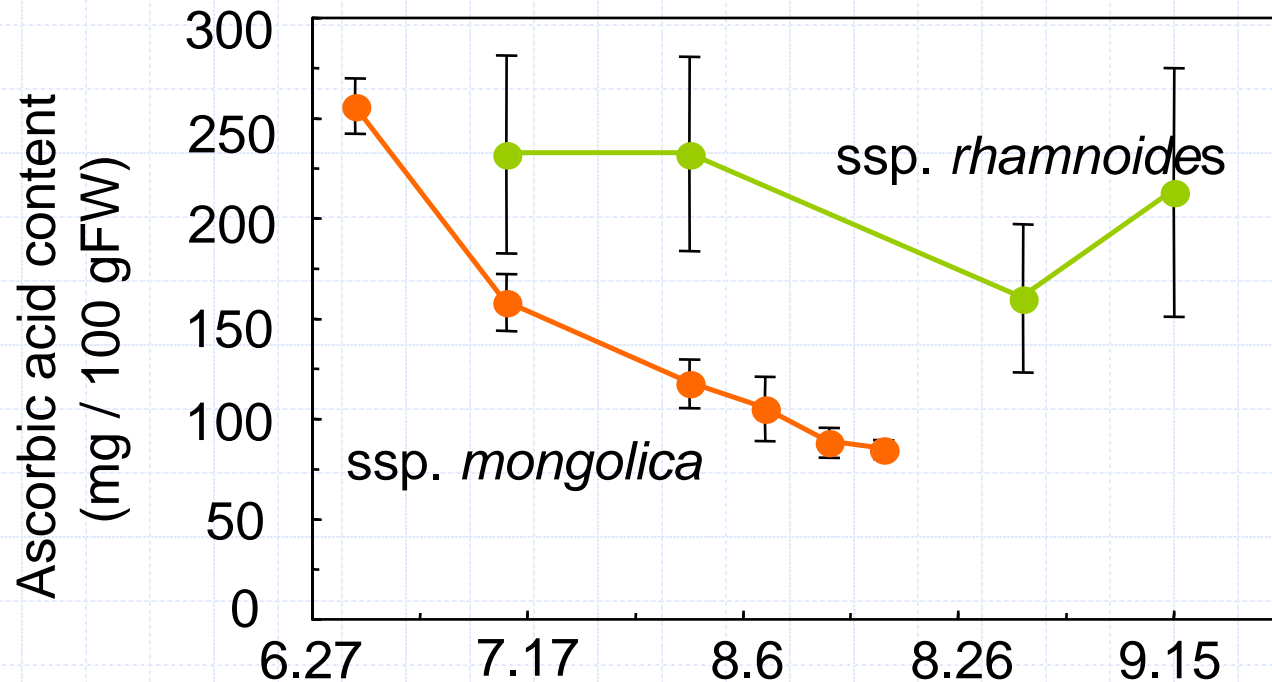
	Titrable acid (g / 100 gFW)	Sugar/acid ratio
spp. <i>mongolica</i>	1.61	1.14
spp. <i>rhamnoides</i>	3.16	0.32

Carotene and tocopherol content in seabuckthorn fruit



High contents of carotene (Provitamin A) and tocopherol (Vitamin E)

