MONITORING OF PLANTS GROWING IN PESTICIDE POLLUTED SOILS

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The purpose

- To identify pesticide tolerant plants that accumulate and/or degrade pesticides and pesticide residues.

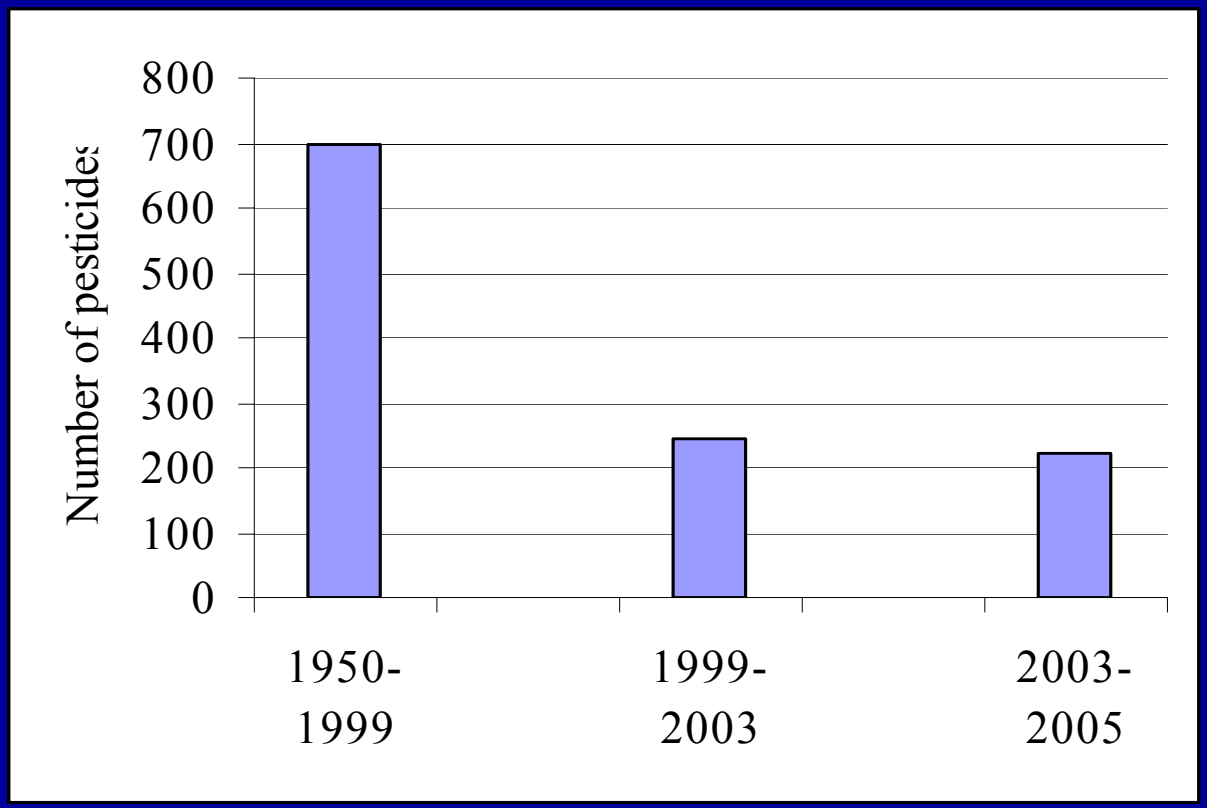
Tasks:

- The measurement of pesticide concentrations in the soils at field sites where the plants are collected.
- The identification of tolerant plants at selected field sites.
- The quantitative and qualitative analysis of residual pesticides in soil and plant tissue.

KAZAKHSTAN

- 2,7 million square kilometers
- 223 million hectares cultivated land or pasture
- 14 oblasts and or states
- The capital - Astana

Pesticide Use in Kazakhstan



- **In NIS countries 700 pesticides (1950-1999)**
- **In Kazakhstan 243 pesticides (1997-2001)**
- **In Kazakhstan 223 registered pesticides (2001-2012)**

Pesticide Use in Kazakhstan

Year	The amount of pesticides	Used in agriculture, ton
1990	**65**	46 000
1991	90	36 000
1992	90	30 000
1993	100	25 000
1994	85	20 000
1995	95	18 000
1996	147	13 660
1997	147	13 000
2000	**182**	32 000

Pesticides Used in Almaty oblast

- "Agrochemcentre“ of the former Soviet Union had 280 pesticide storage warehouses where stocks of obsolete pesticides were stored.
- The amount of obsolete pesticides in all warehouses is about 1 million tons.
- These warehouses are located near the largest city of Kazakhstan – Almaty.

