

果樹栽培と放射能汚染



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S1大学院「農業環境における放射線影響 ゼミナール」

学部4年生「農業環境の放射線影響」

2016年5月23日

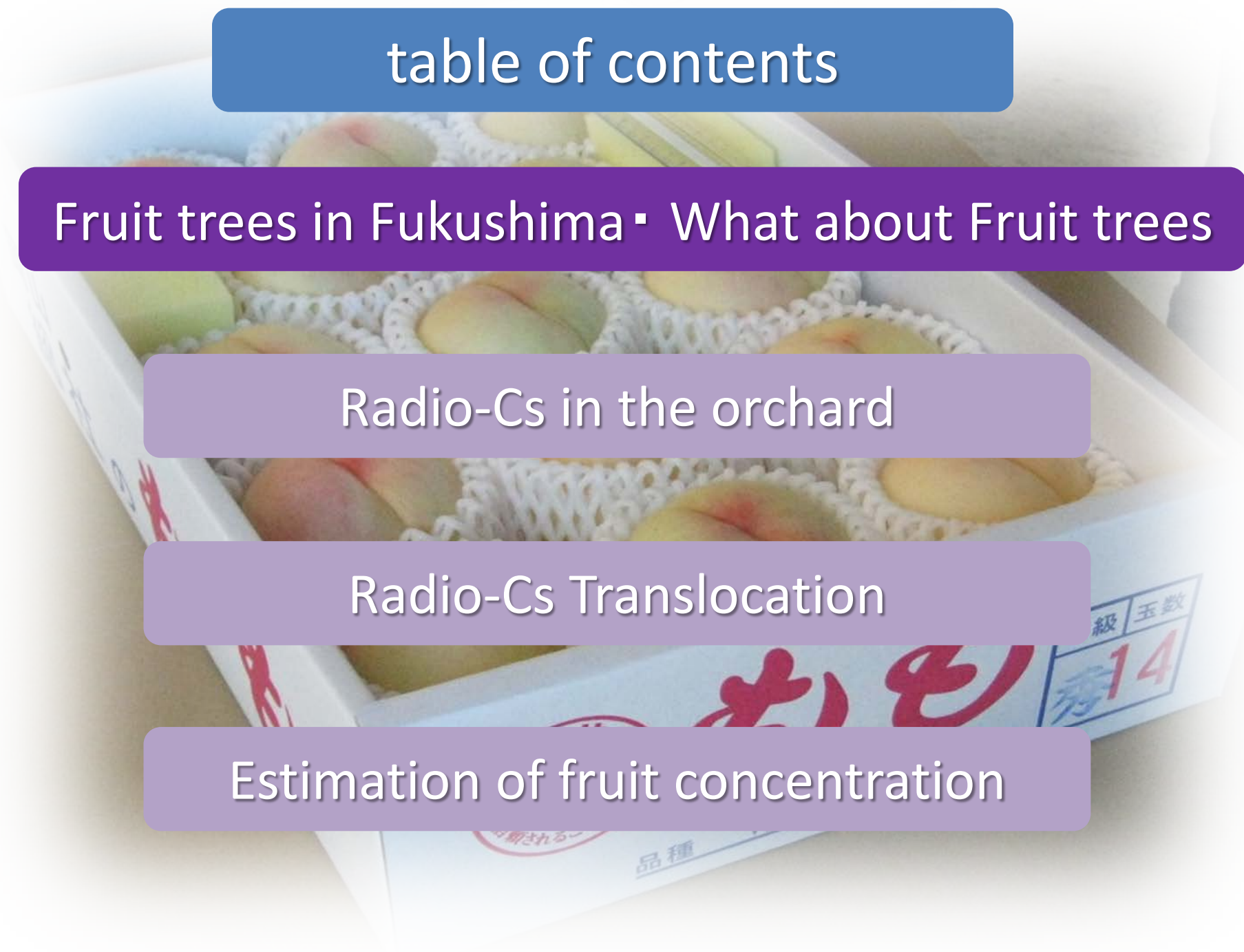
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Fruit trees in Fukushima - What about Fruit trees

Radio-Cs in the orchard

Radio-Cs Translocation

Estimation of fruit concentration



Fruit tree in Fukushima



Peach



Japanese Pear



Semi dried persimmon



Apple



Grapes (Original Cultivar)



Cherry

Fruit tree in Fukushima

Many production of deciduous fruit tree in Fukushima

Shipments, crop yields and cultivated area of Fukushima Prefecture in 2013
(from Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries, 2013)

Fruit trees	Ranked	Cultivated area (ha)	Crop yields (t)	Shipments (t)
Peach	2nd	1,780	29,300	27,100
Apple	6th	1,380	26,800	23,500
Persimmon	5th	1,340	3,790	3,790
Japanese pear	4th	974	19,800	18,300
Grapes	13th	288	2,960	2,960

the crop yield of peaches ranked 2nd (share 23% in Japan)

Fruit tree in Fukushima

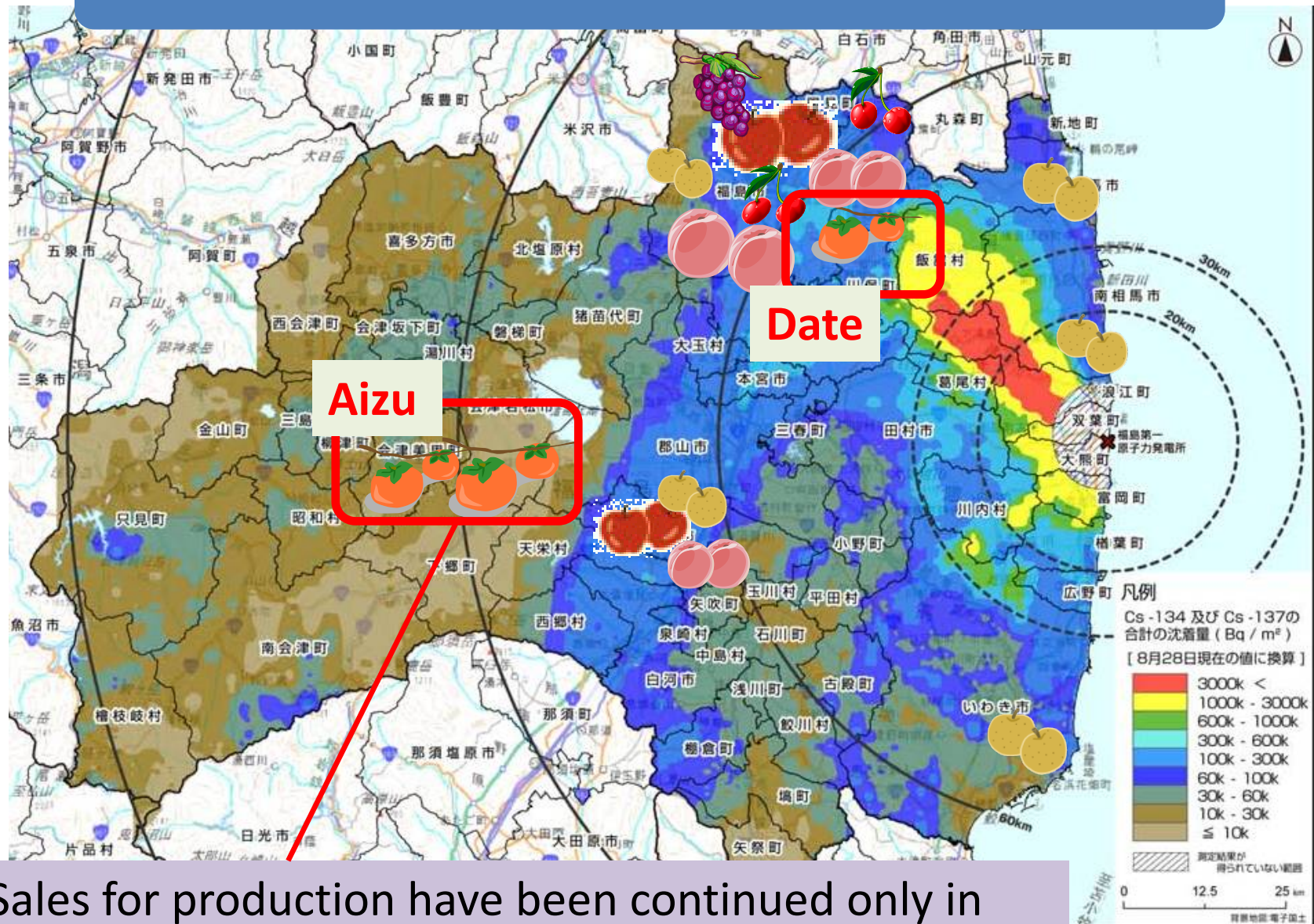
Changes in shipments and crop yields and cultivated area of peach and persimmon in Fukushima Prefecture
(from Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries, 2013)

Year	Peach			Persimmon		
	Cultivated area (ha)	Crop yields (t)	Shipments (t)	Cultivated area (ha)	Crop yields (t)	Shipments (t)
1990	2,610	40,200	37,600	1,350	10,200	8,270
2000	1,800	31,500	29,400	1,420	11,000	8,670
2004	1,750	30,700	28,400	1,430	13,500	11,200
2008	1,790	31,800	29,400	1,420	16,100	13,500
2009	1,790	30,100	27,900	1,410	13,600	11,300
2010	1,780	28,200	26,200	1,400	14,000	12,000
2011 ^z	1,780	29,000	26,500	1,390	4,550	3,540
2012	1,780	27,500	25,200	1,350	4,480	3,390
2013	1,780	29,300	27,100	1,350	4,890	3,790
2013 in Japan	10,700	124,700	114,100	22,300	214,000	177,400

^z Accident year

In Date City (production area of semi-dry persimmon),
continue by selling self-restraint (until 2014)

Fruit tree in Fukushima



Sales for production have been continued only in Aizu (the production area of fresh persimmon)

Fruit tree in Fukushima

Stock volume, Market share and wholesale price of monthly Fukushima Prefecture peach in Tokyo
(from Monthly report of Tokyo metropolitan central wholesale market, 2013)

Year	August			September		
	Stock volume (t)	Market share (%)	Wholesale price (Yen/kg)	Stock volume (t)	Market share (%)	Wholesale price (Yen/kg)
2008	2,837	43.0	359	755	45.2	408
2009	2,751	48.5	384	537	43.3	411
2010	2,421	42.5	439	868	41.9	481
2011 ^z	4,631	54.1	196	786	38.3	300
2012	2,834	48.4	344	998	42.0	364
2013	3,916	61.5	342	622	36.7	421

^z Accident year

- Increased shipment of crops, such as peaches through agricultural cooperatives v.s. direct sales and orchard sales → decreased.
These factors led to an increase in the stock volume
The wholesale price dropped when compared to the previous year

What about Fruit trees

Life cycle

whole life

Juvenile



Non-fruiting

Vegetative
growth

Young

Start fruiting

Variability



Adult



Stability

Peak period

Old

Decline stage

Consider
replanting



What about Fruit trees

Life cycle

One year (spring-winter)

Breaking(flowering)

Storage and
accumulation

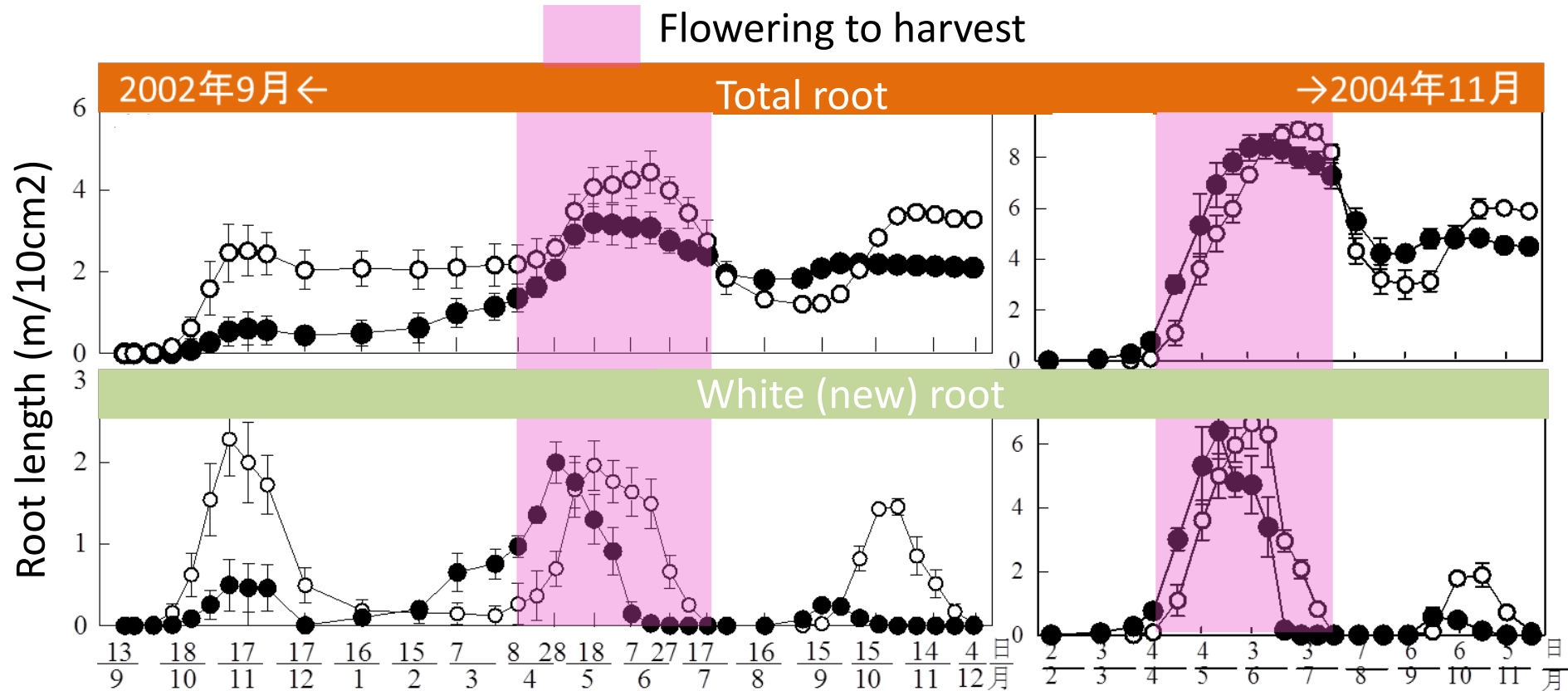
Fruit growth

Dormant



What about Fruit trees

Root growth (peach)



What about Fruit trees

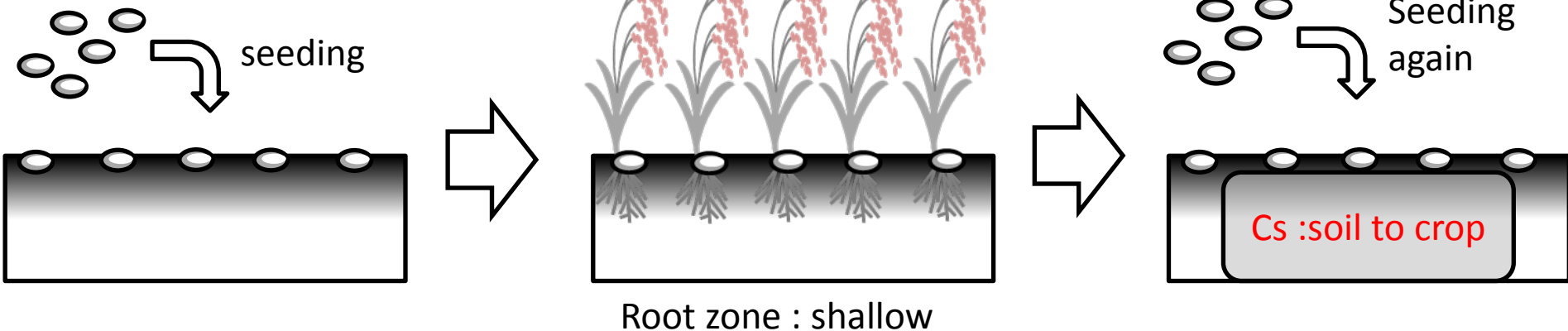
Root zone (peach)