Changes in ascorbic acid content in seabuckthorn fruit

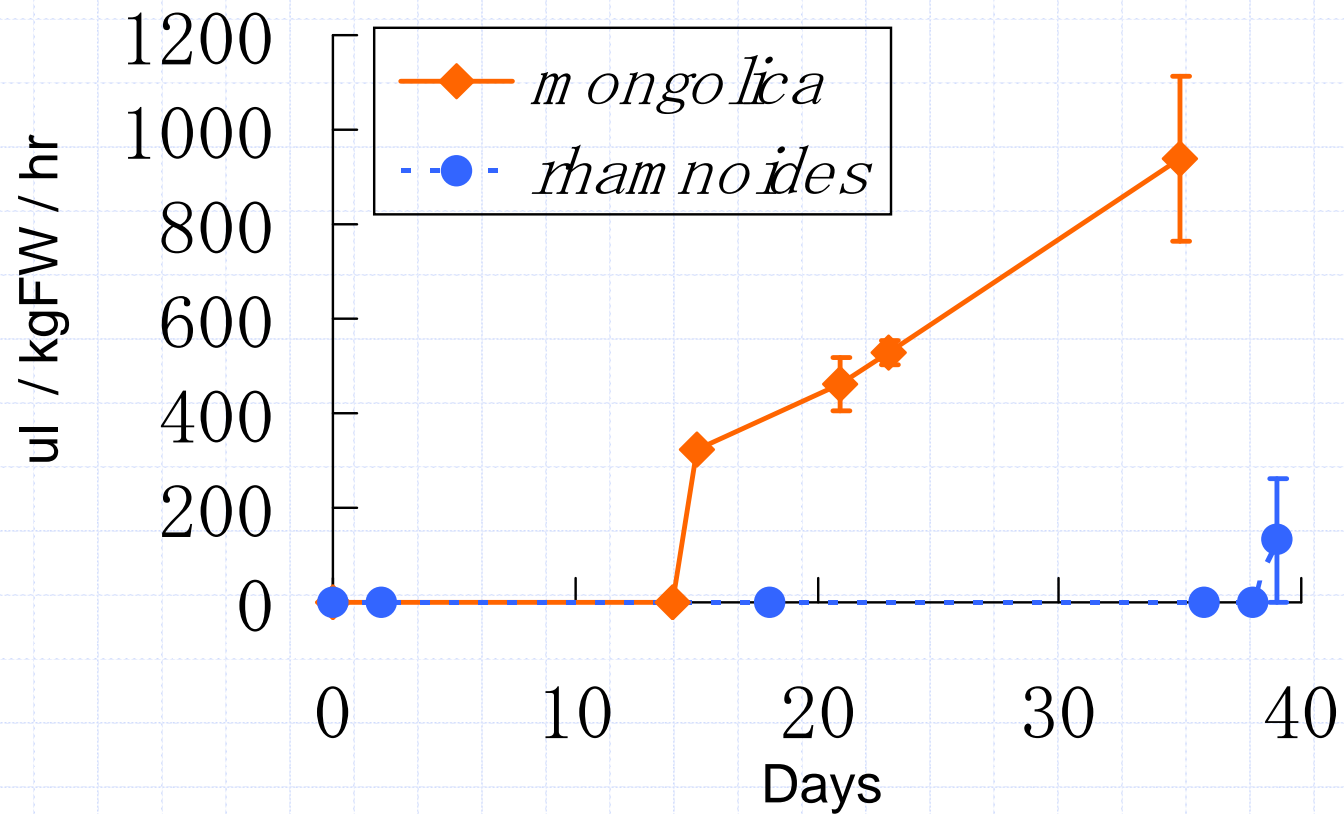


High ascorbic acid content

Decreased during fruit development unlike strawberry.

The content in spp. *mongolica* could be improved.

Ethylene evolution during maturation

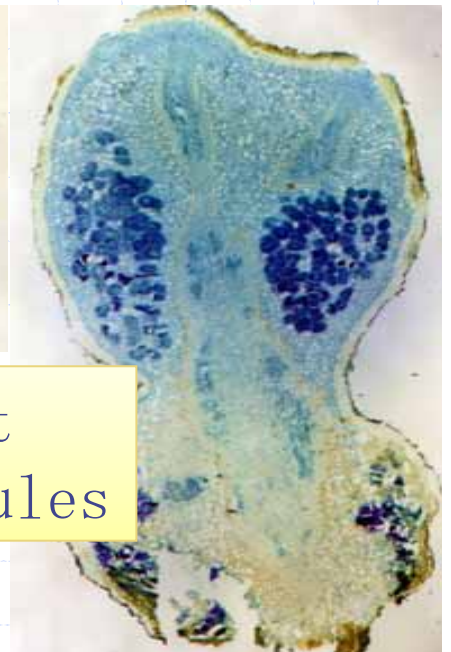
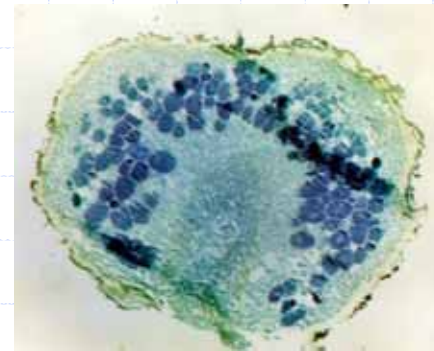


spp. *mongolica*: Climacteric type

spp. *rhamnoides*: Non-climacteric type (Long shelf)