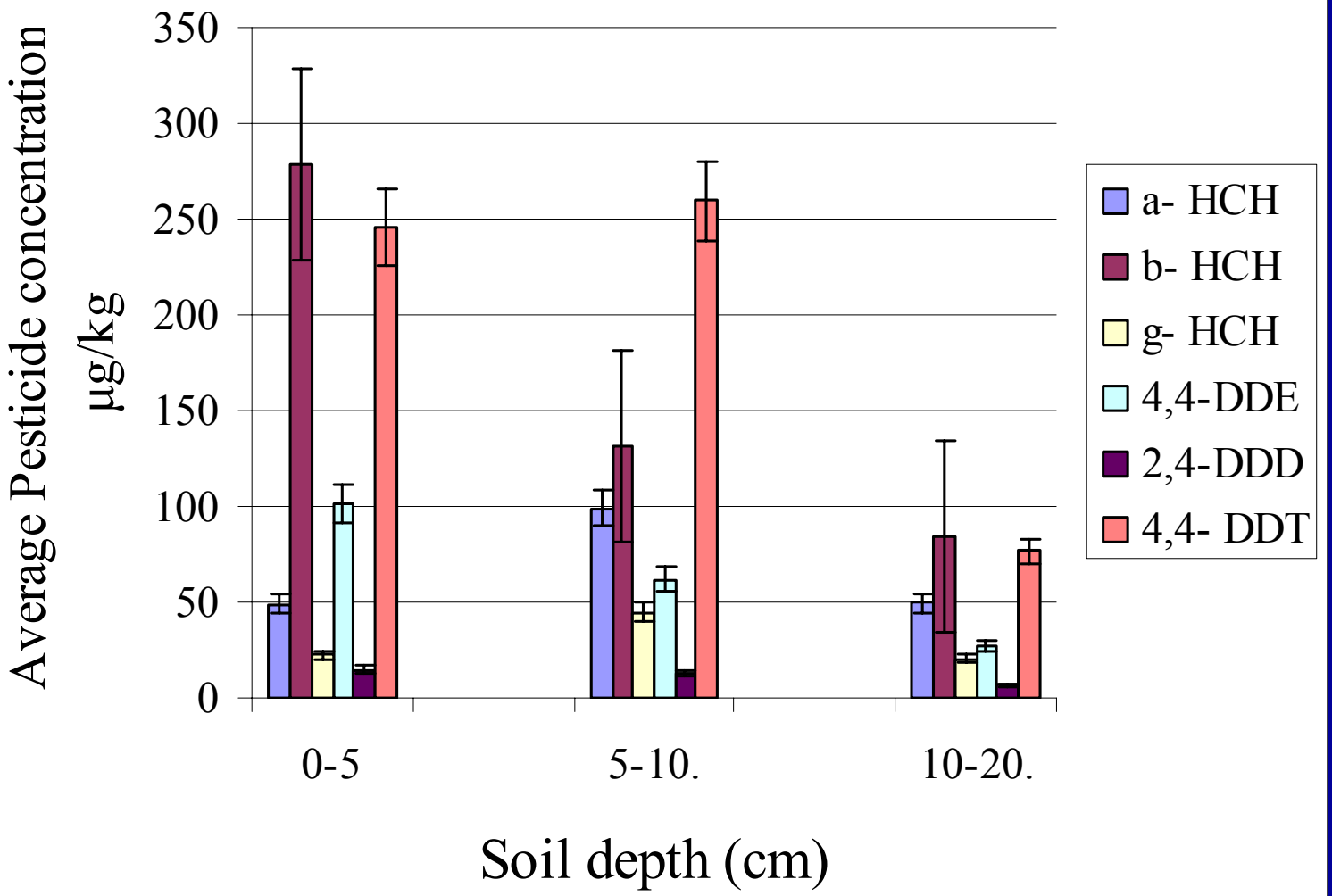
Almaty oblast

First point
(located 15 km away from Almaty)