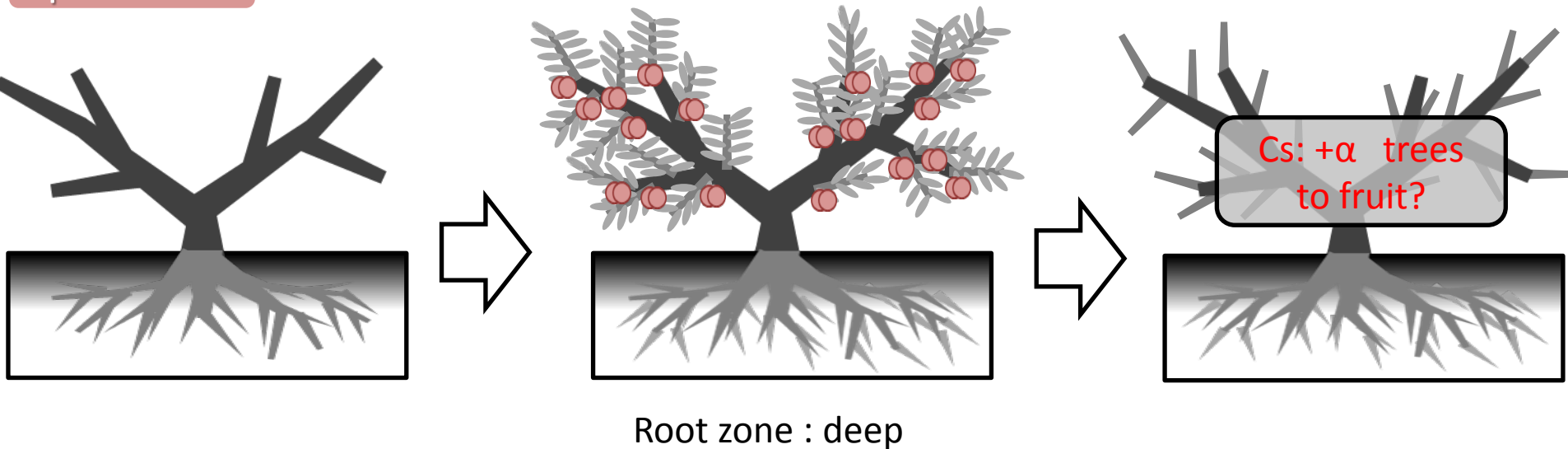
What about Fruit trees

Difference with annual crop

annual



perennial



What about Fruit trees

Root zone (peach)

Start rooting (April or September)

Lignification (June or November)

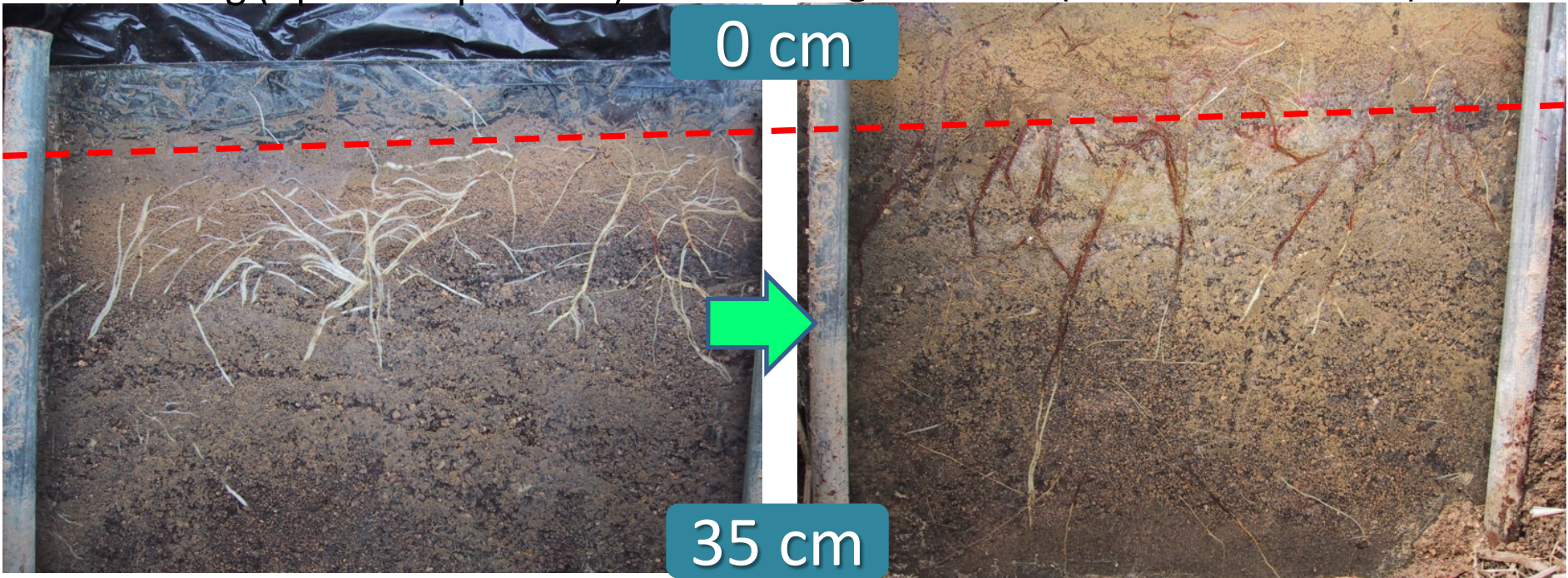


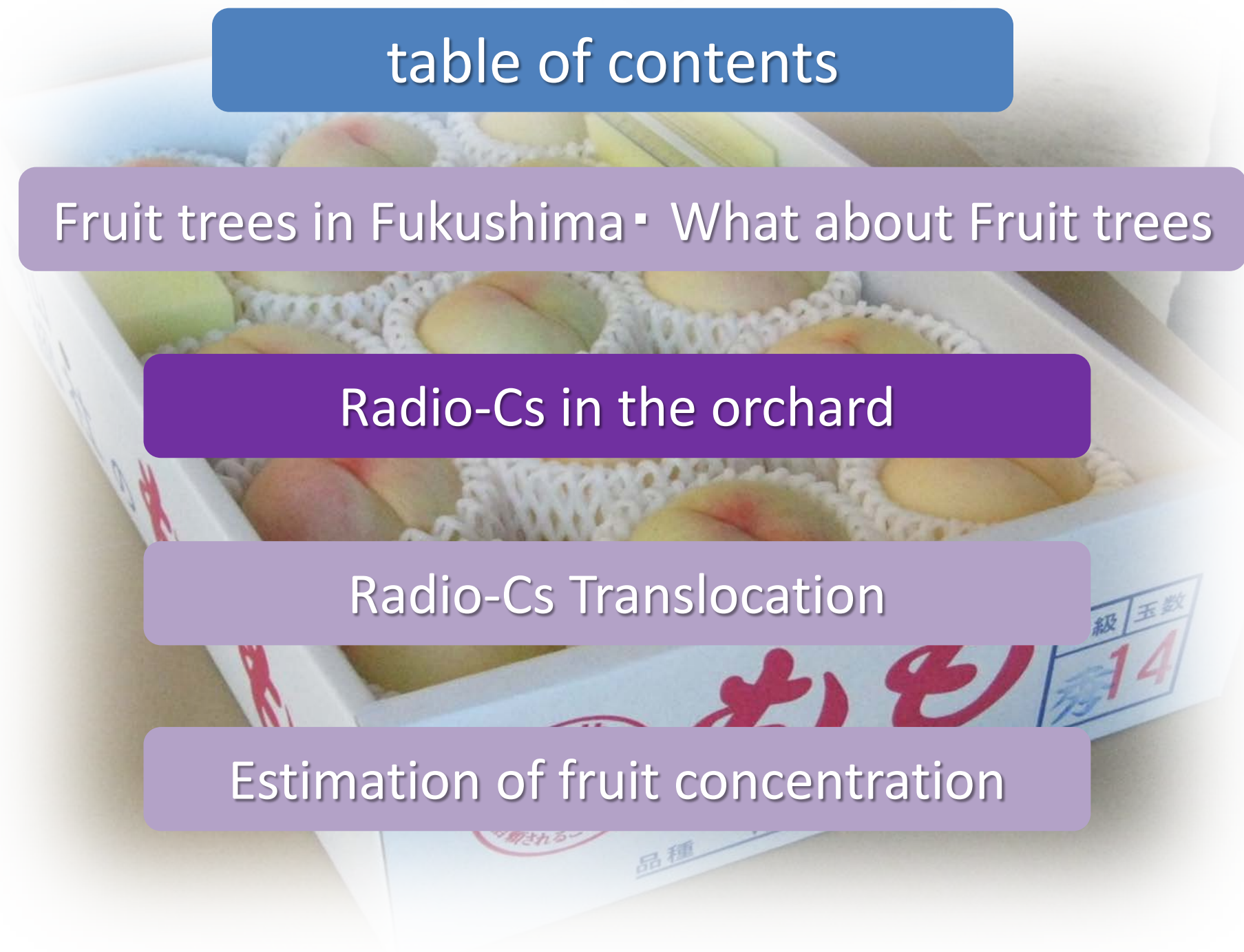
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Radio-Cs in the orchard

Radio-Cs Translocation

Estimation of fruit concentration



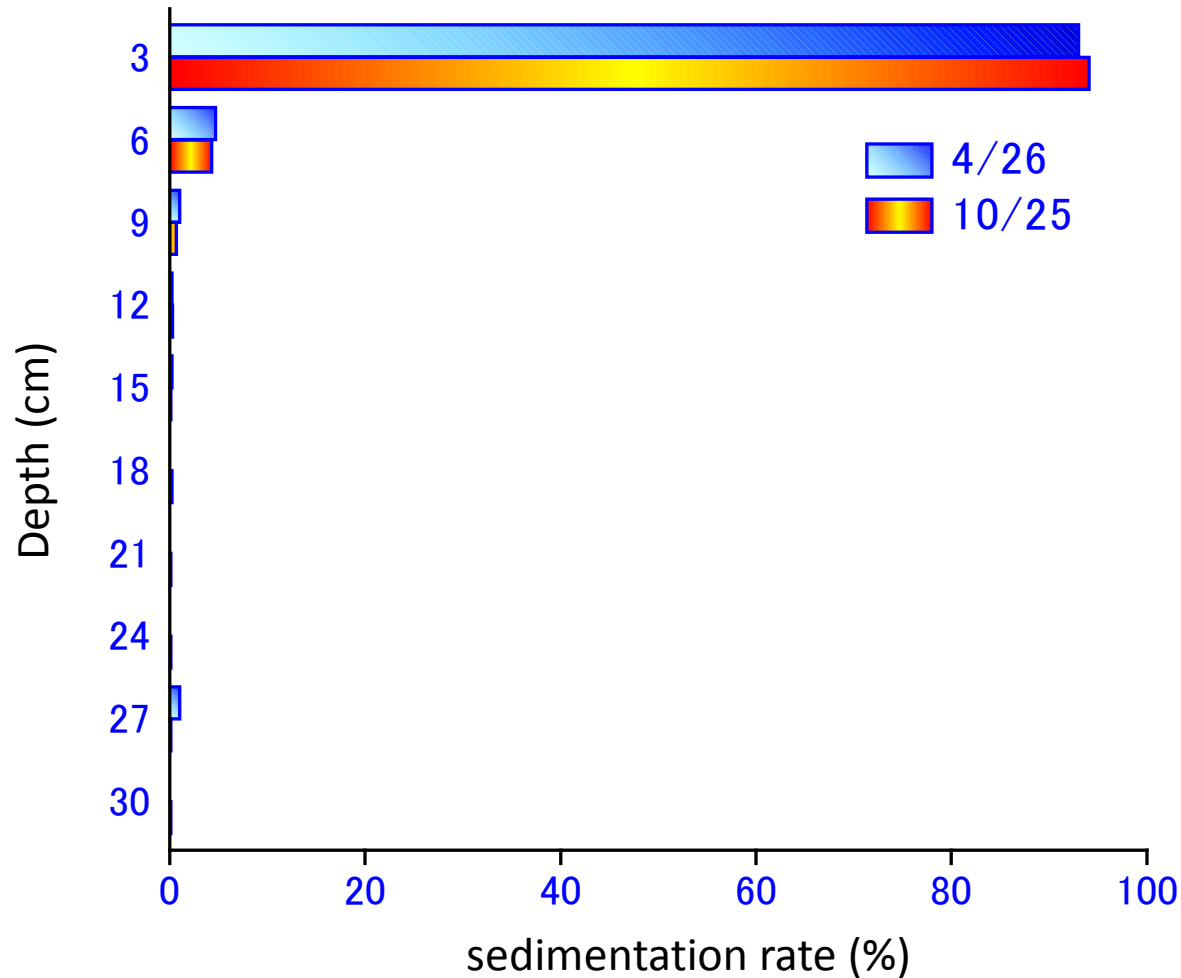
Radio-Cs in the orchard

Orchard soil



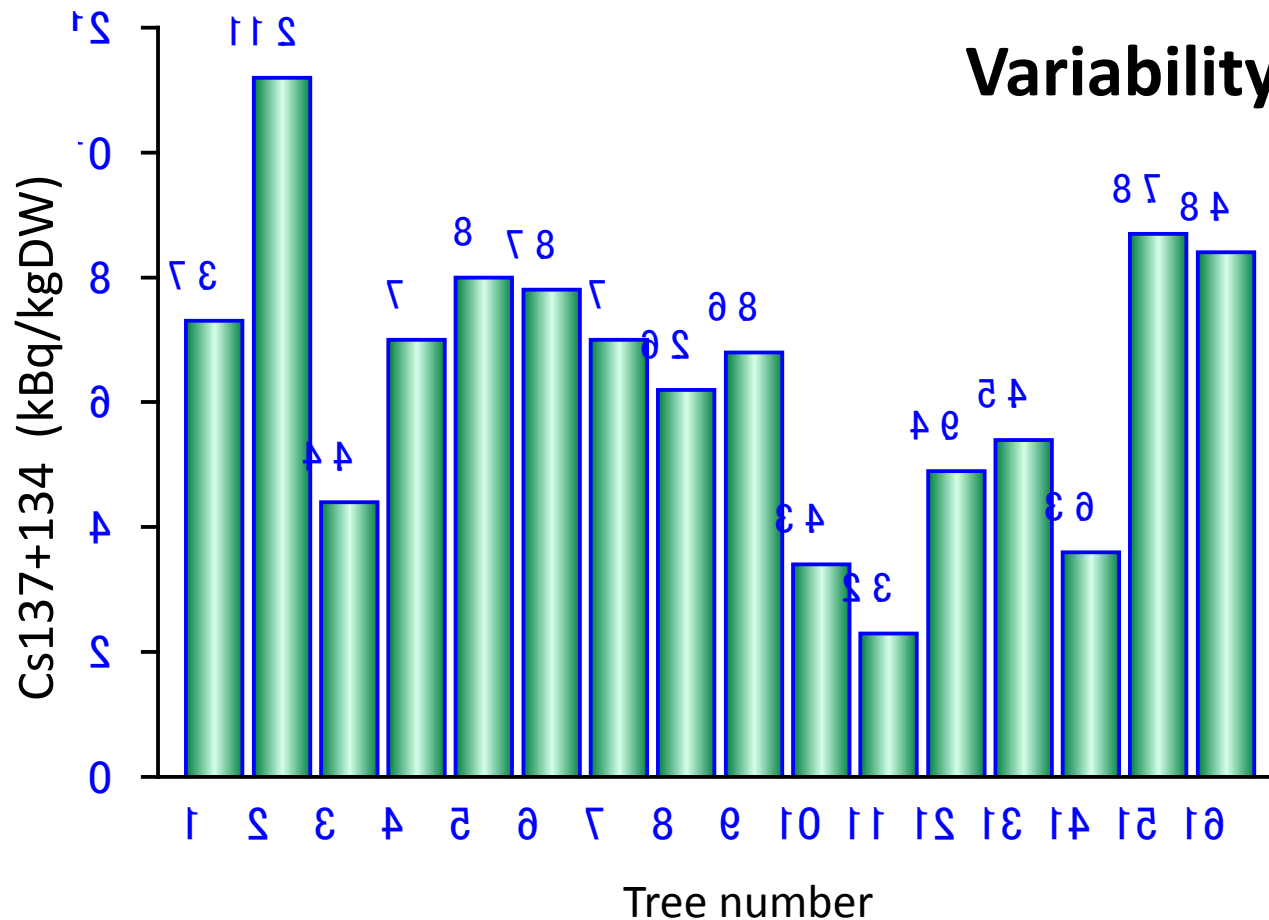
Radio-Cs in the orchard

Orchard soil (Vertical)