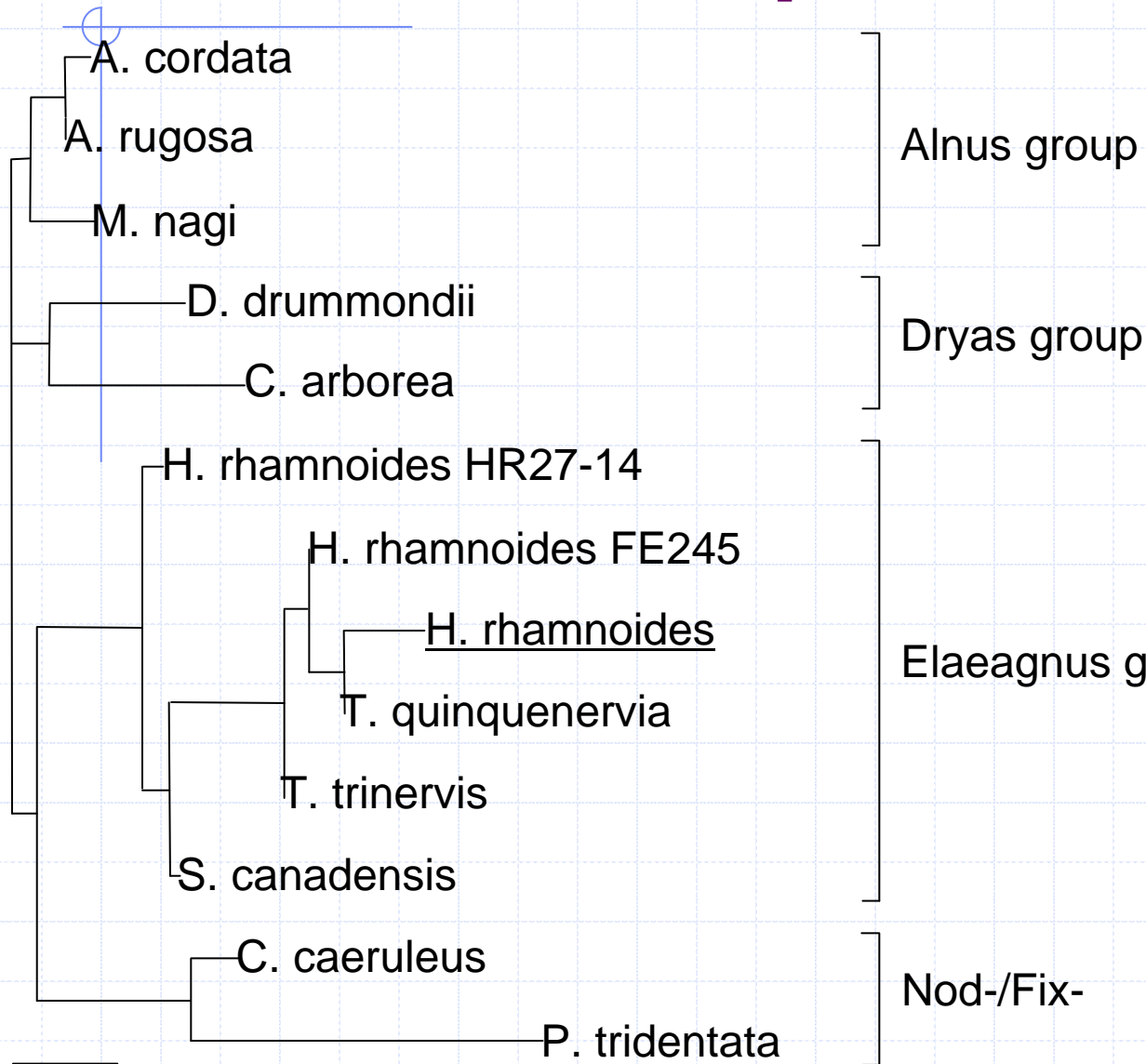
Morphology of seabuckthorn root nodules

Frankia is included in actinomycetic, nitrogen-fixing, nodule-forming endophytes of woody trees and shrubs. The symbiotic plants infected with Frankia are called actinorhizal plants.