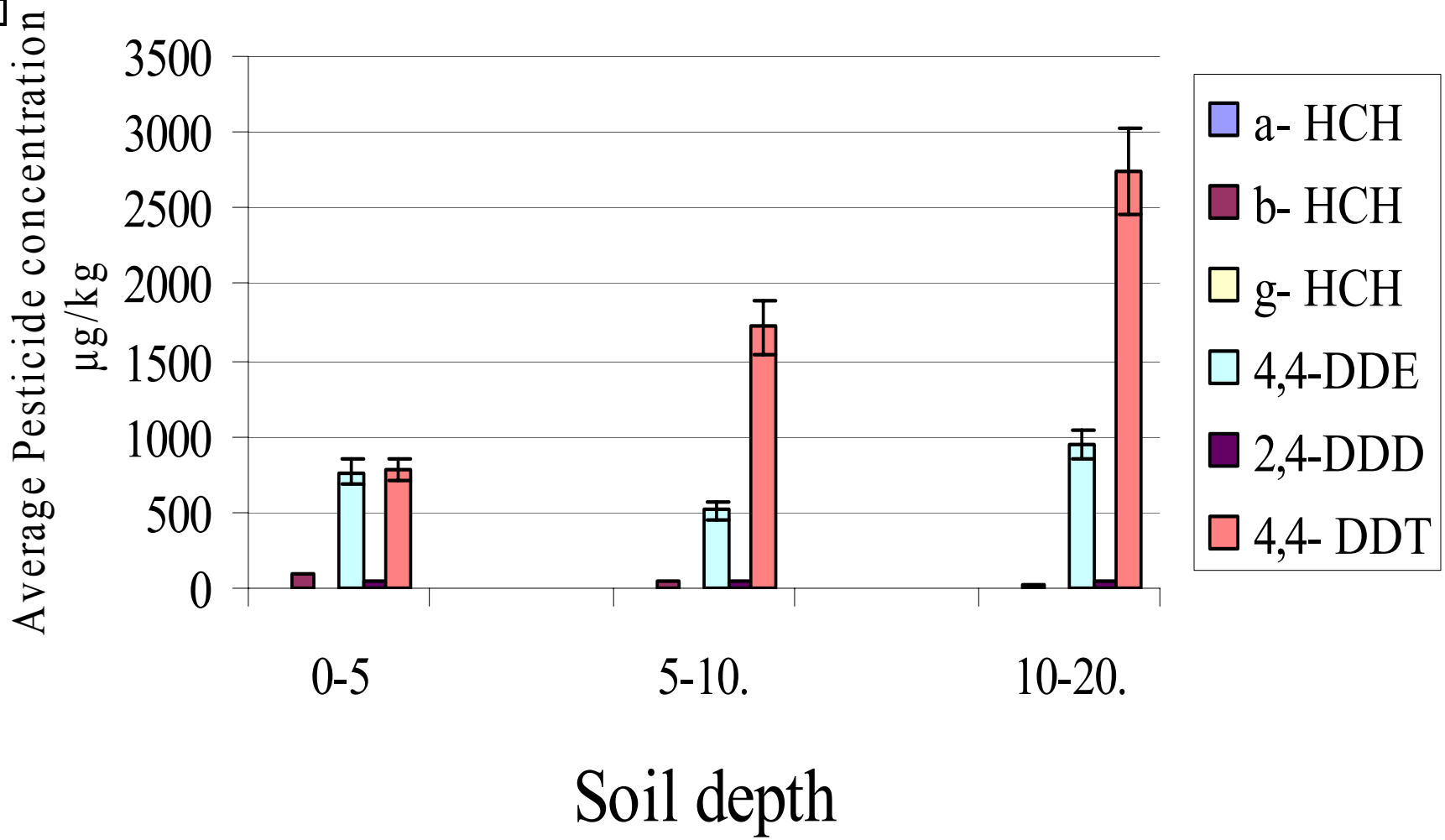
Second point
(located 50 km away from Almaty)

Third point
(located 36 km away from Almaty)

Remaining pesticide concentrations in soil Almaty region -- Point 1



Residual pesticide concentrations in soil
Almaty region – Point 2



Mutations caused by DDT and HCH

- We studied the effect of DDT and HCH on chromosome structural mutations in barley.
- We treated barley plants with the range of concentrations observed in the field.
- We compared to a control of water and hexane.

The influence of DDT on structural chromosome mutations of barley

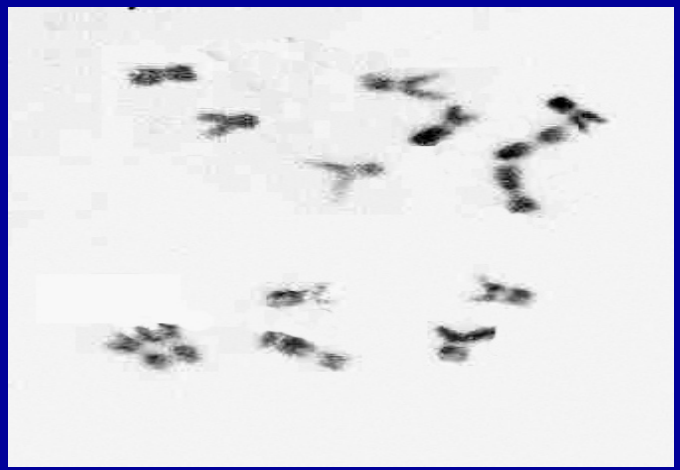
Pesticide or metabolite	Pesticide concentration	%
Control -water		3,19
Control- Hexane		2,17
4,4 DDT	200	5,35
	1000	6,62
	5000	16,05
2,4 DDD	5	5,36
	50	12,25
	150	13,07
4,4 DDE	100	12,59
	800	9,29
	1800	14,33

The influence of HCH on structural chromosome mutations of barley

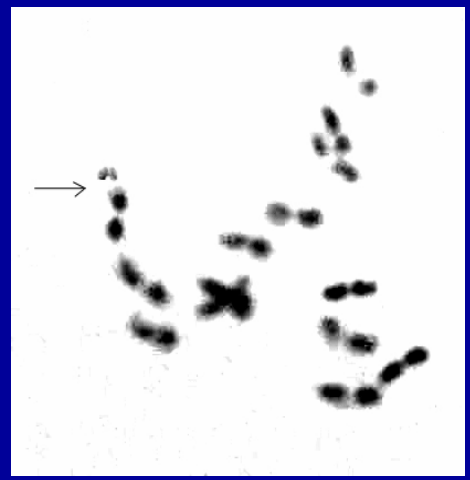
Pesticide or metabolite	Pesticide concentration	%
Control -water		3,19
Control- Hexane		2,17
α̃ - HCḤ	3	4,81
	50	8,55
	200	15,56
β̃ - HCḤ	100	4,59
	200	5,03
	800	11,76
γ̃ - HCḤ	5	5,38
	100	13,95
	200	15,61