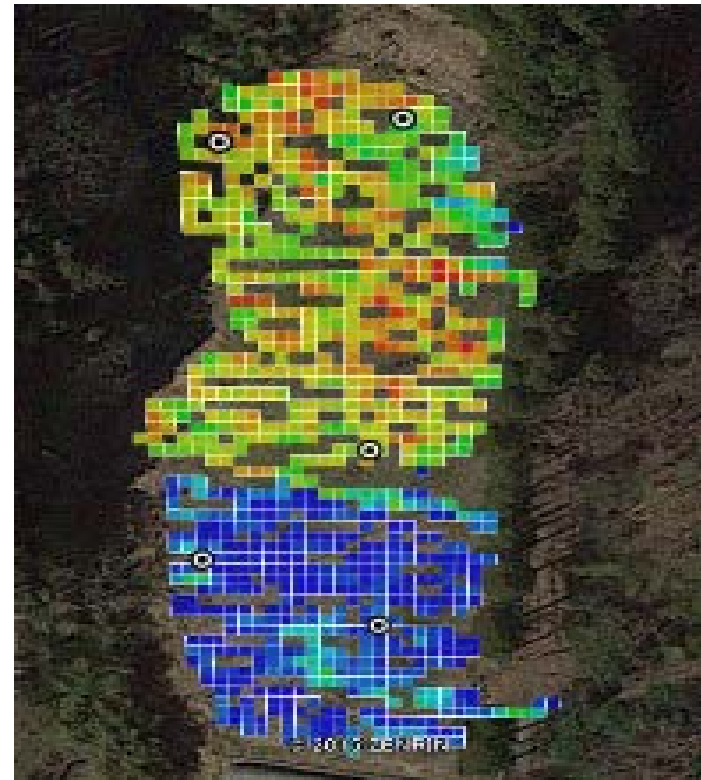
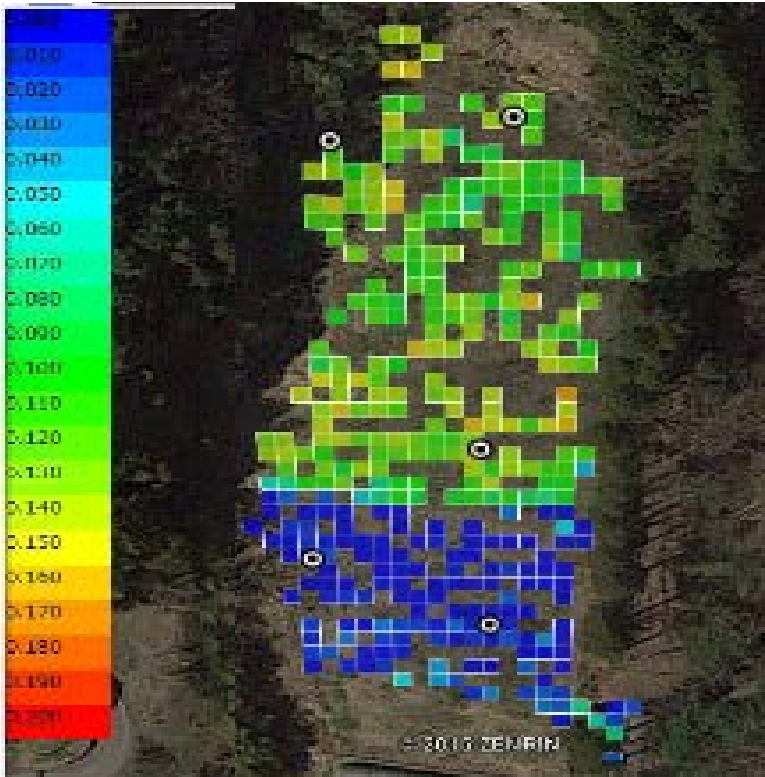
Radio-Cs in the orchard

Orchard soil
(horizontal)



Radio-Cs in the orchard

Orchard soil (horizontal)

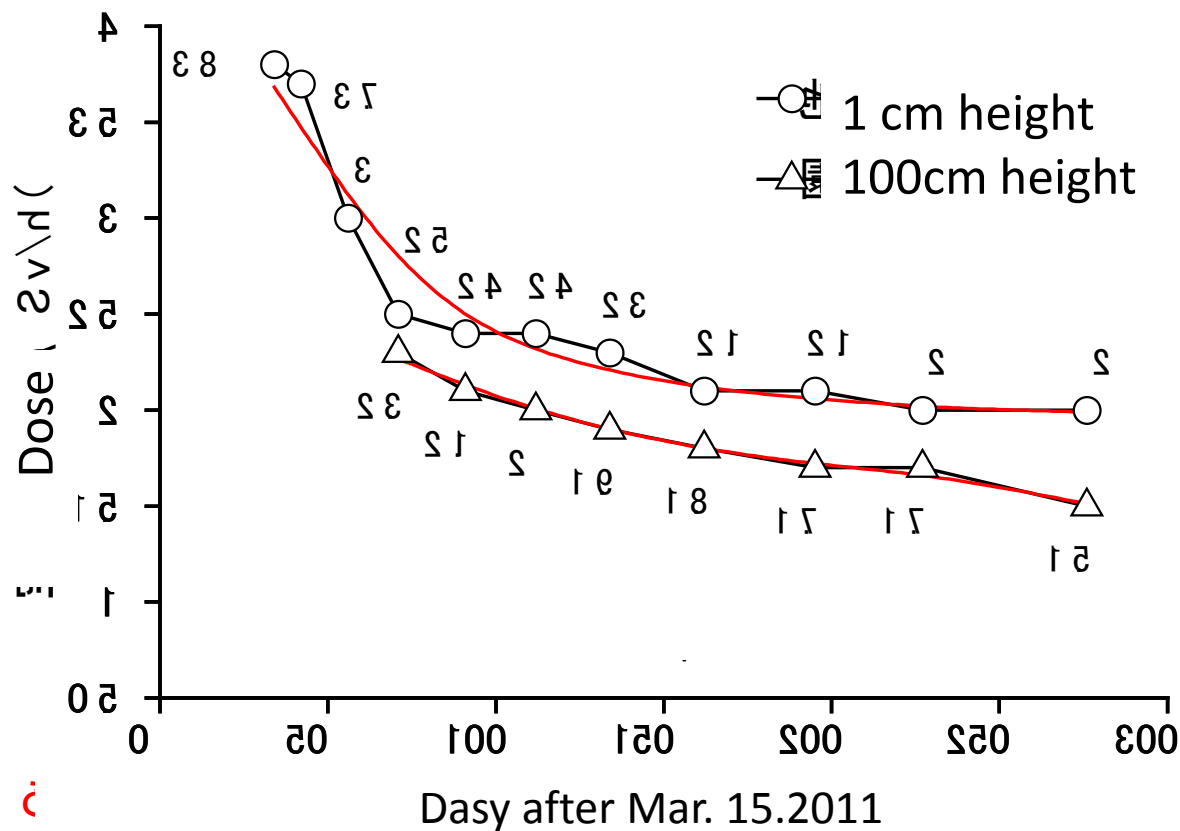


Remove surface soil

Whether effective for orchards?

Radio-Cs in the orchard

Air radiation dose in orchard



Until May 25 : 30%↓

affected by loss of ^{131}I (1/512)

200 days from 25 days from May 25 : 20%↓

Radio-Cs in the orchard

Fruit Cs concentration in 2011

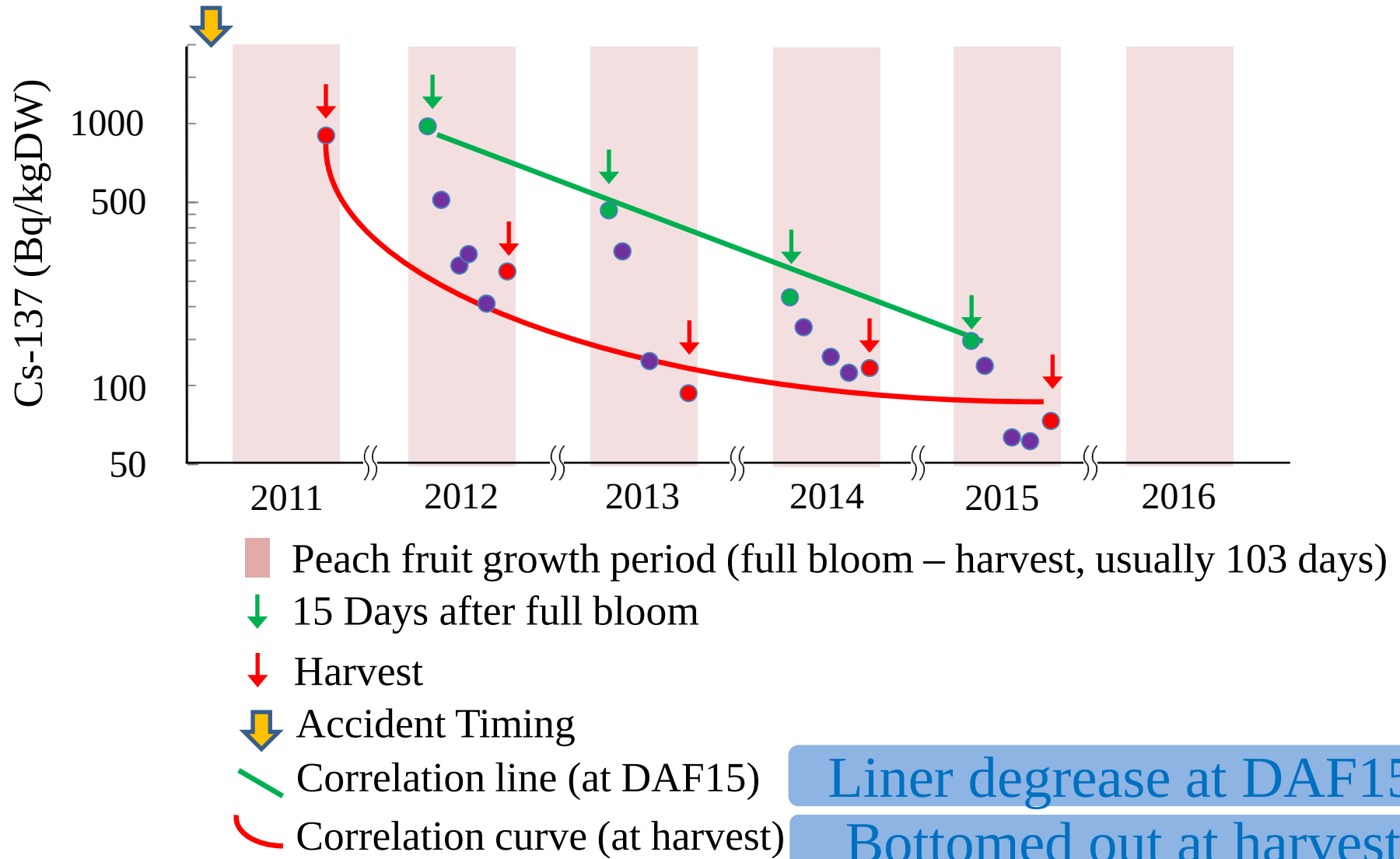
落葉・常緑樹 樹種		※ カリ濃度 (mg/kg)	緊急モ ニタリ ング調 査数	果実中の放射性セシウム濃度割合(%)				暫定規制値超過市町村 (500Bq/kg以上)		超過原因推定等
				ND	N.D.以上 100Bq/kg 未満	100以上 500Bq/kg 未満	500Bq/kg 以上	県北地方	相双地方	
落葉	ブルーベリー	70	40	28	65	8	0			
落葉	アケビ	95	15	13	80	7	0			
落葉	リンゴ	110	225	53	47	0	0			
落葉	ブドウ	130	84	56	43	1	0			
落葉	日本ナシ	140	106	69	32	0	0			
落葉	西洋ナシ	140	30	57	43	0	0			
常緑	ユズ	140	36	3	28	53	17	福島市、伊達市、桑折町	南相馬市	放射性物質降下時に旧葉等に付着
落葉	スモモ	150	22	23	64	14	0			
常緑	ビワ	160	8	0	88	0	13		南相馬市	放射性物質降下時に旧葉等に付着
落葉	イチジク	170	54	39	48	11	2		南相馬市	放射性物質降下時に夏果あり
落葉	モモ	180	247	31	68	1	0			
落葉	カキ	200	185	39	54	7	1		南相馬市	樹園地周辺に林あり
落葉	オウトウ	210	25	32	68	0	0			
落葉	ネクタリン	210	11	9	91	0	0			
落葉	ウメ	240	106	1	26	63	10	福島市、伊達市、桑折町	南相馬市、相馬市	放射性物質降下時に花～幼果に付着
落葉	ザクロ	250	7	14	29	43	14	伊達市		樹園地周辺に林あり、砂質土壌
落葉	キウイフルーツ	290	40	20	58	18	5		南相馬市	樹園地周辺に林あり
落葉	クリ	420	65	17	48	32	3	伊達市	南相馬市	樹園地周辺に林あり
落葉	クルミ	540	11	36	55	9	0			
落葉	ギンナン	700	39	10	72	18	0			

※カリ濃度：厚生労働省「食品成分表」

(2011年11月15日当時)