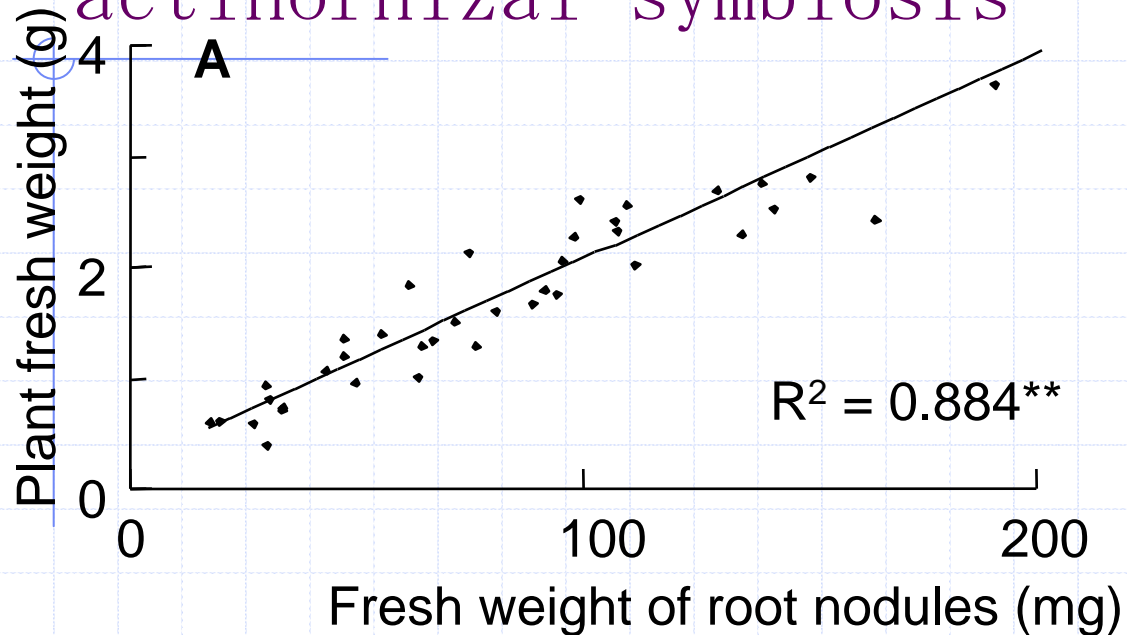
The morphological properties were consistent with those of Frankia-actinorhizal root nodules