Structural mutations of barley chromosomes

Normal Caryotype



Deletion



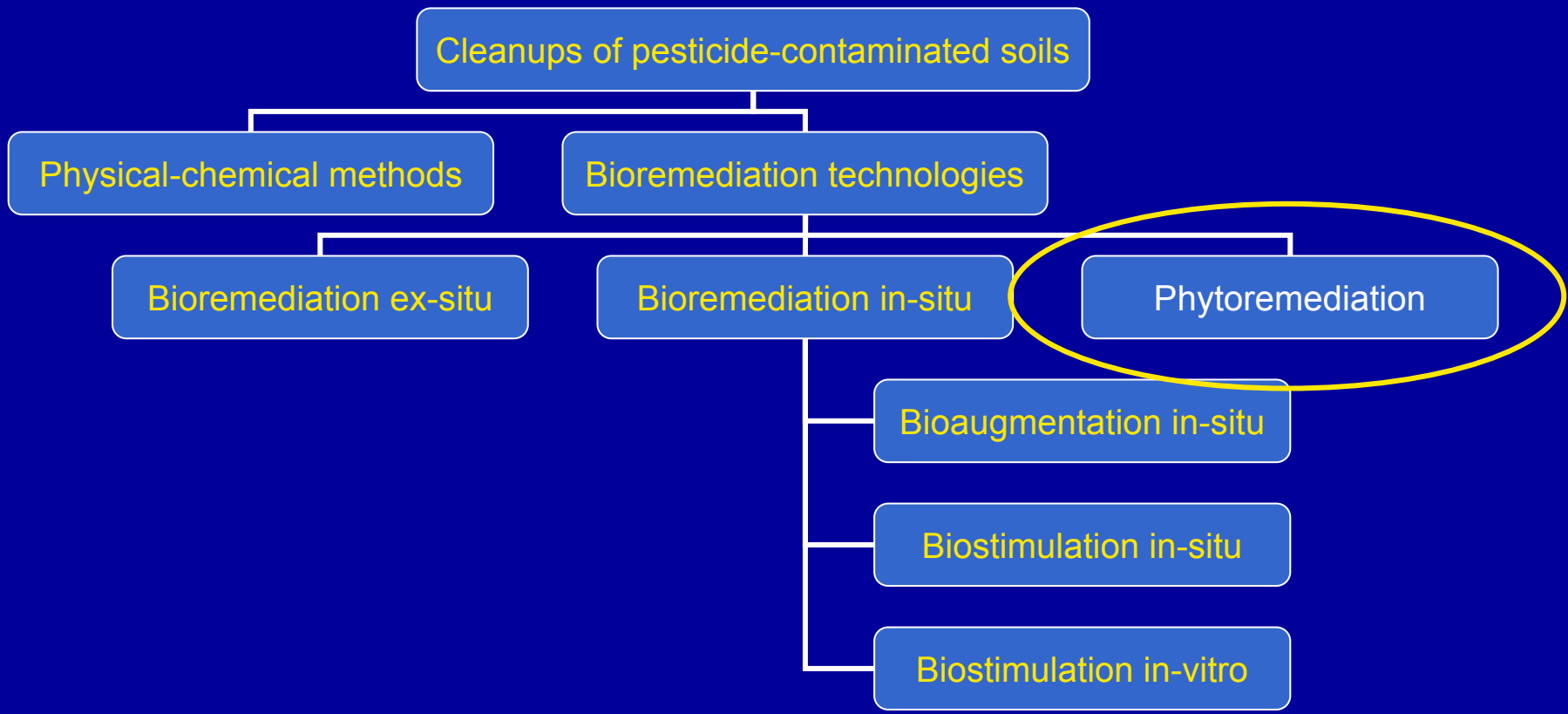
Translocation

Ring

THE PROBLEM OF «OBSOLETE PESTICIDES»

- “Hot spots ” exceeded the Maximum Acceptable Concentrations of DDT metabolites and HCH isomers by the Standards of Kazakhstan.
- High pesticide concentrations in soil is dangerous for the environment.
- Observed levels of DDT metabolites and HCH isomers caused chromosomal mutations.
- Solution of this problem is necessary.

Remediation Technologies for Pesticide Contaminated Soil



Plant Community Structure (Phytocenosis)

- We surveyed vegetation growing at each Hot Point

- Plants that colonize pesticide contaminated sites may have phytoremediation ability.

Vegetation Survey of Plants at Point 1 (Almaty oblast)

Vegetation Survey of Plants at Point 2 (Almaty oblast)

Erigeron canadensis

Artemisia annua

Kochia scoparia at Point 2

Analyze of vegetation

Plant species number growing in the center of contamination at each Hot Point

Month	Point 1	Point 2	Point 3
April	7	9	5
May	12	12	10
June	12	12	13
July	12	12	12
August	14	12	15

Dominant plant species growing at center of contamination Point 1

Annuals	Bi-annuals
Artemisia annua	*Barbarea vulgaris*
Amaranthus retroflexus	*Erigeron canadensis*
Ambrosia artemisiafolia	*Lactuca tatarica*
Bromus tectorum	*Onopordon acanthium*
Cannabis ruderalis	*Polygonum aviculare*
Descurainia sophia	*Poa pratensis*
Kochia scoparia	*Rumex confertus*