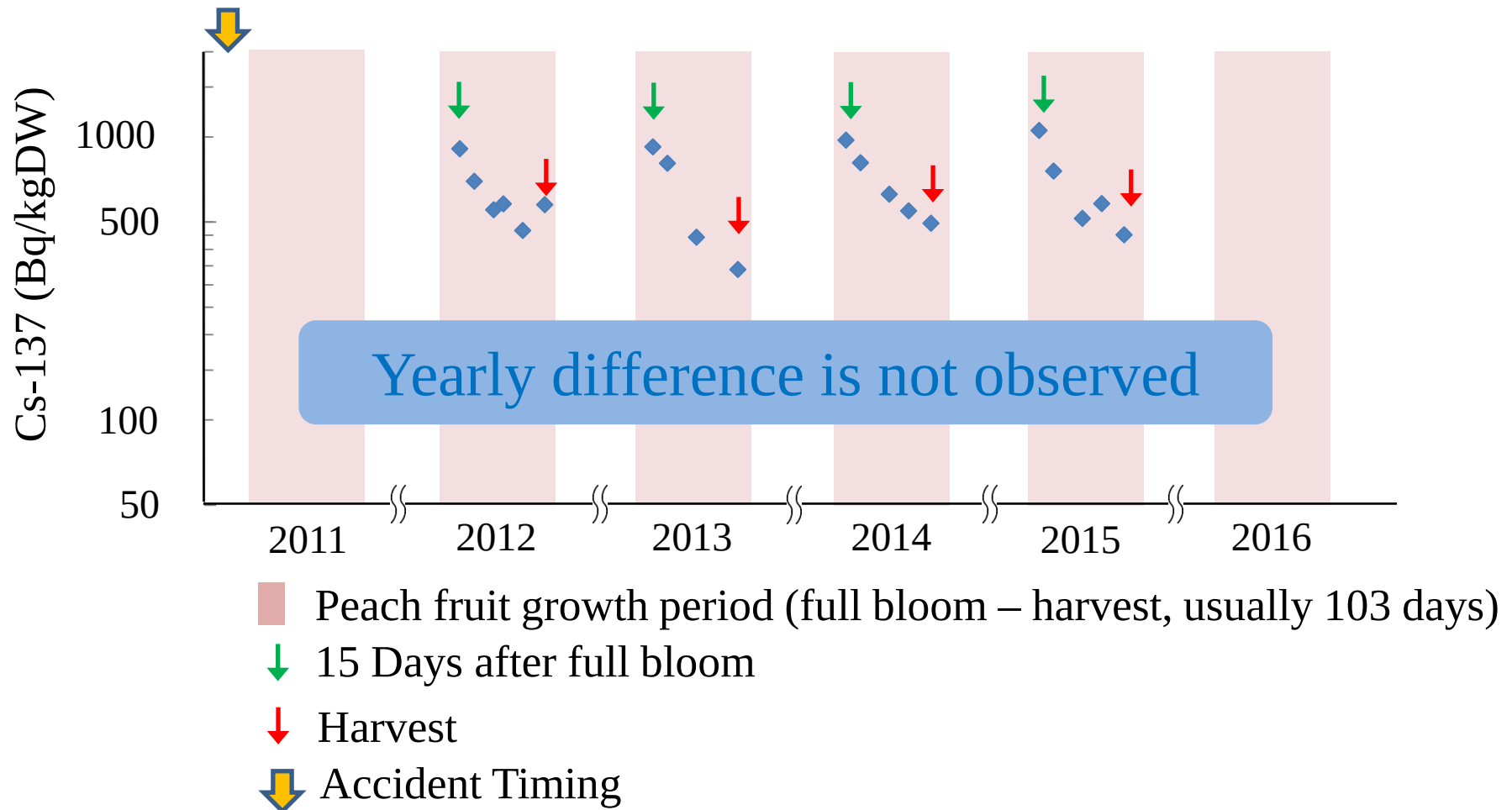
Radio-Cs in the orchard

Annual Changes in Peach Fruit **Cs-137** Concentration



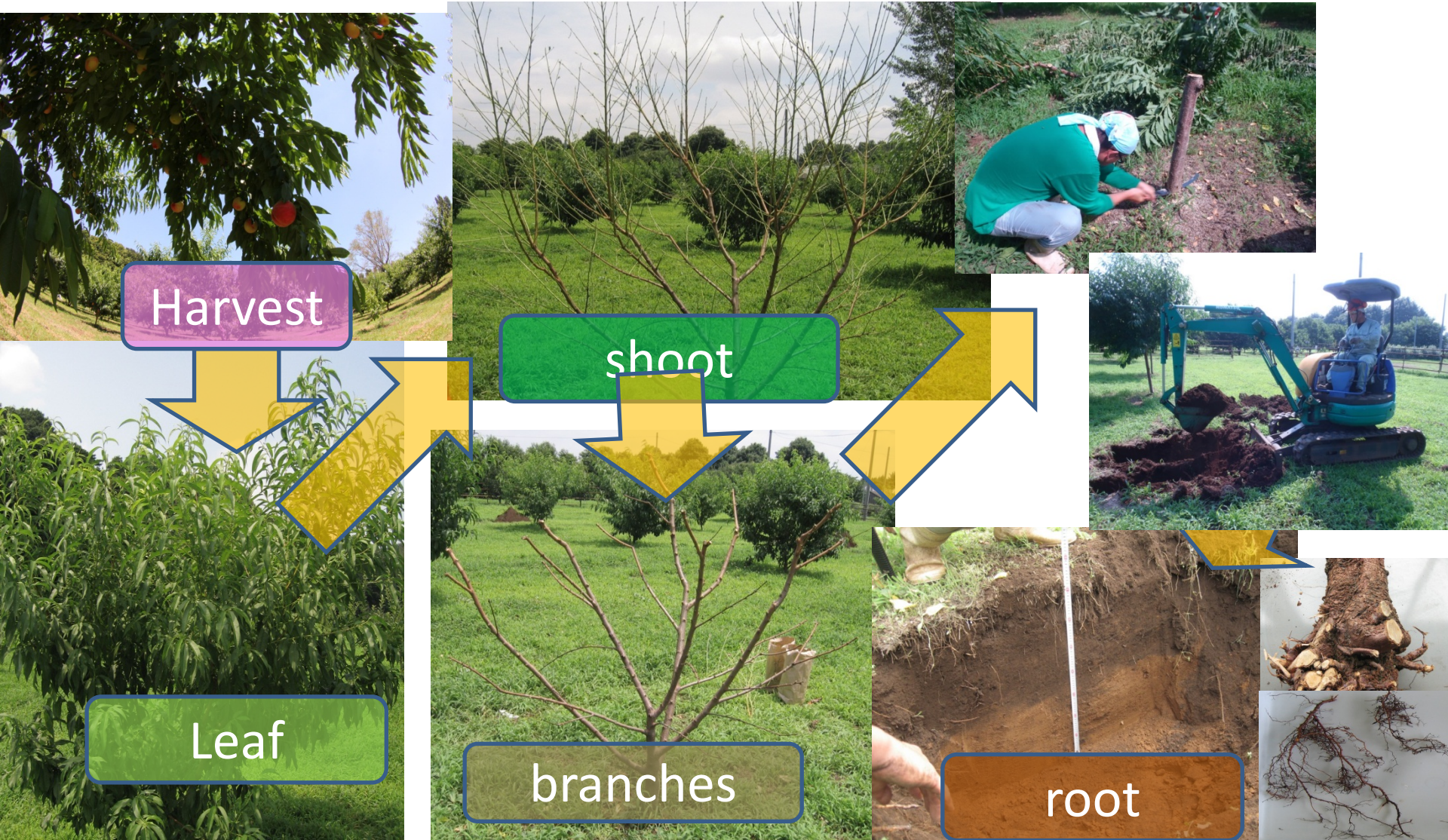
Radio-Cs in the orchard

Annual Changes in Peach Fruit **K-40** Concentration



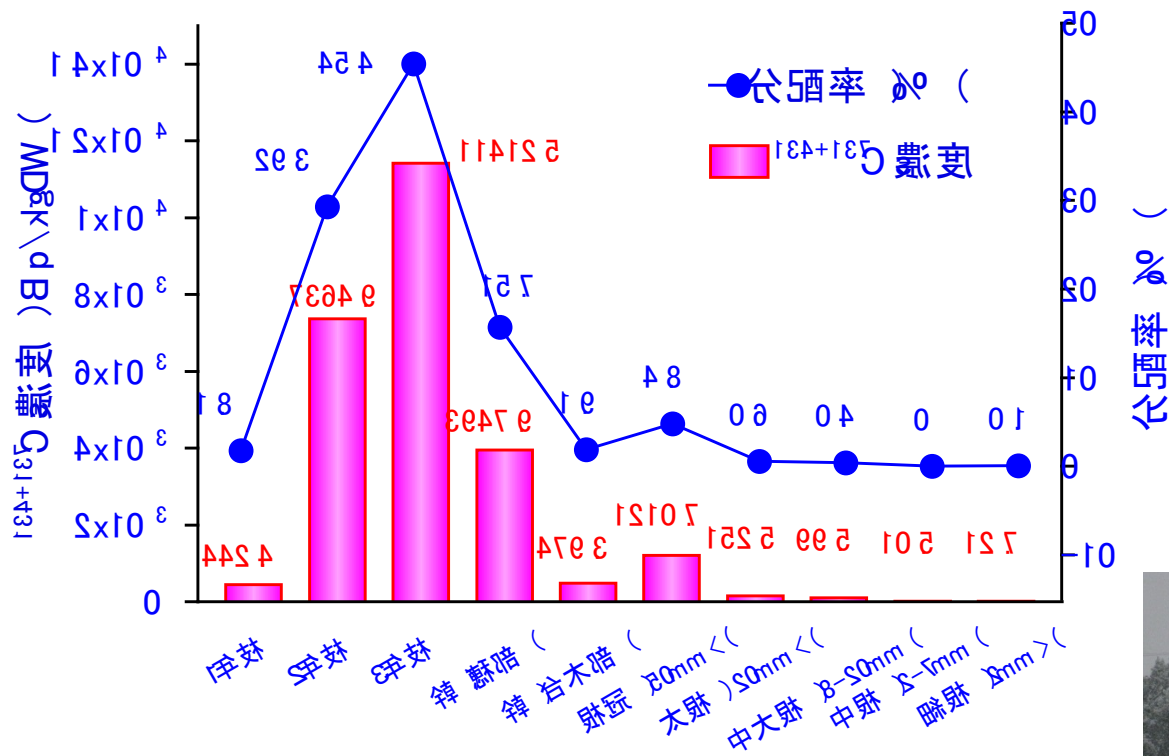
Radio-Cs in the orchard

Digging and disassembly



Radio-Cs in the orchard

Peach trees (concentration)



Radio-Cs in the orchard

Peach trees (content)

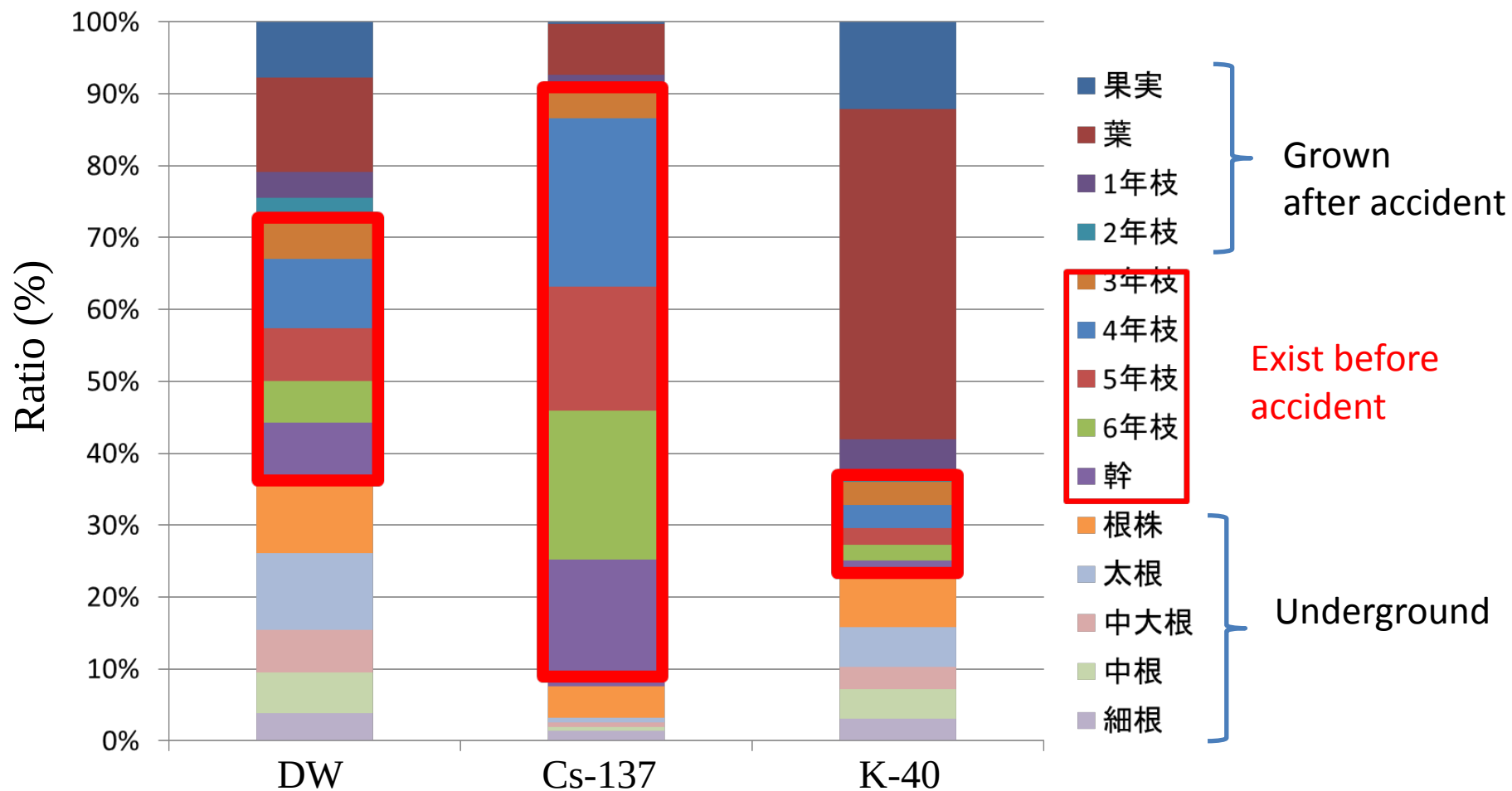


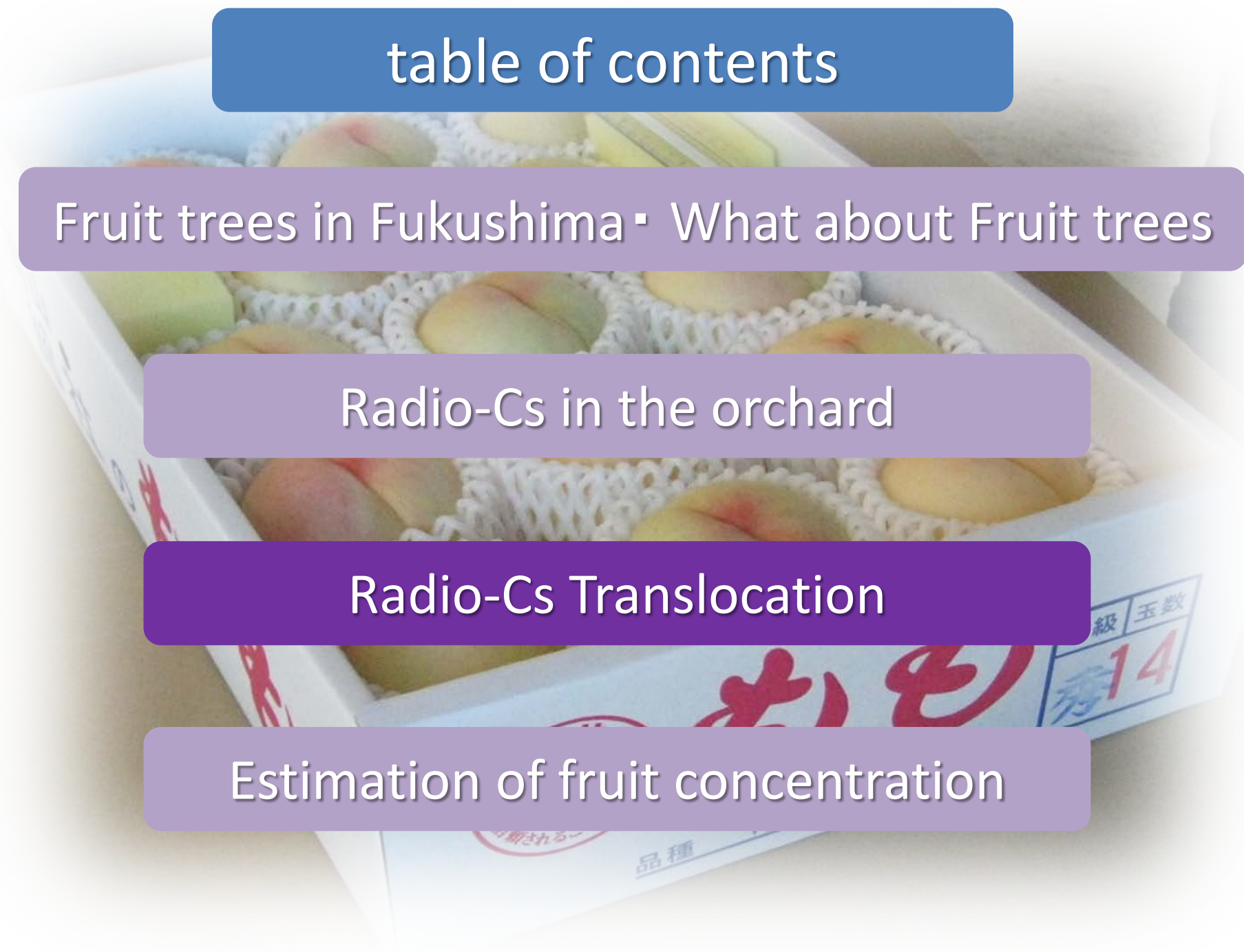
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Radio-Cs in the orchard

Radio-Cs Translocation

Estimation of fruit concentration



Radio-Cs Translocation

Learned from the Chernobyl accident

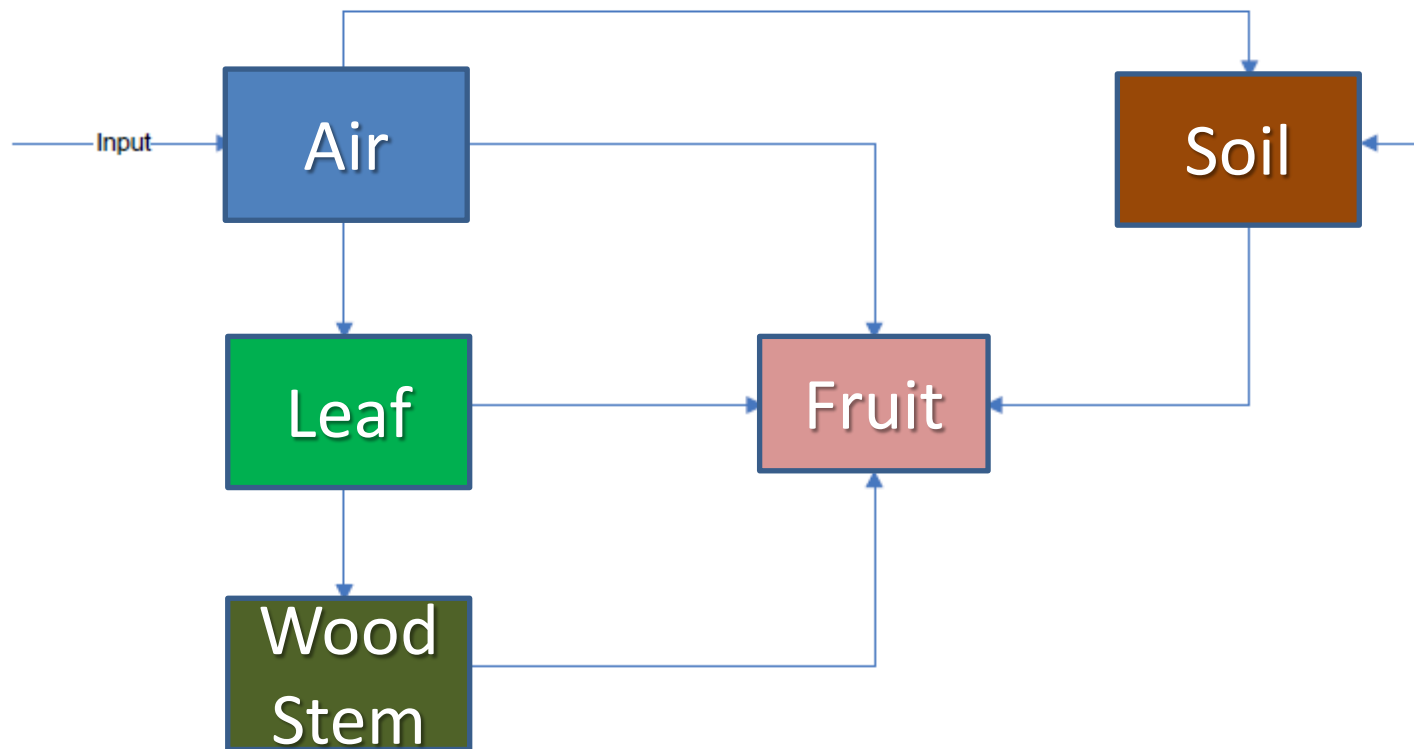


Figure 1: Conceptual fruit model developed by the Fruit Working Group of the IAEA BIOMASS programme