Phylogenetic tree base on *Frankia* 16S ribosomal DNA sequence



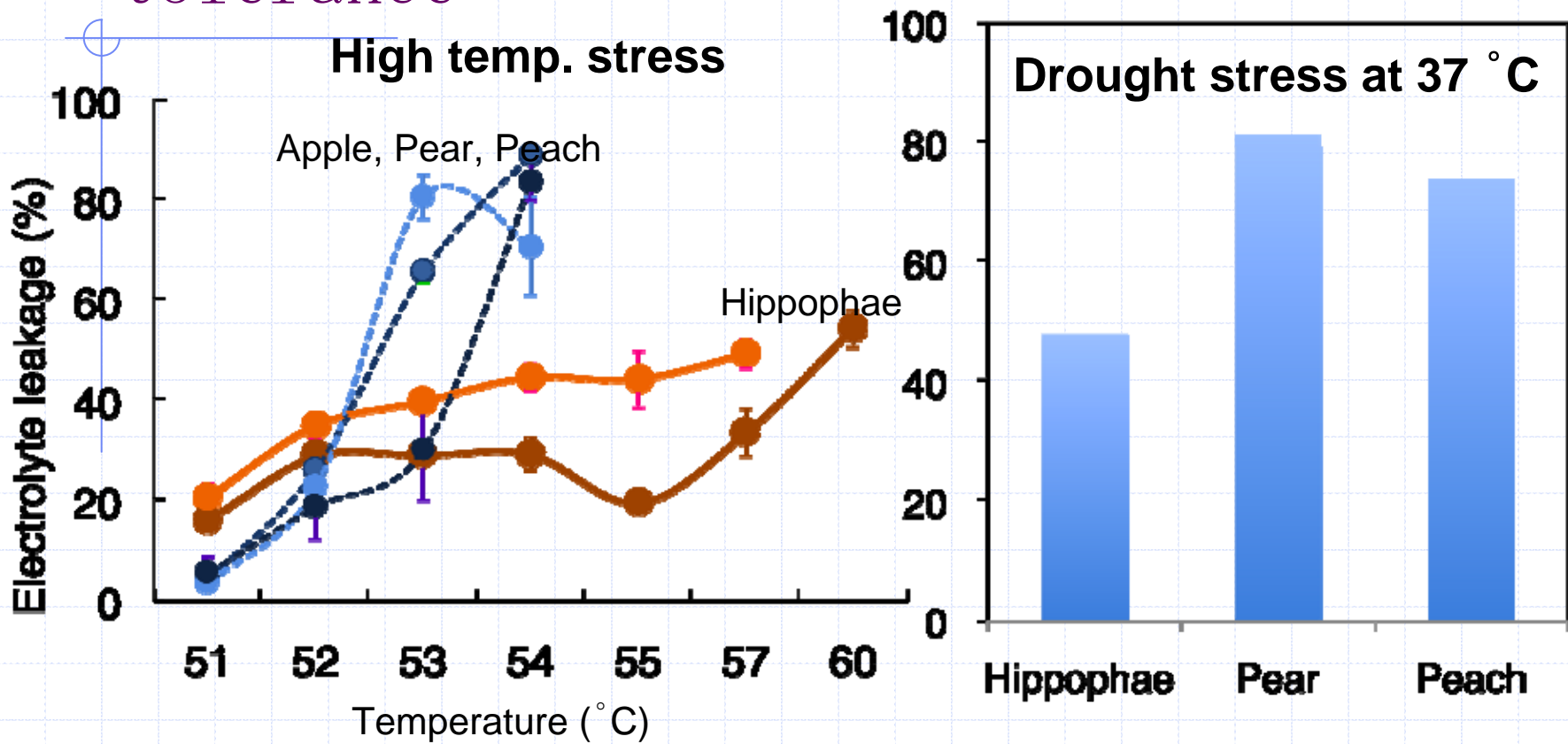
Actinorhizal plants involves many species, which are classified to eight families that contain 25 genera comprising more than 220 species

High potential of *Frankia*-actinorhizal symbiosis



The high positive correlation was observed between nodule fresh weight and plant fresh weight. Seabuckthorn seedlings that were well nodulated showed normal growth and seemed not to lack nitrogen under nitrogen-free condition.