Dominant plant species growing at center of contamination Point 2

Annuals	Bi-annuals
Artemisia annua	*Barbarea vulgaris*
Amaranthus retroflexus	*Erigeron canadensis*
Ambrosia artemisiafolia	*Lactuca tatarica*
Bromus tectorum	*Onopordon acanthium*
Cannabis ruderalis	*Polygonum aviculare*
Chenopodium album	*Poa pratensis*
Descurainia sophia	*Rumex confertus*
Kochia scoparia	
Xanthium struramum	

Dominant plant species growing at center of contamination Point 3

Annuals	Bi-annuals
Artemisia annua	*Barbarea vulgaris*
Amaranthus retroflexus	*Brionia alba*
Ambrosia artemisiafolia	*Conium Maculatum*
Bromus tectorum	*Cichorium intybus*
Cannabis ruderalis	*Dactylis Glomerata*
Chenopodium album	*Echium vulgare*
Descurainia sophia	*Galium aparine*

Pesticide tolerant species of plants

Family	Pesticide tolerant species
Asteraceae	*Artemisia annua, Ambrosia artemisifolia, Xanthium strumarium, Erigeron canadensis, Artemisia absinthium, Onopordon acanthium, Lactuca tatarica*
Amaranthaceae	*Amaranthus retroflexus*
Chenopodiceae	*Kochia scoparia; Atriplex tatarica*
Brassicaceae	*Barbarea vulgaris; Descurainia Sophia*
Polygonaceae	*Rumex confertus; Polygonium aviculare*
Cucurbitaceae	*Brionia alba*
Poaceae	*Aelgilops cylindrical, Bromus tectorum*

QUESTIONS
Regarding Pesticide Tolerant Plants

- Are the plants growing on «hot points » capable of phytoremediation?

- Which plant species are necessary for phytoremediation of pesticide polluted soils?

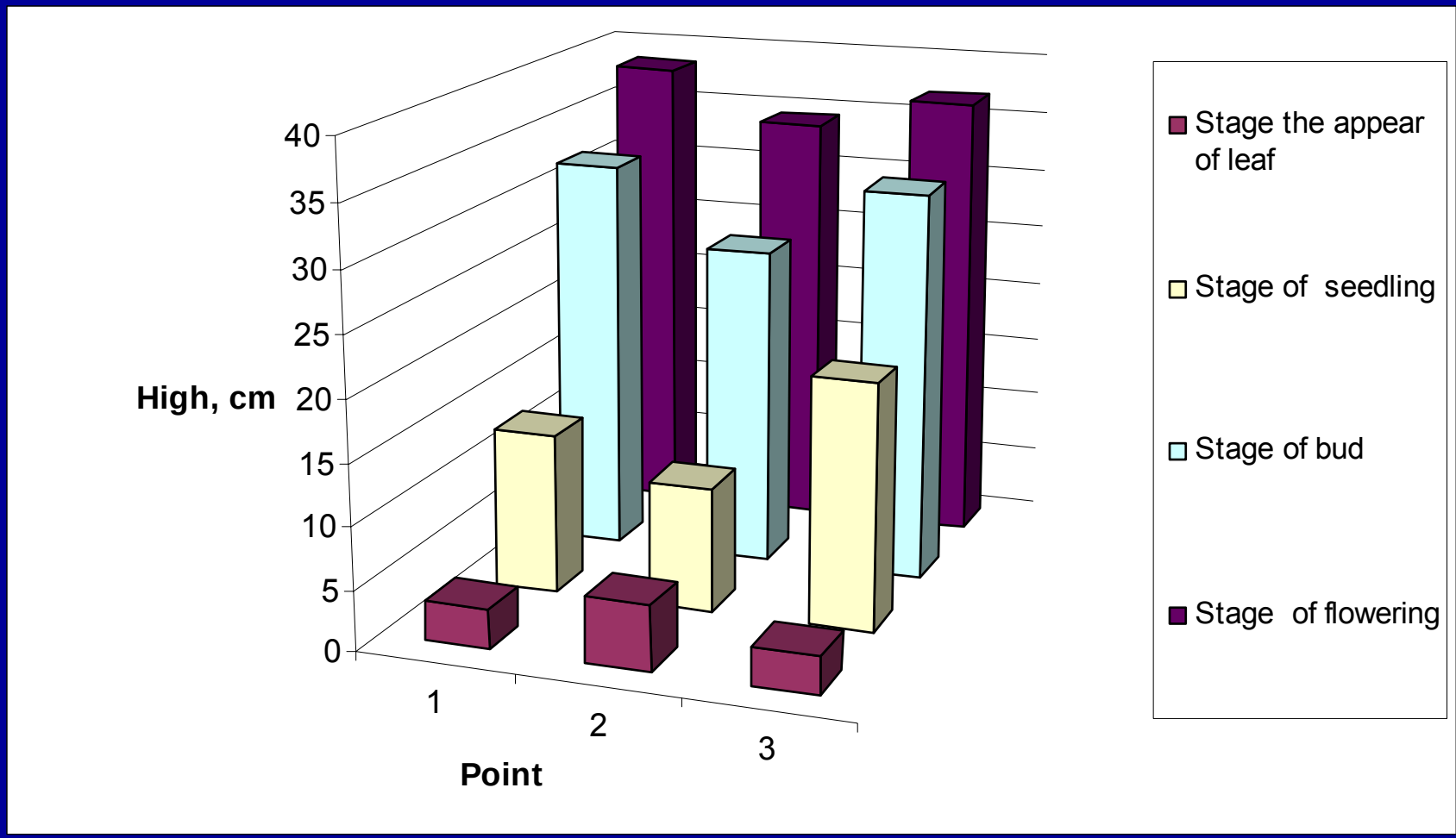
Plants growing in soil from Point 1 in greenhouse