Peach trees at Late spring in Japan

Chernobyl accident happened in May



Peach trees at Late winter in Japan

No leaf, Only wood and old stem



Peach trees at Late winter in Japan

Situation at the accident

Bud brack date in 2011Fukushima

Peach : Mar. 28

J-Pear : Apr. 8

Apple : Mar. 31

Cherry : Mar. 31



Dormant season

No Flower, No Leaf at accident
(without Japanese apricot and
evergreen fruits)

ウメ



開花後

モモ



ブドウ



萌芽前 (花は新梢の中)

カキ



萌芽前 (花は新梢の中)



Radio-Cs Translocation

Conjecture at the Fukushima accident

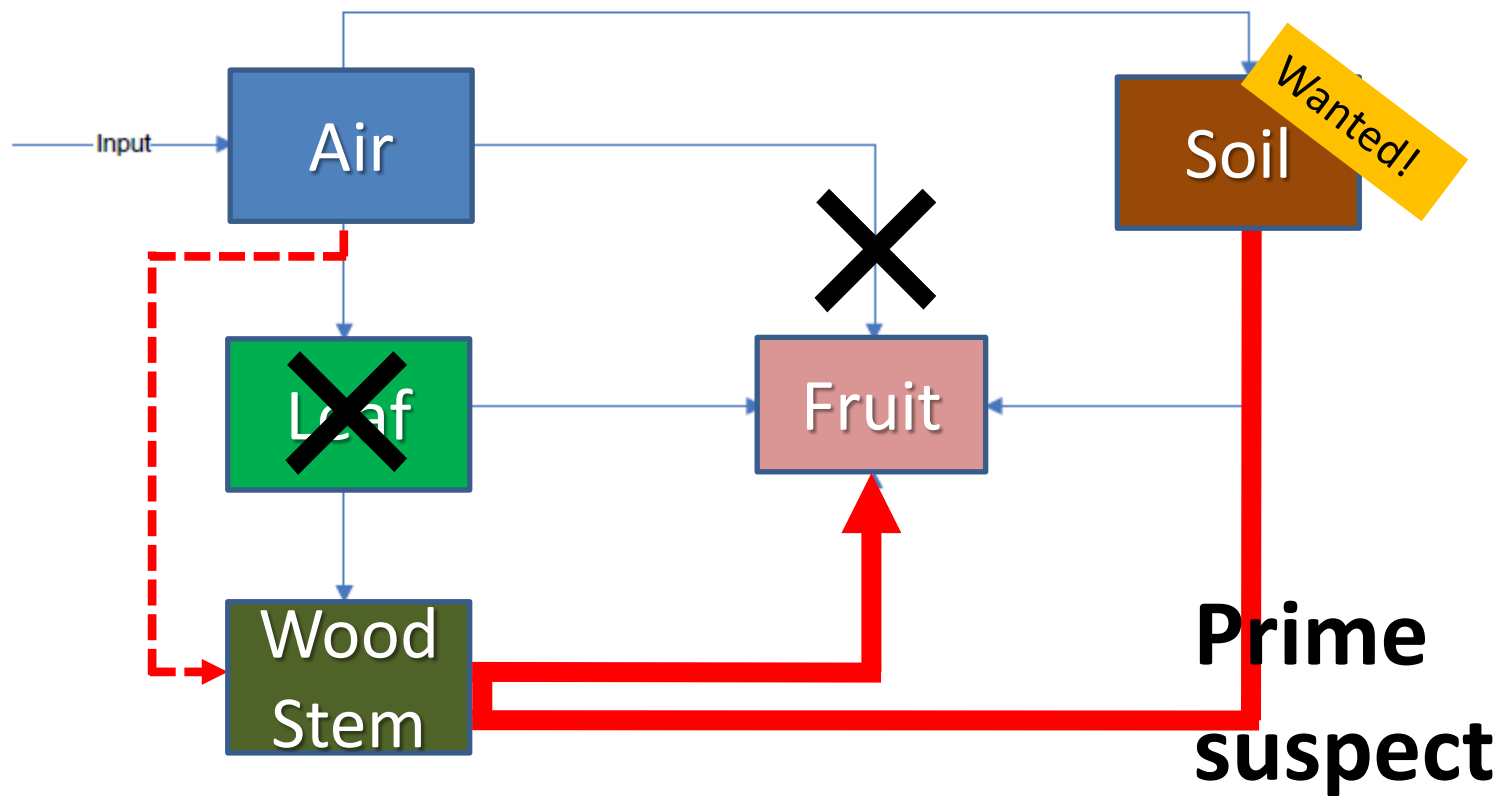


Figure 1: Conceptual fruit model developed by the Fruit Working Group of the IAEA BIOMASS programme

Soil to Fruits

Before Accident

Non-covered

Covered

Fallout to tree(stem) + **soil**

Fallout **ONLY** tree



Lower Soil
concentration
because covered

Approximately $1/7$ (163→27)

How many Cs in fruit?



31 Bq/kgDW

Fruit

163 Bq/kgDW

Soil

27

Soil to Fruits

Root depth



kiwifruit



blueberry



fig

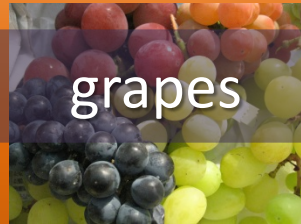
shallow



chestnuts



peach



grapes



pear



apple



persimmon

deep

Soil to Fruits

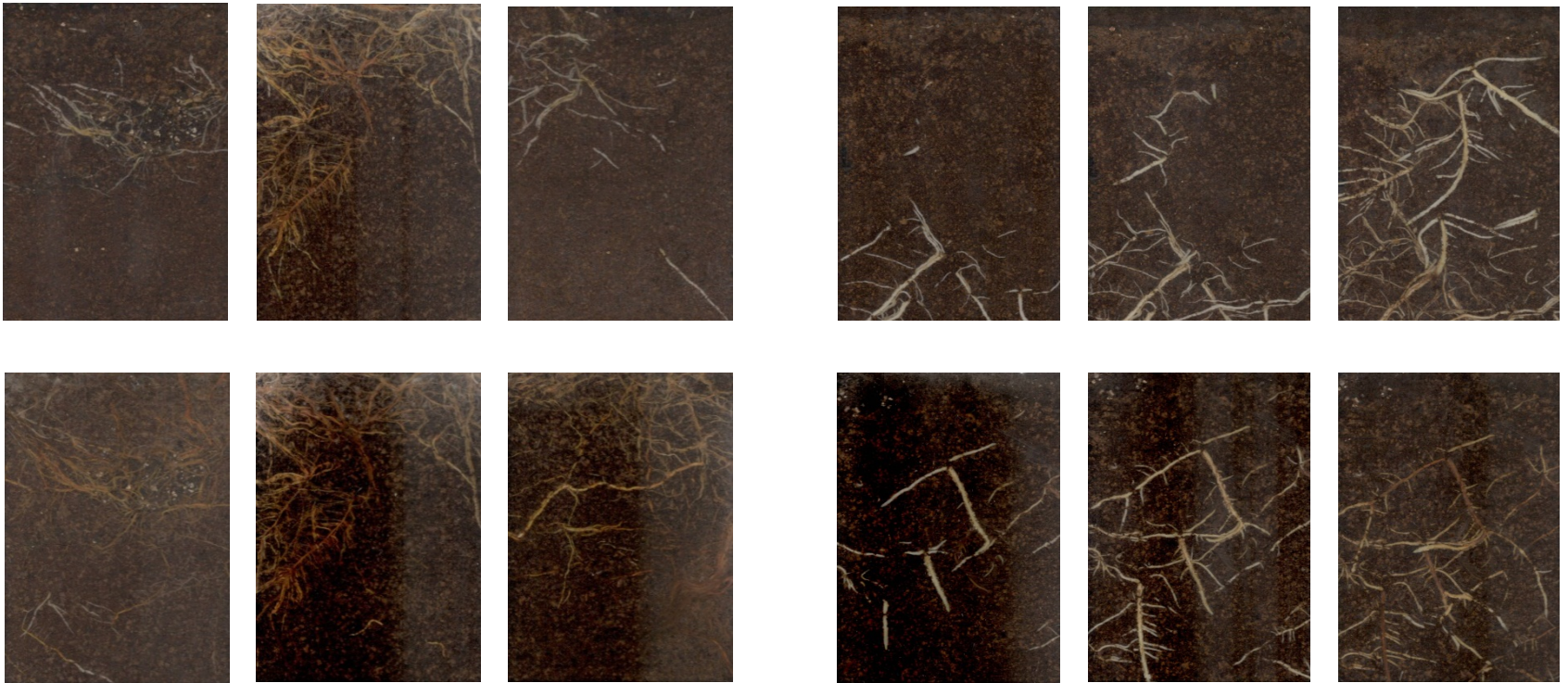
Root depth

shallow

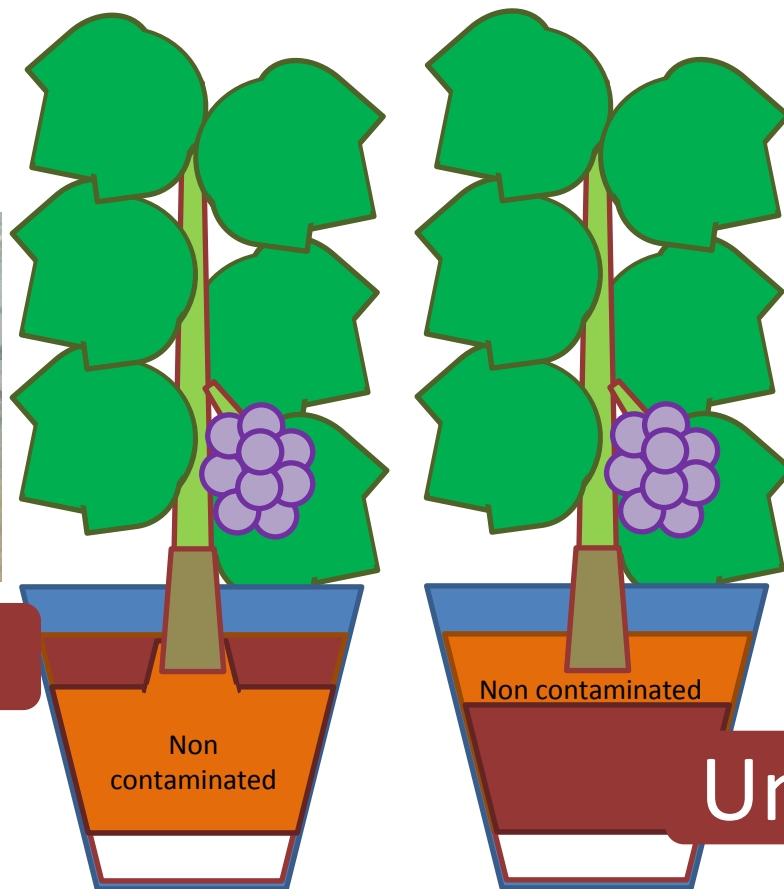
Fig

Non-shallow

grapes



Soil to Fruits



Surface +Cs

Underlayer +Cs



Soil to Fruits

TF

grapes



Surface +Cs

0.0017



Underlayer +Cs

0.0040



Fig

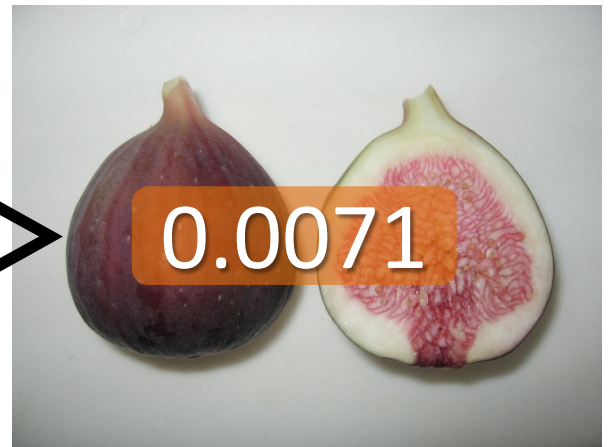


Shallow

0.0266



0.0071



To be honest,,, generally lower than annual crops

Radio-Cs Translocation

Conjecture at the Fukushima accident

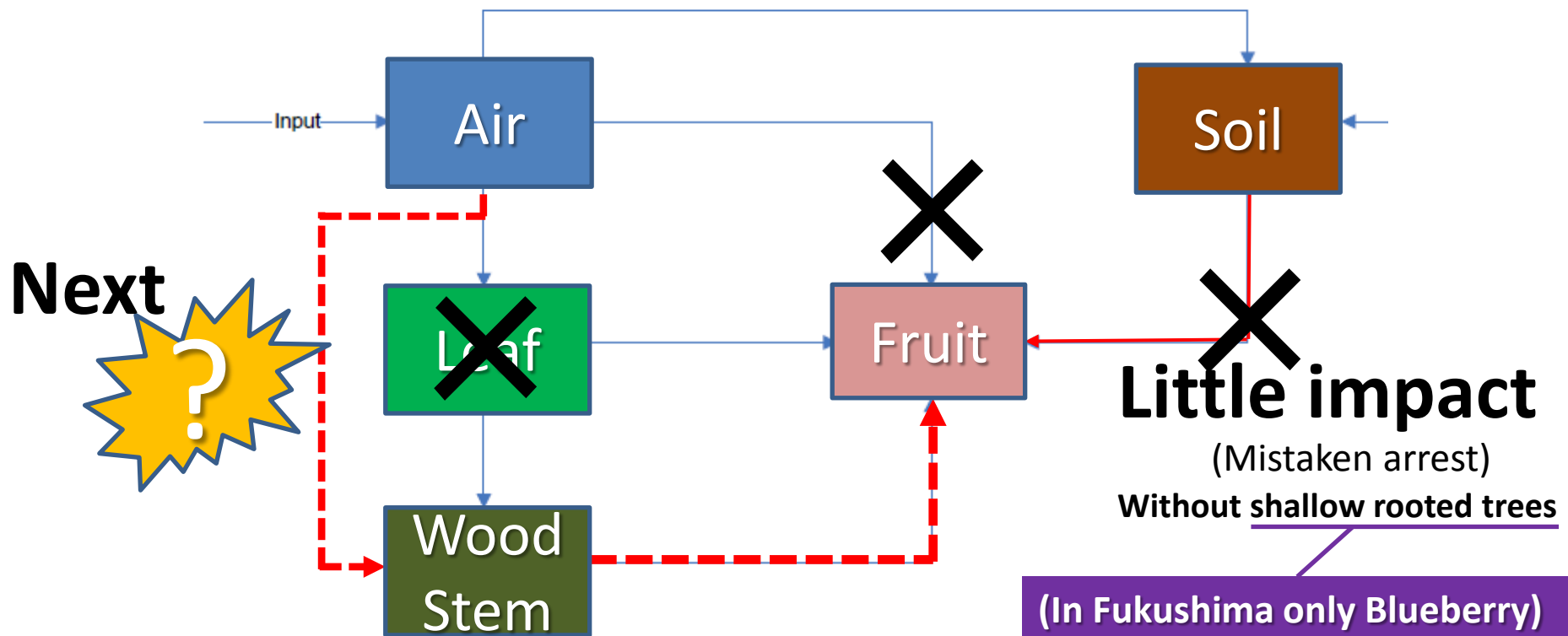
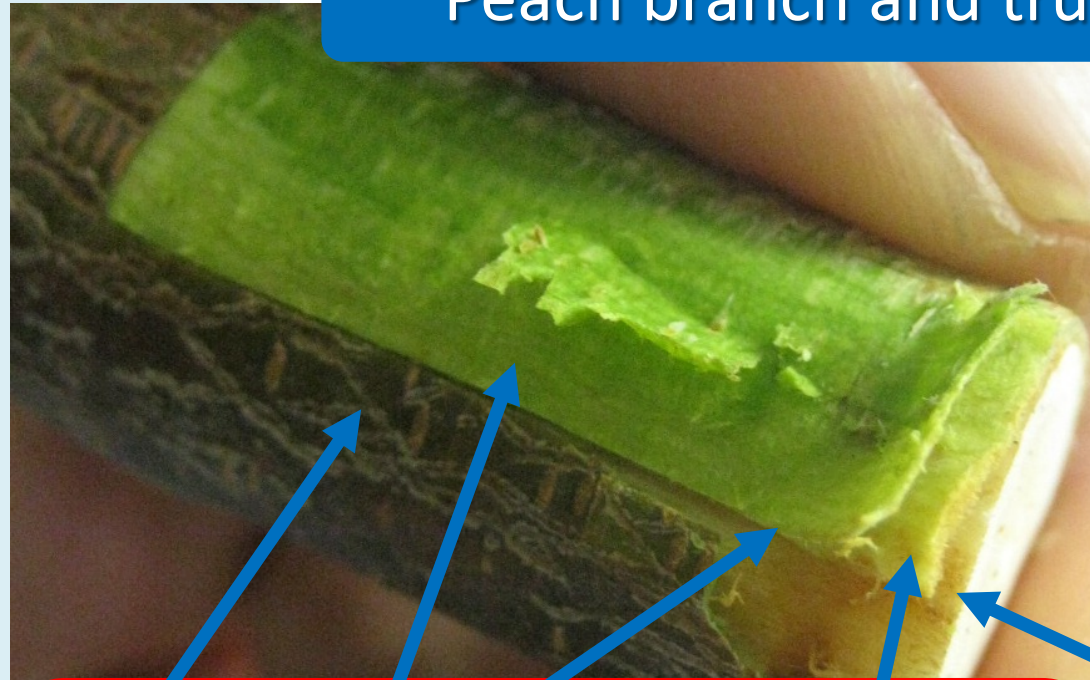


Figure 1: Conceptual fruit model developed by the Fruit Working Group of the IAEA BIOMASS programme

Air to Wood ?