High temperature and drought stress tolerance



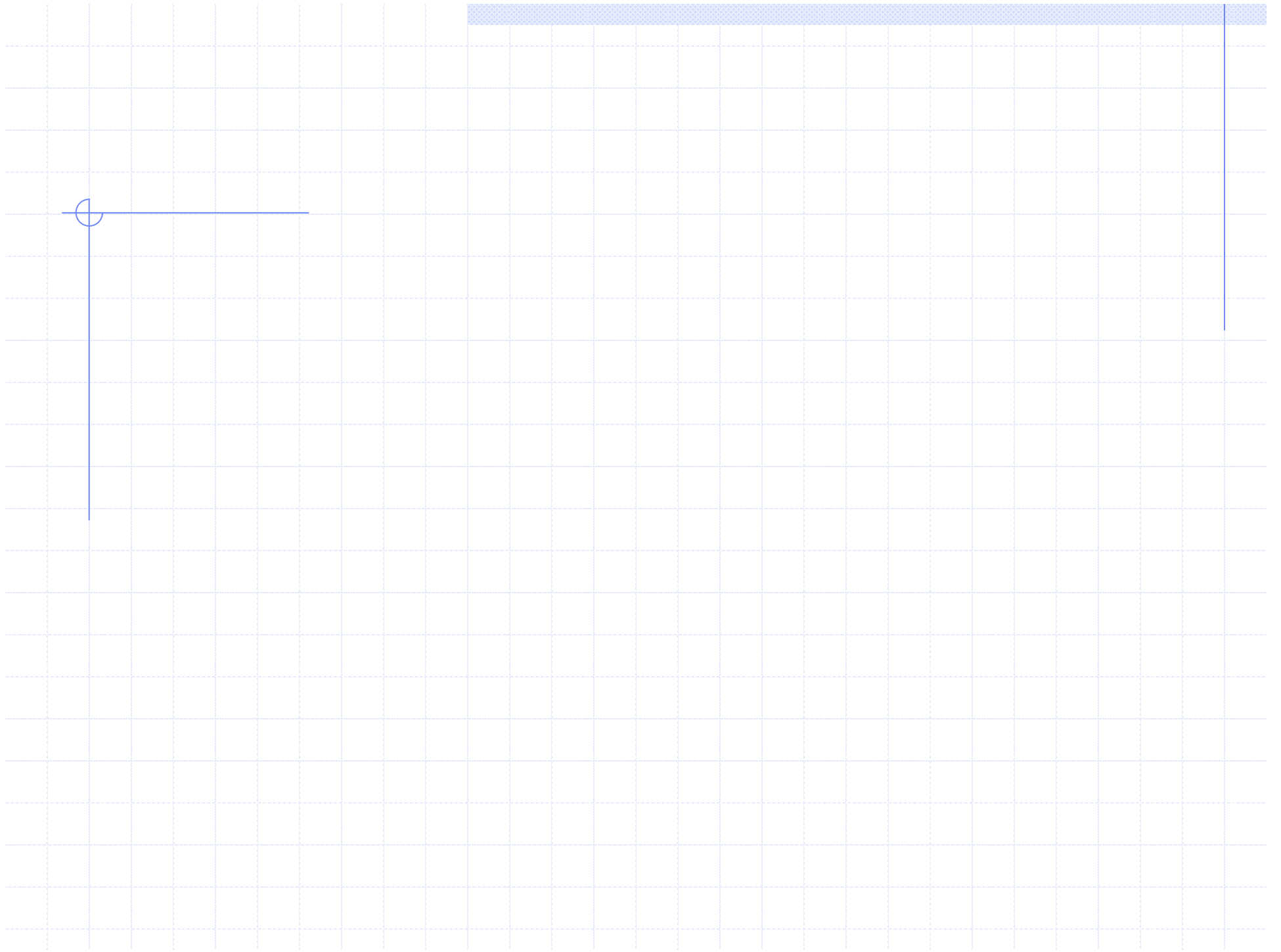
High temperature and drought-tolerant
Accumulation of ascorbic acid and myo-inositol