Plants growing in soil from Point 2 in greenhouse

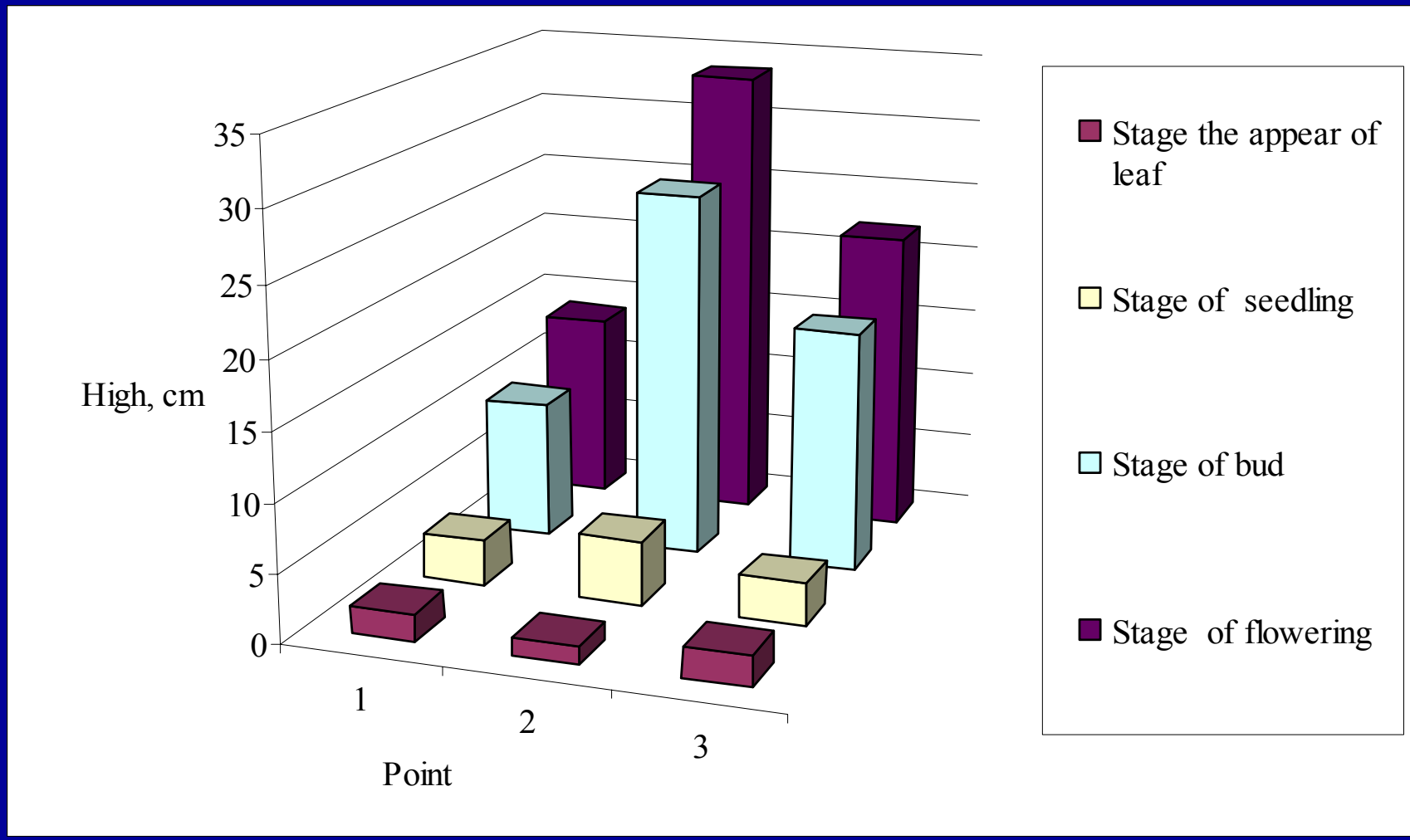
Average concentrations of pesticide residuals in soil before experiment – USEPA methods in Stepnogorsk (μg/kg)

	Point	α-HCH	β-HCH	γ HCH	4,4 DDE	2,4 DDD	4,4 DDT	Sum
MAC		0	100	100	100	0	100	
Soil	1	68	176	23	85	17	366	734
Soil	2	16	84	13	1869	107	4187	6273
Soil	Control	0	0	0	302	0	41	343
Ceramsite		76	311	13	195	28	595	1217
Sand		0	0	0	0	0	0	