Peach branch and trunk



表皮

epidermis

皮層

cortex

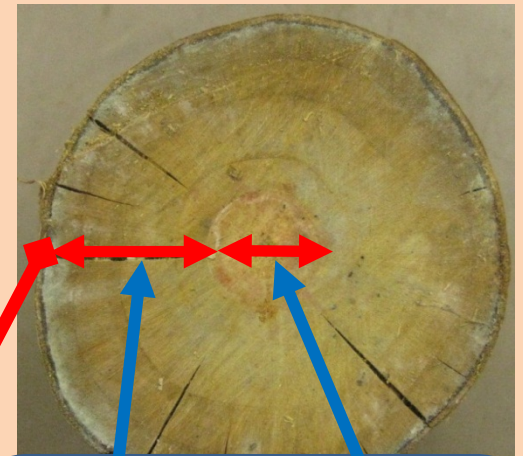
二次師部
+形成層

Secondary phloem
with cambium

表皮直下

Directory under epidermis

樹皮(Bark)



辺材

sapwood

心材

heartwood

材(wood)

outer

inner

Bark to Wood ?

peach 3-year-old
branch



wood

Heart
wood
(inner)

Accident year

Before accident

Annual ring



Bark

Secondary
phloem

inner ←

Cortex

→ outer



bark

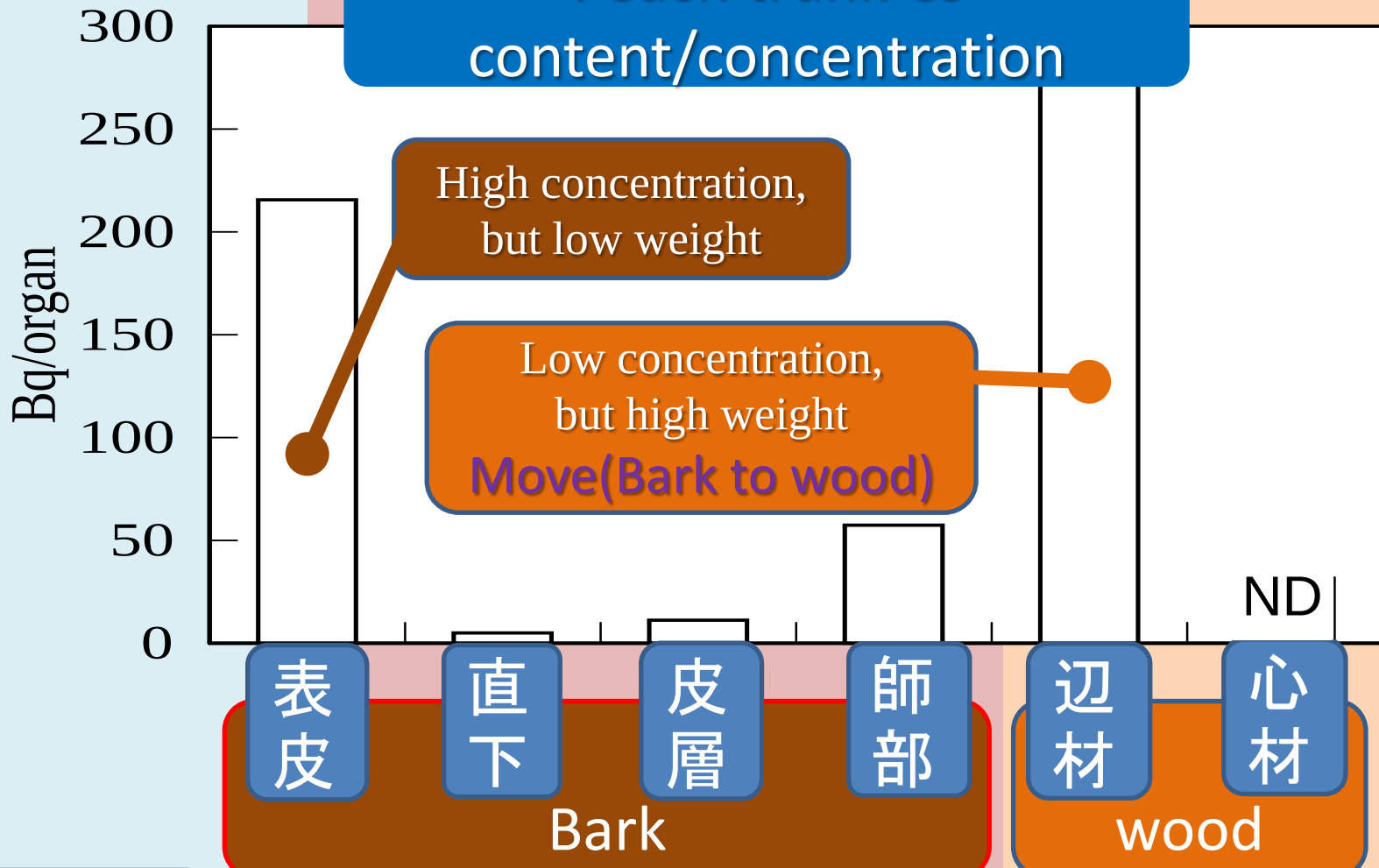
Under epidermis

Epidermis

Don't move
Bark to wood ??

Air to Wood ?

Peach trunk Cs
content/concentration



Bq/kgDW

536.0

11.2

15.9

48.3

39.1

ND *

Content = concentration × dry weight

Radio-Cs Translocation

Conjecture at the Fukushima accident

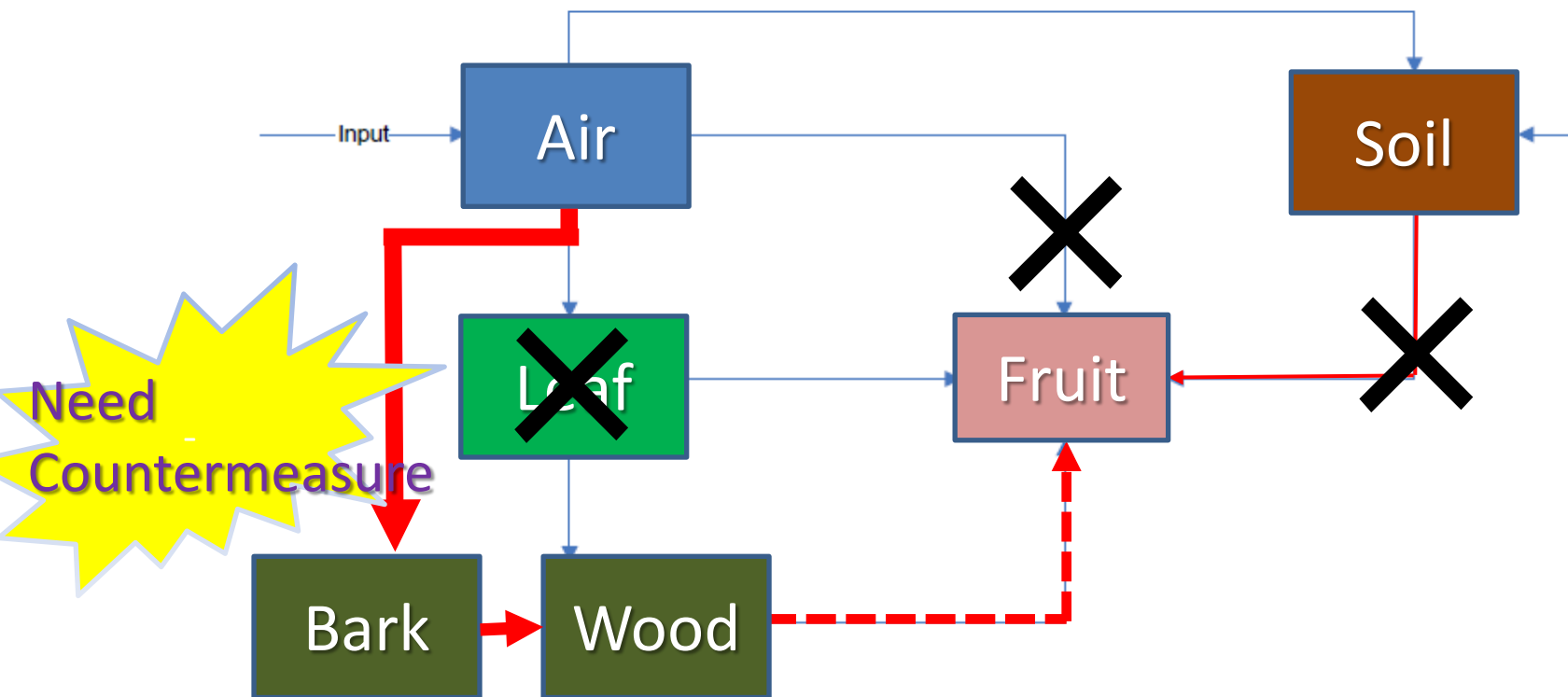
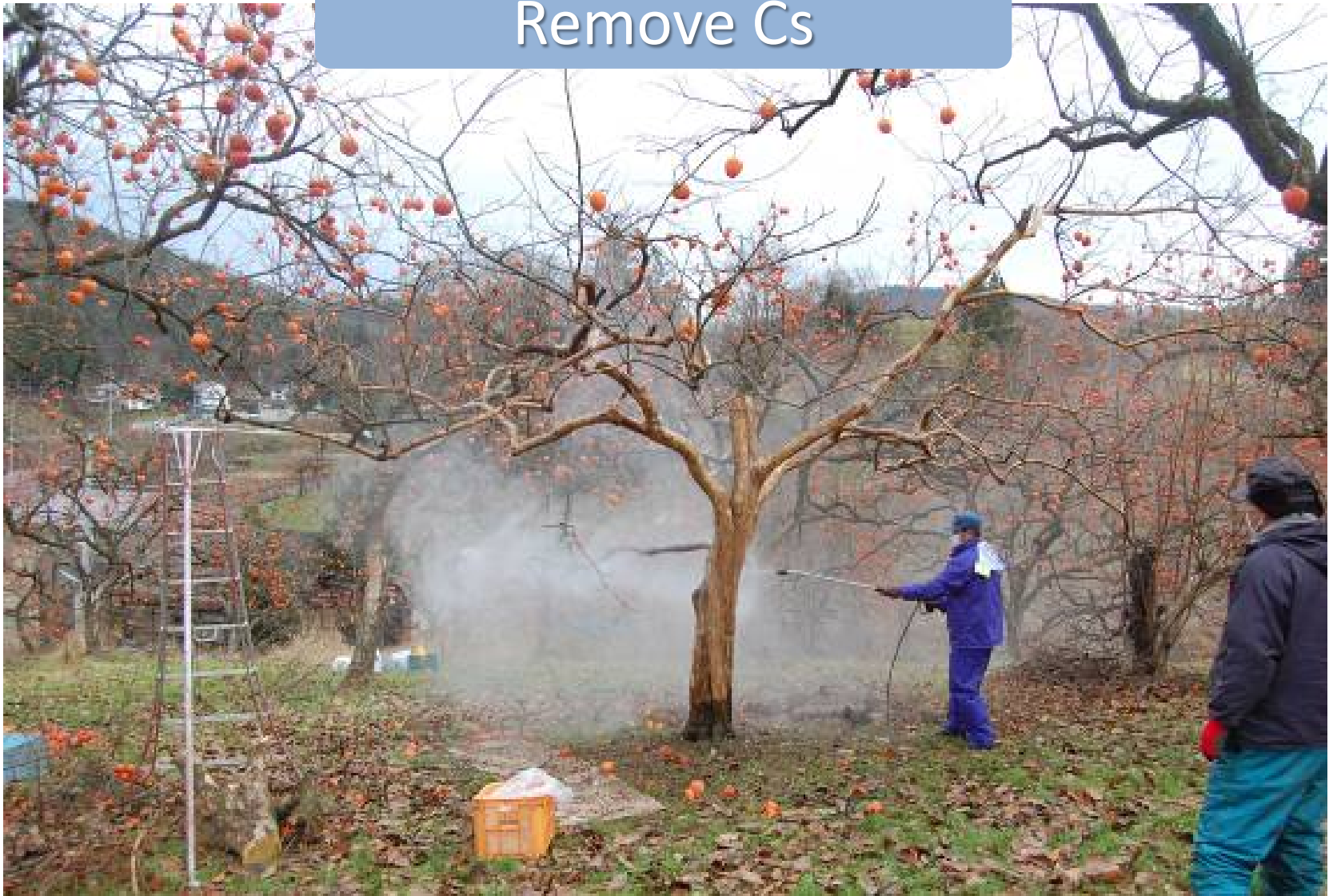


Figure 1: Conceptual fruit model developed by the Fruit Working Group of the IAEA BIOMASS programme

Old part to fruits ?

Remove Cs

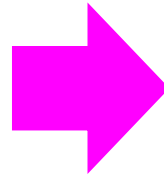


Old part to fruits ?

Removing the outer layers of bark
using high-pressure water sprays



Non-treated
trees



Treated trees

Fruit Cs
(Bq/kgFW)

13.9

6.4

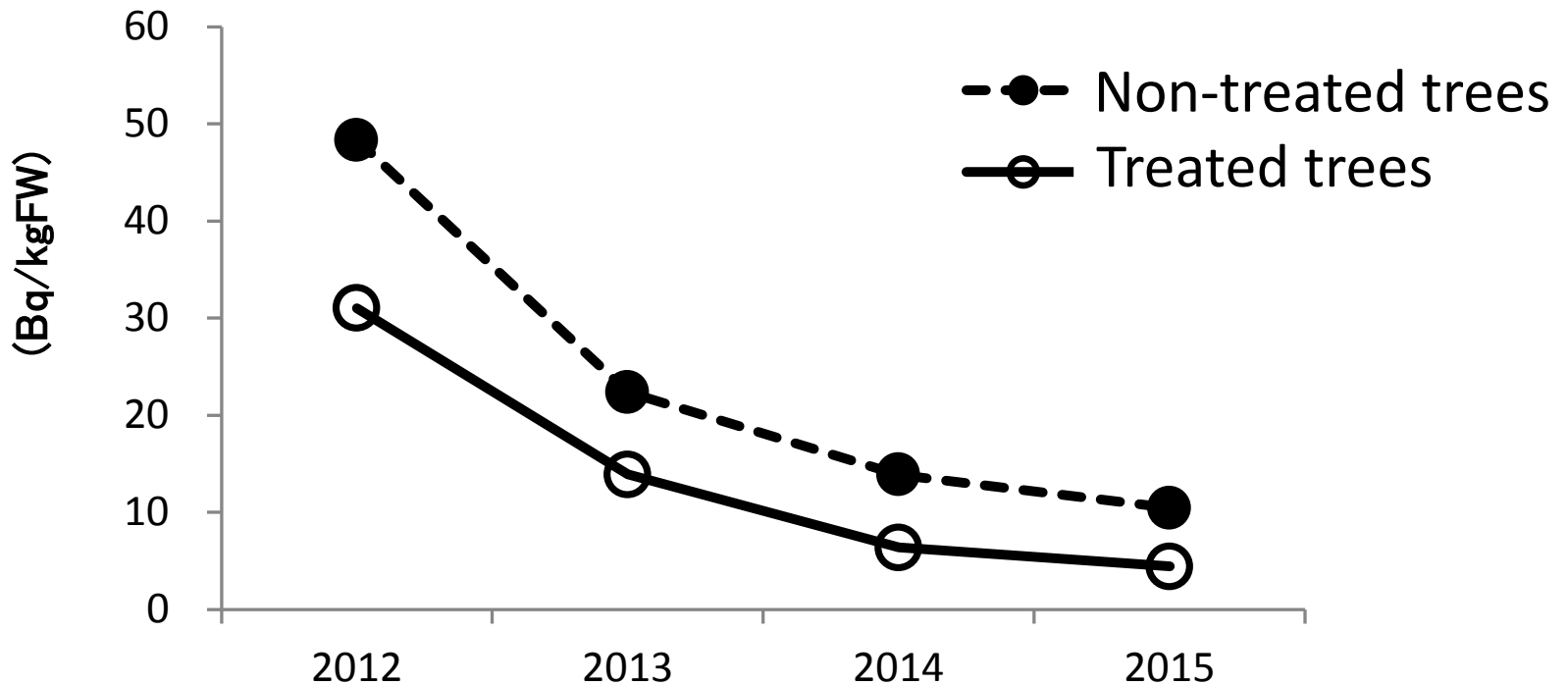
Dose (Kcpm)

0.36

0.28

Old part to fruits ?