Concluding remarks

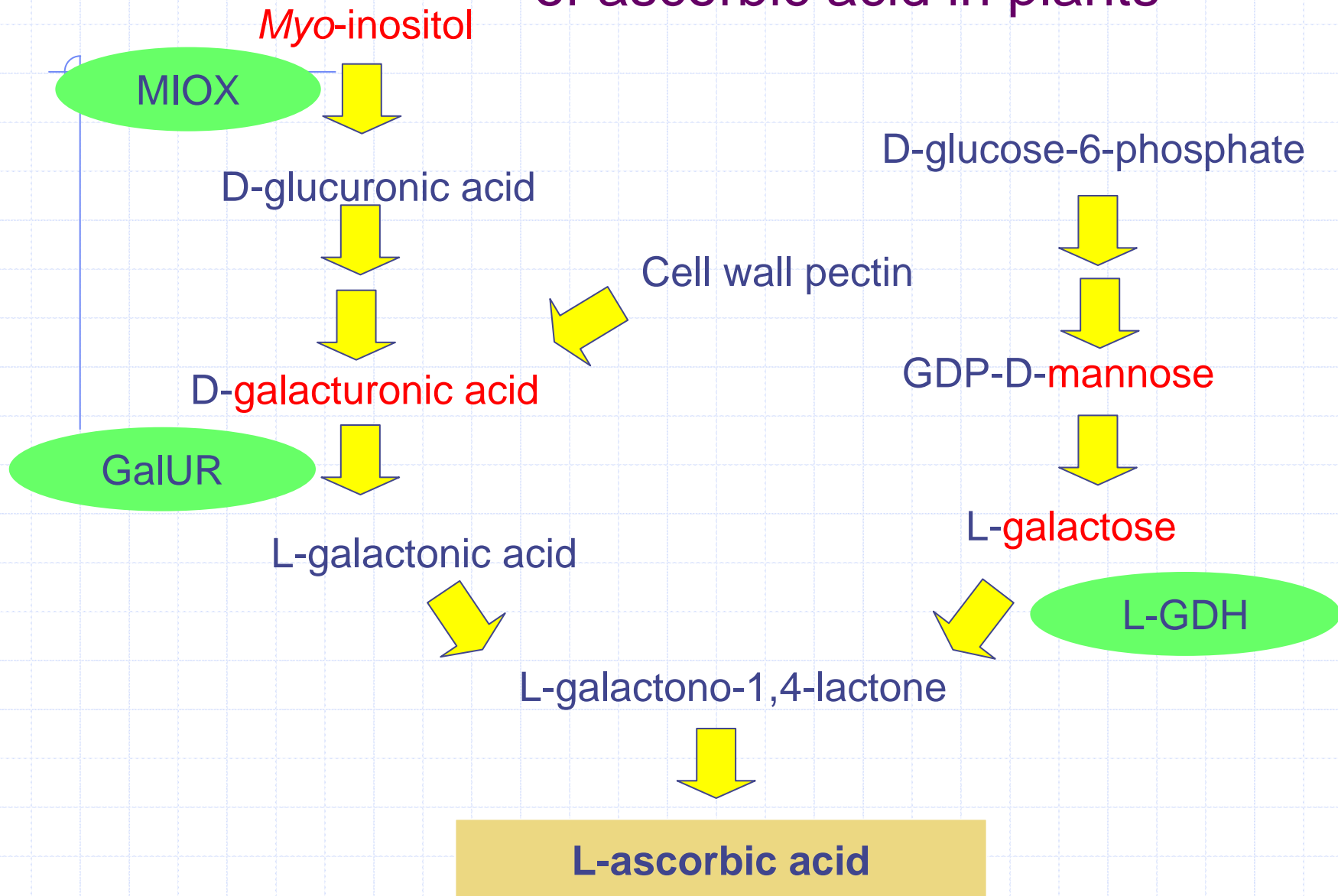
- ◆ High ascorbic acid and tocopherol content were observed in fruits of seabuckthorn subspecies *mongolica* and *rhamnoides*.
- ◆ The fruit of ssp *mongolica* shows a favorable sugar/acid ratio and fruit size
- ◆ High nitrogen fixation activity in Frankia root nodules during the growth of seabuckthorn.
- ◆ High stress tolerance with high ascorbic acid and myo-inositol content

Future study in Tohoku University Africa Program

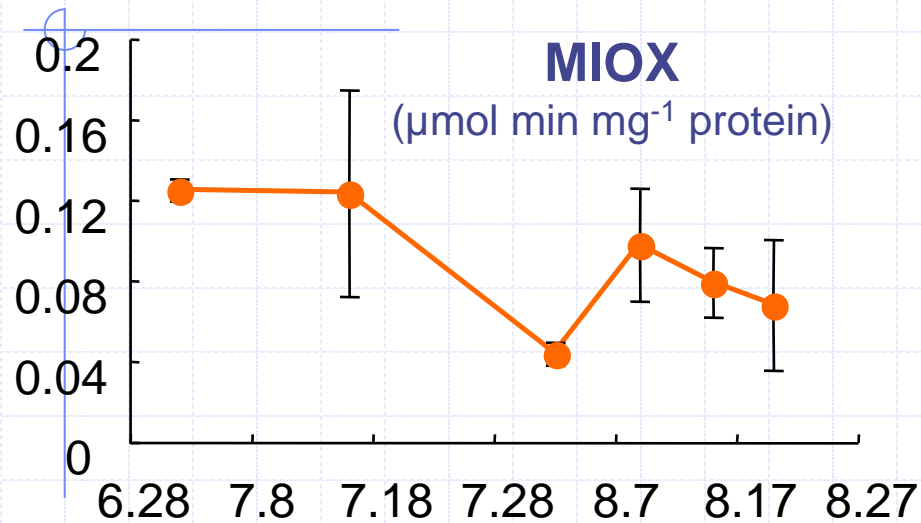
- ◆ Develop the cultivation of small fruit trees with high vitamins, nitrogen fixation ability, and environmental stress tolerant
- ◆ Explore and evaluate some species that are useful for sustainable cultivation and food security in Africa
- ◆ Studies on other underutilized plant resources like tomato wild species based on biodiversity