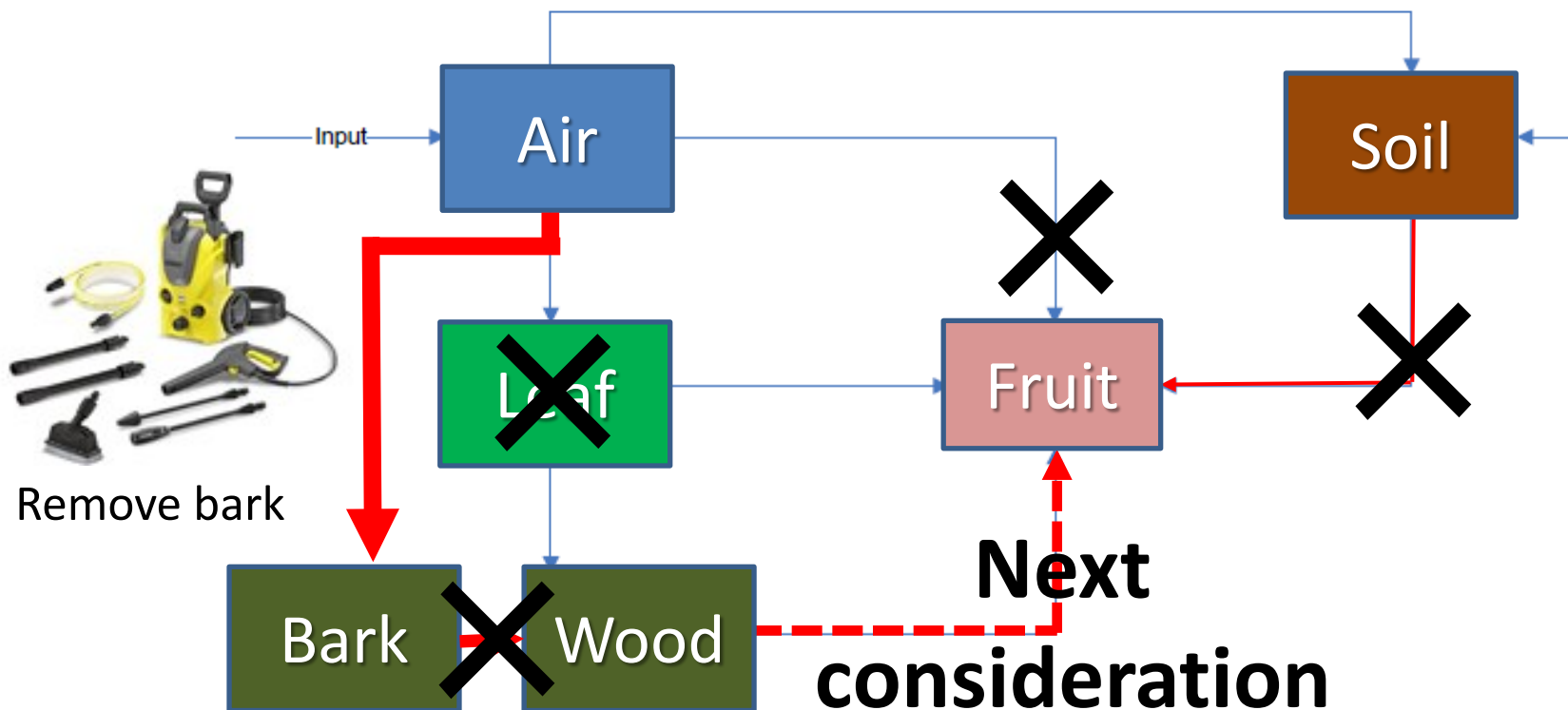
Removing the outer layers of bark
using high-pressure water sprays



Persimmon fruit Cs-137 concentration

Radio-Cs Translocation

Conjecture at the Fukushima accident

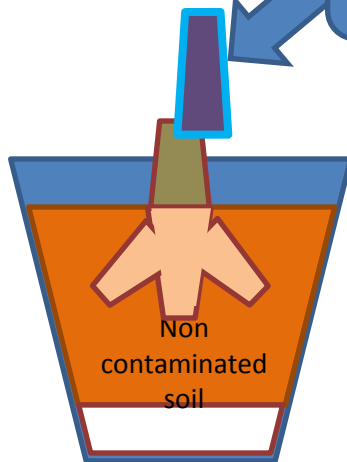


Old part to fruits ?

Grapes Grafted Study

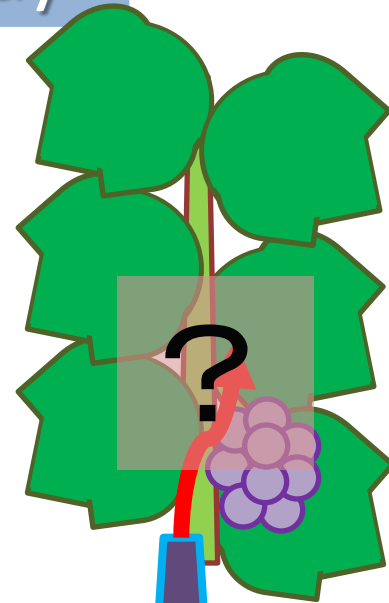
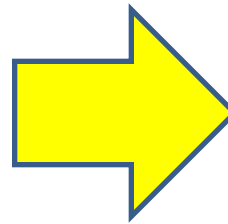


Contaminated
1-year-old
branch



Non contaminated
trees

Before bud break



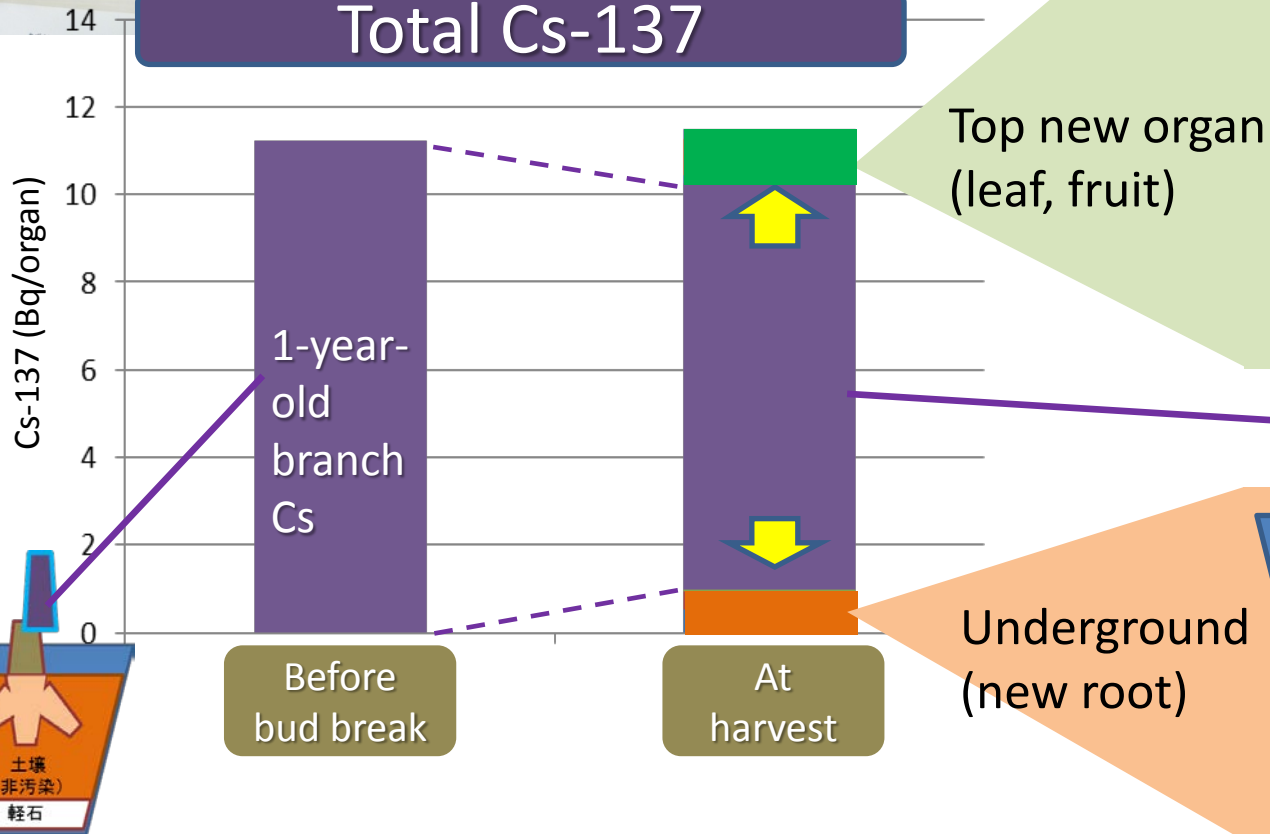
At harvest

Old part to fruits ?

Grapes Grafted Study



Total Cs-137



Radio-Cs Translocation

Cs derived from Fukushima accident

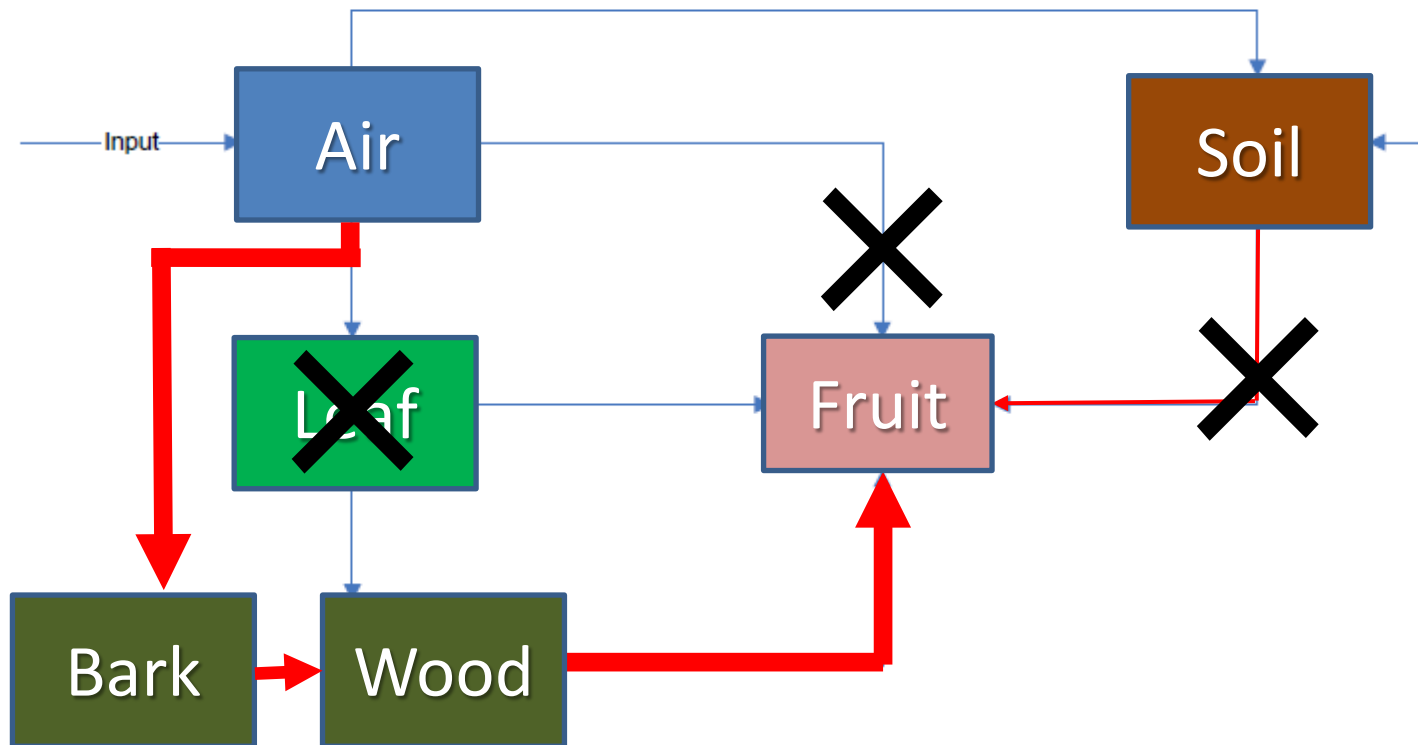


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Radio-Cs in the orchard

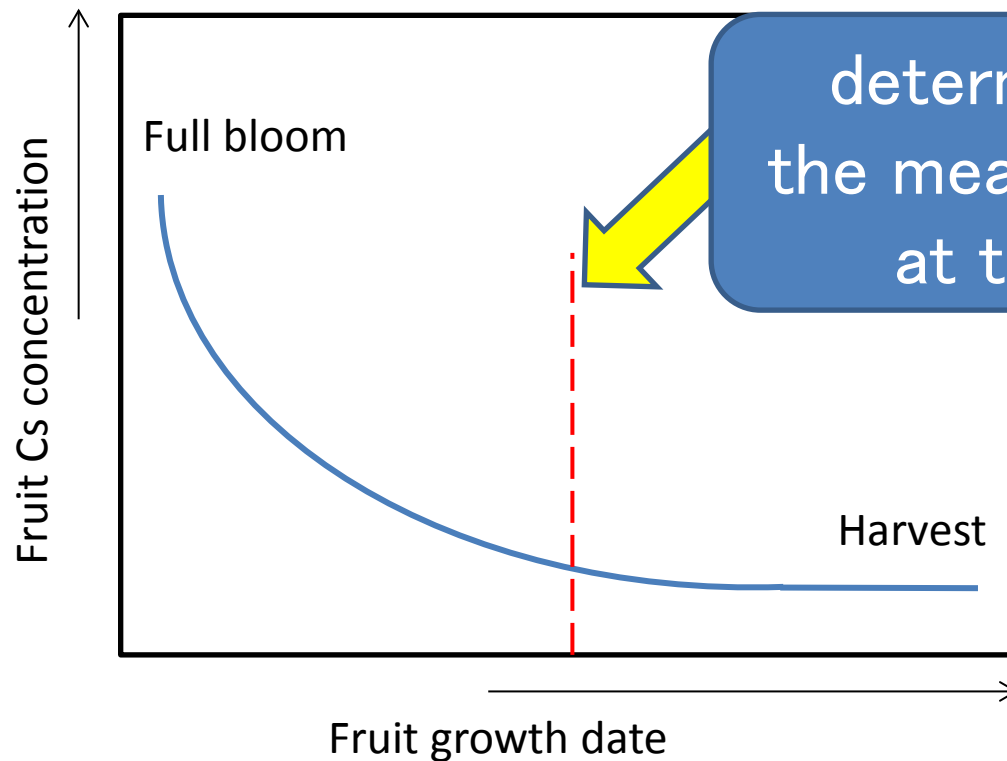
Radio-Cs Translocation

Estimation of fruit concentration

Estimate of the Cs concentration is not most important.
Important to determine whether less than the reference value.

Estimation of fruit concentration

Peach fruit Cs concentration

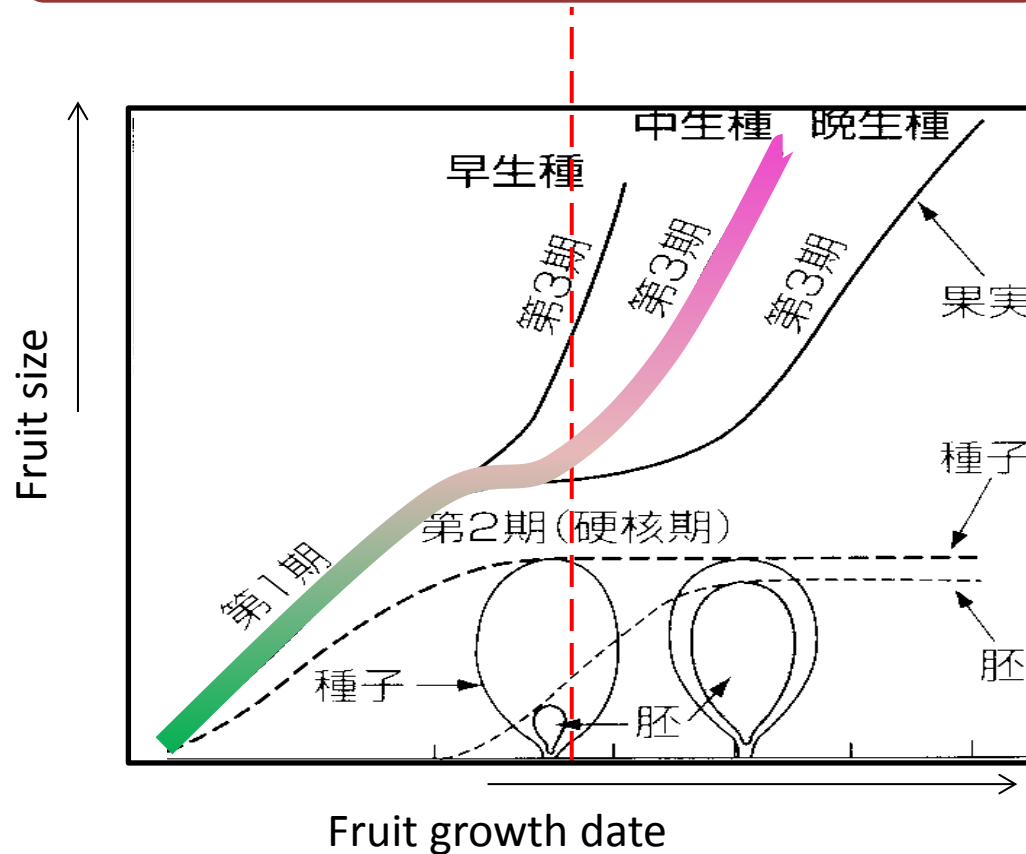


determined from
the measured value
at this time

**What is this
timing for
fruit growth?**

Estimation of fruit concentration

Peach fruit growth

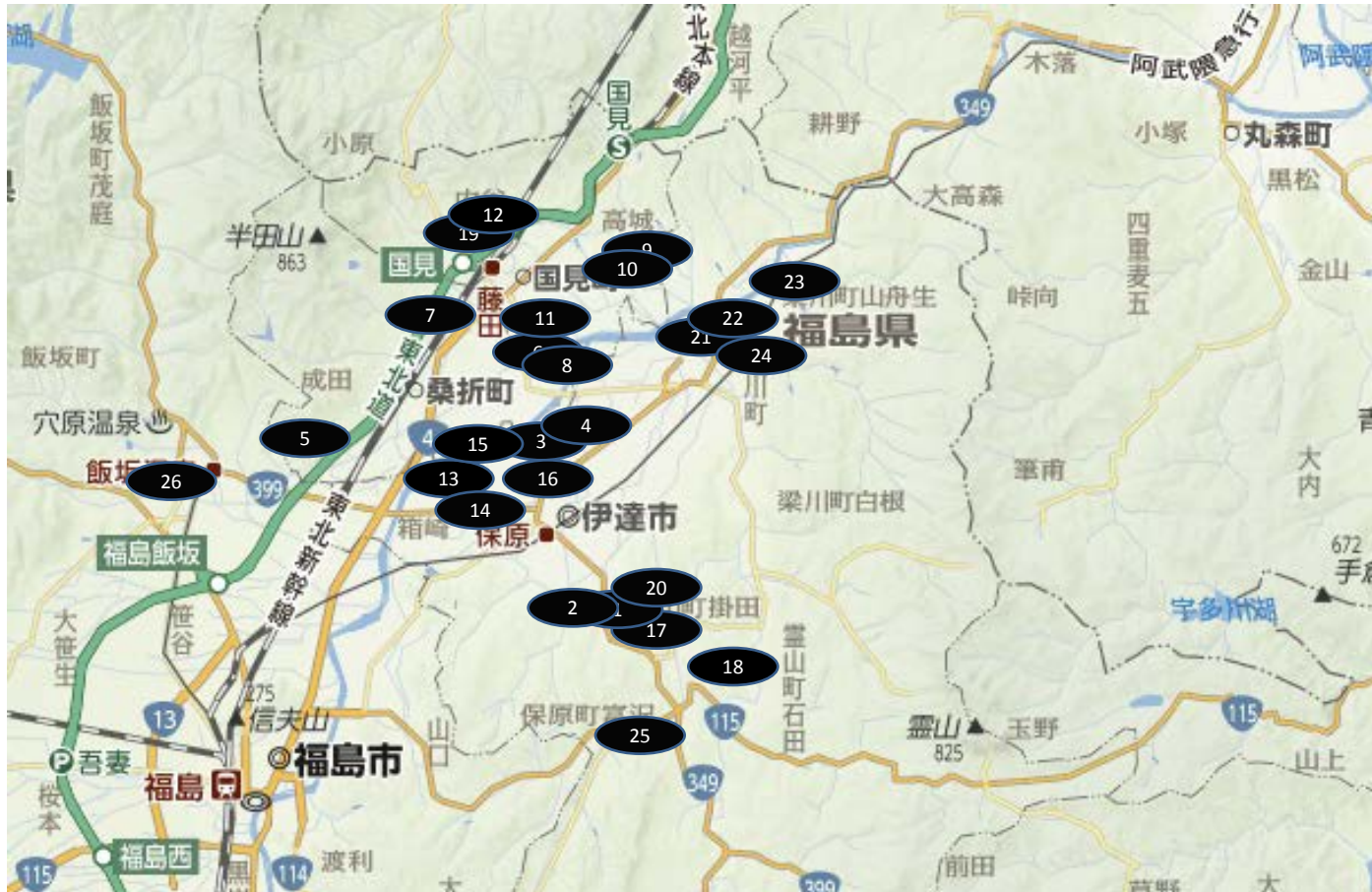


Growth period: seed hardening

Farm work: second thinning (decide harvest fruit number)

Estimation of fruit concentration

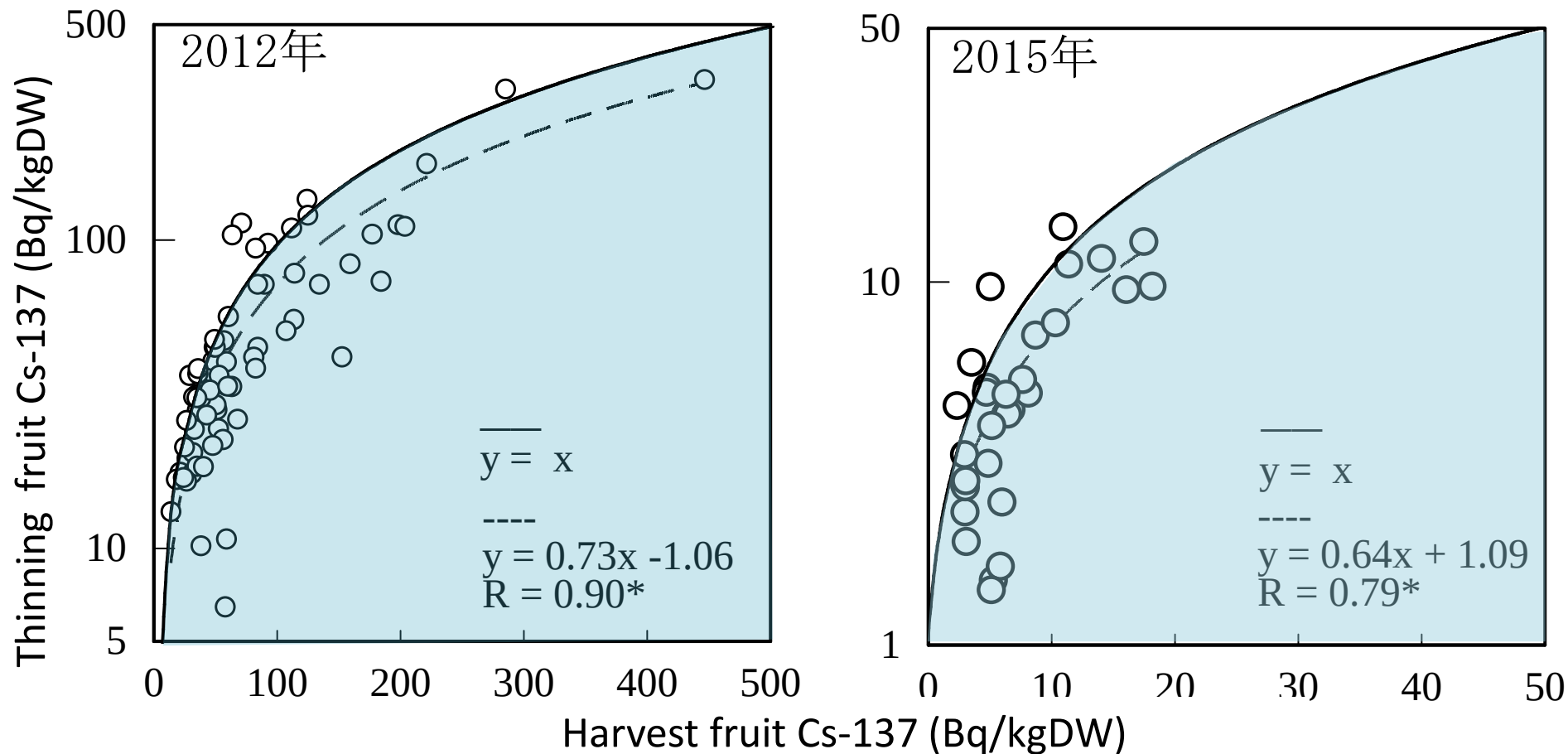
26 orchard in Date city, Fukushima
3 'Akastuki' peach trees in each orchard



Sample timing : 60DAF and harvest

Estimation of fruit concentration

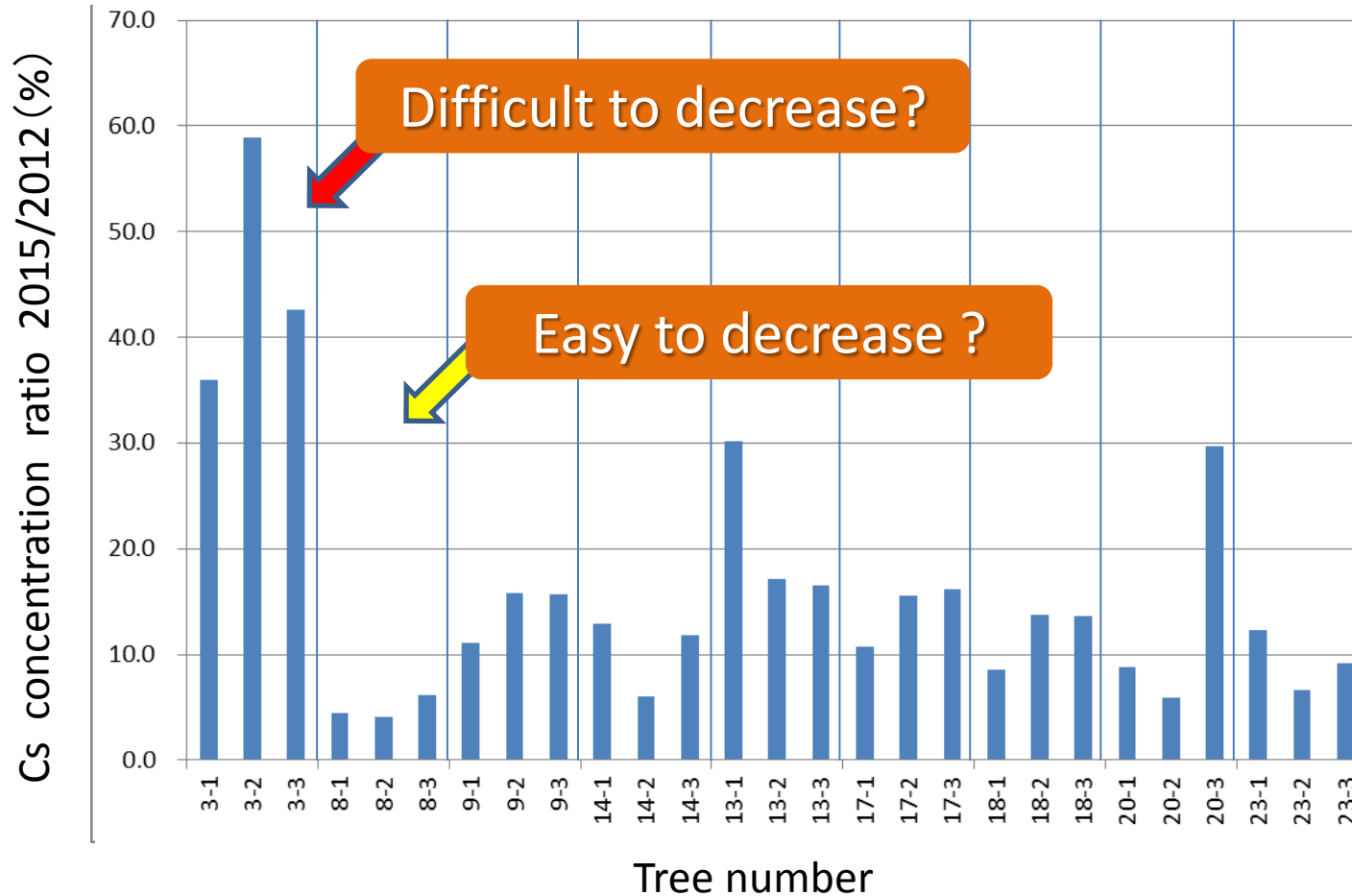
Relationship between thinning fruit and harvested fruits in Cs-137 (2012, 2015)



Tree in which the concentration of the harvest fruit does not exceed the concentration of thinning fruit

Estimation of fruit concentration

Harvest fruit Cs ratio (2015/2012)



Estimation of fruit concentration

Relation between harvest fruit Cs ratio (2015/2012)
and Cs concentration in 2012

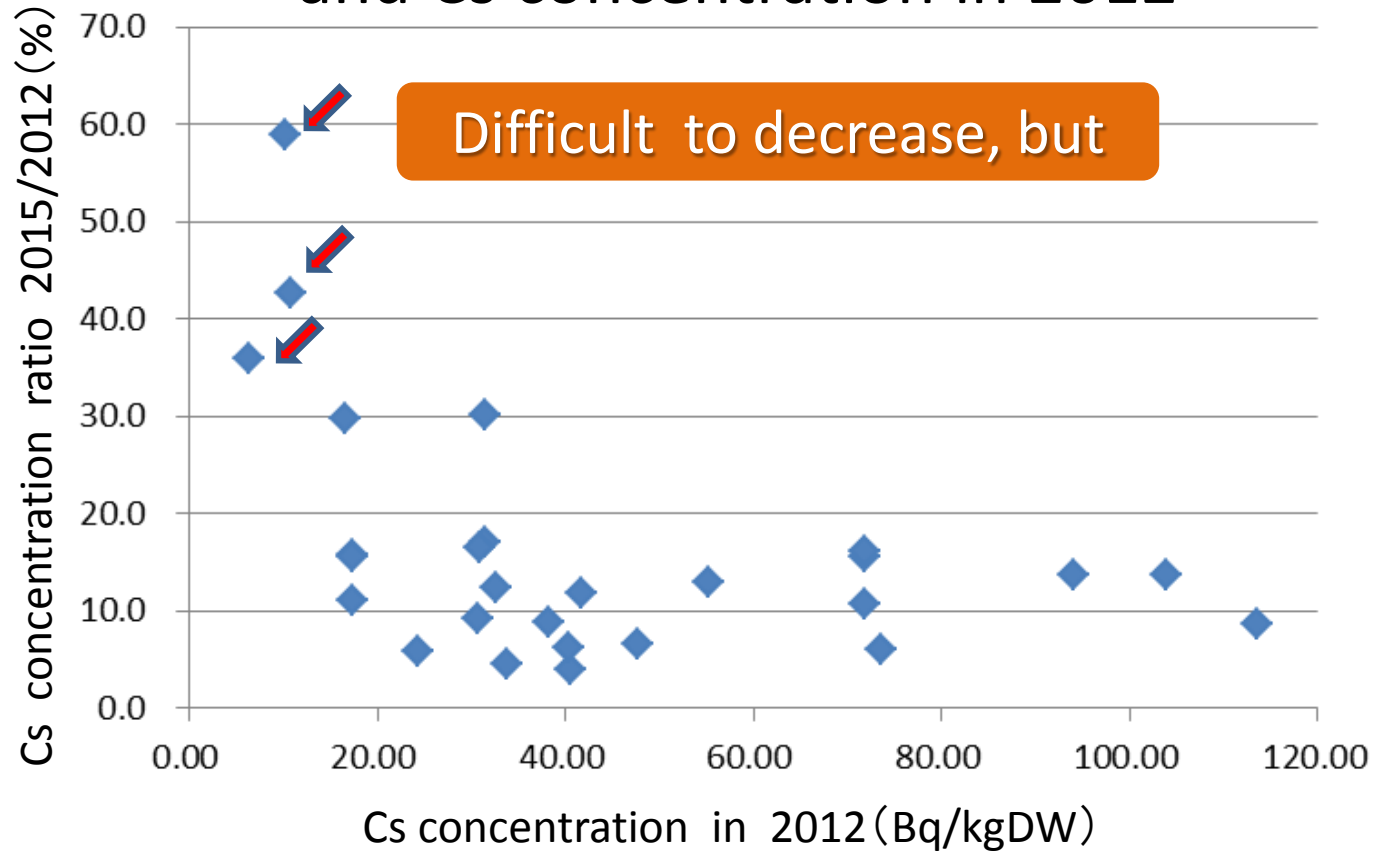


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Radio-Cs in the orchard

Cs is abundant in the tree old part > K
Annual Cs decrease began to bottom out

Radio-Cs Translocation

Bark→fruit > Soil→fruit

Estimation of fruit concentration

Strong correlation between harvest fruit Cs and thinning fruit Cs
Can excluding internal trees with Cs concentration extremely close to the shipment limit