Proposed biosynthetic pathway of ascorbic acid in plants

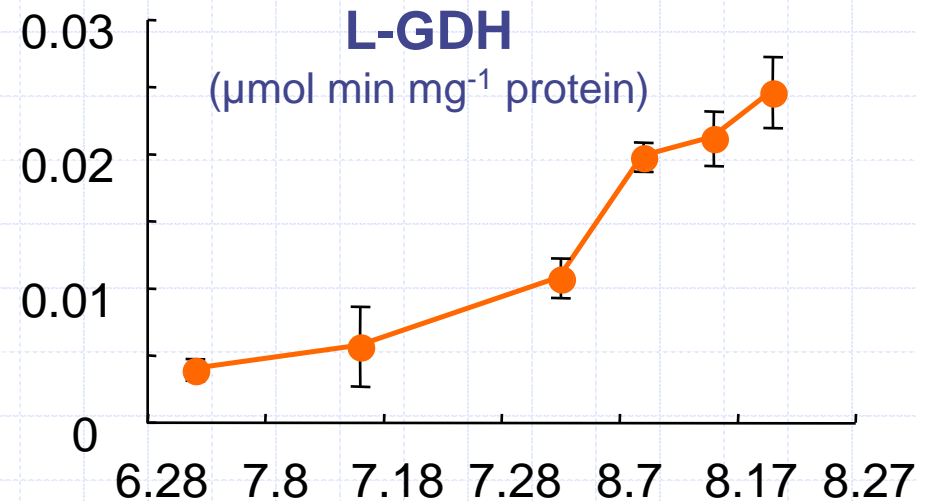
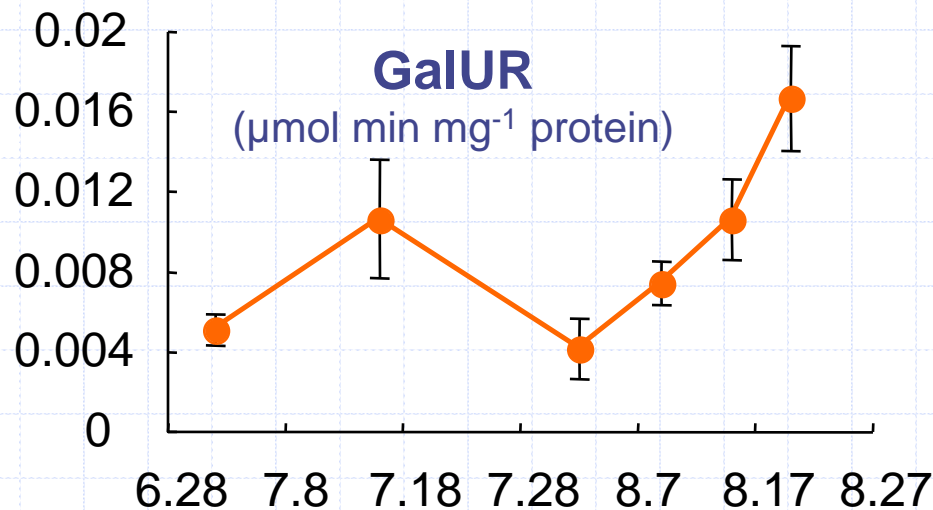


Changes in MIOX, GalUR, and L-GDH activities in *ssp. mongolica* 'Russian orange' fruit



Key enzymes in three ascorbic acid biosynthetic pathways may work.

The seasonal pattern of **MIOX** activity was similar to that of ascorbic acid content.



L-Galactose dehydrogenase (L-GDH) activity in seabuckthorn and other species

	GlaUR	L-GDH	MIOX	
	nmol min mg ⁻¹ protein			
Seabuckthorn	7.4	19.8	97.9	This study
Arabidopsis	-	0.1	-	Gatzek et al. 2002
Strawberry	16.2	-	-	Agius et al. 2003
Pea	-	0.2*	-	Gatzek et al. 2002
Oat	-	-	57.0	Lorence et al. 2004

*Less than 0.2 nmol min mg⁻¹ protein of activity was also observed in tobacco, maize, and *Brassica napus*.

Ascorbic acid and *myo*-inositol accumulation in leaves