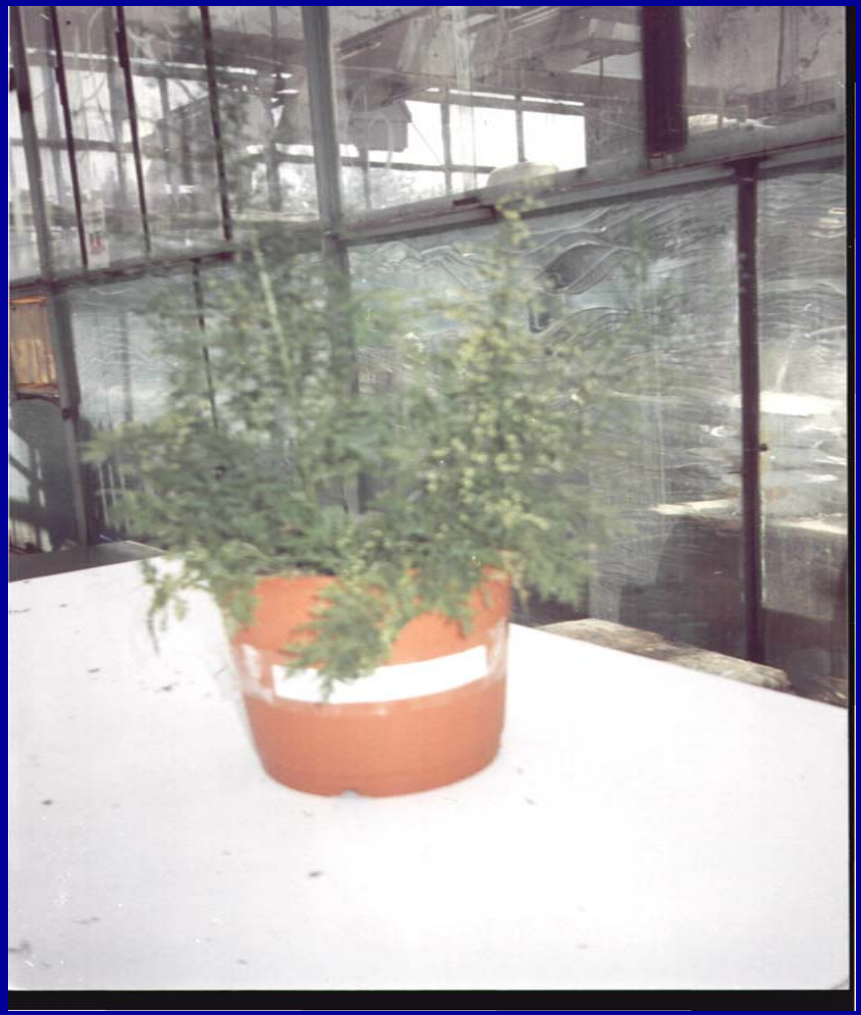
Phenology of *Artemisia annua*



Phenology of *Kochia scoparia*

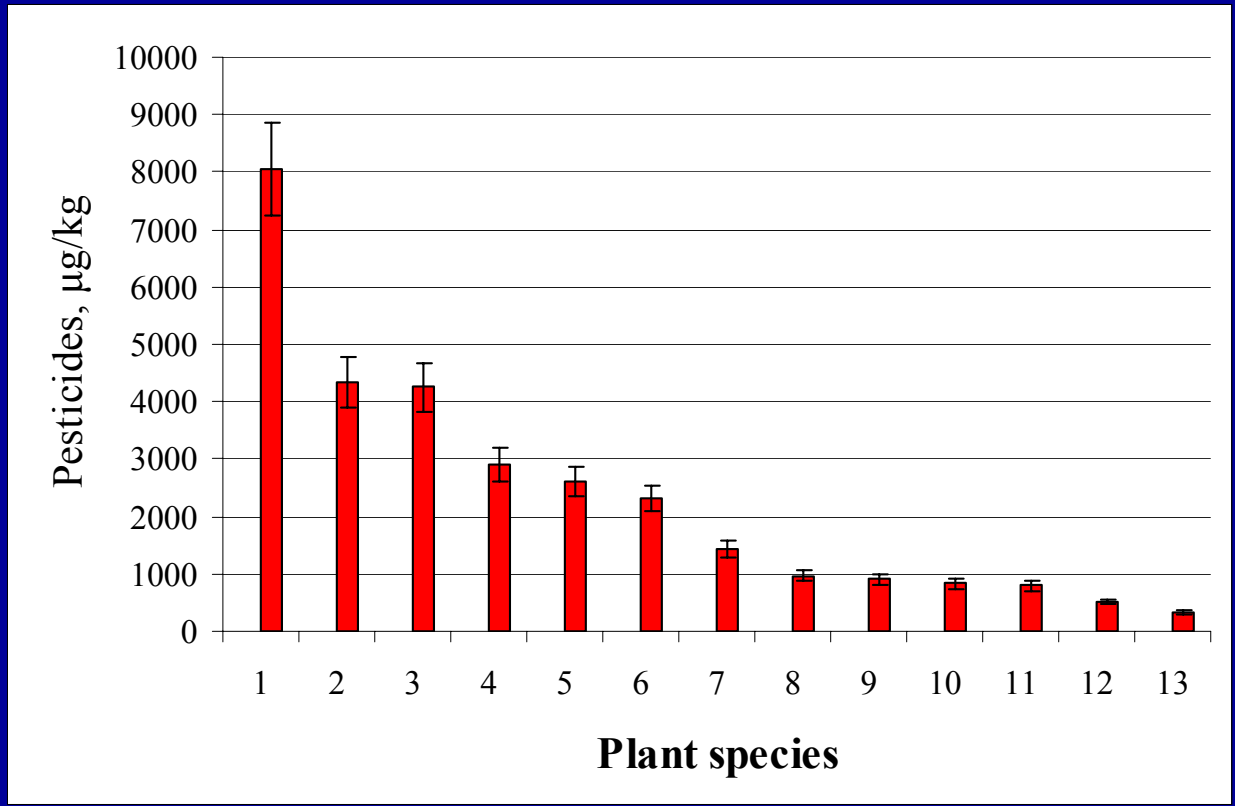


The plant sampling method



Total Residual Concentration of chlororganic pesticides in plant tissue (Point 2 – USEPA methods)

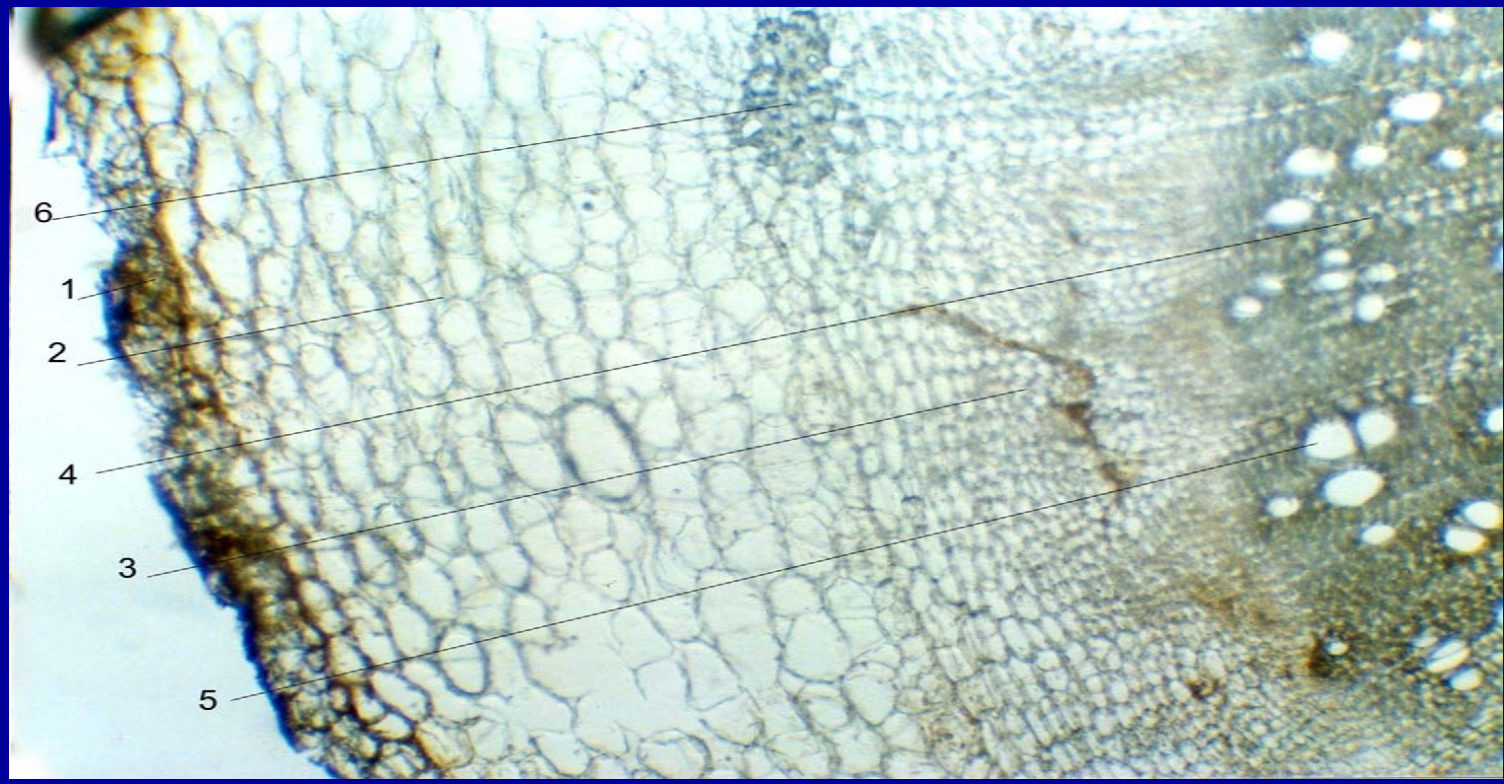
1- *Artemisia annua.*
2 - *Erigeron canadensis*
3 - *Xanthium strumarium*
4 - *Kochia scoparia*
5 - *Barbareae vulgaris*
6 - *Kochia sieversiana*
7 -*Amaranthus tricola cult*
8 - *Ambrosia artemisifolia*
9 - *Solanum dulcamara*
10 - *Artemisia absinthium*
11 - *Medicago sativa*
12 - *Aelgilops cylindrical*
13 - *Rumex confertus*



Location of Accumulated pesticide in plant tissue

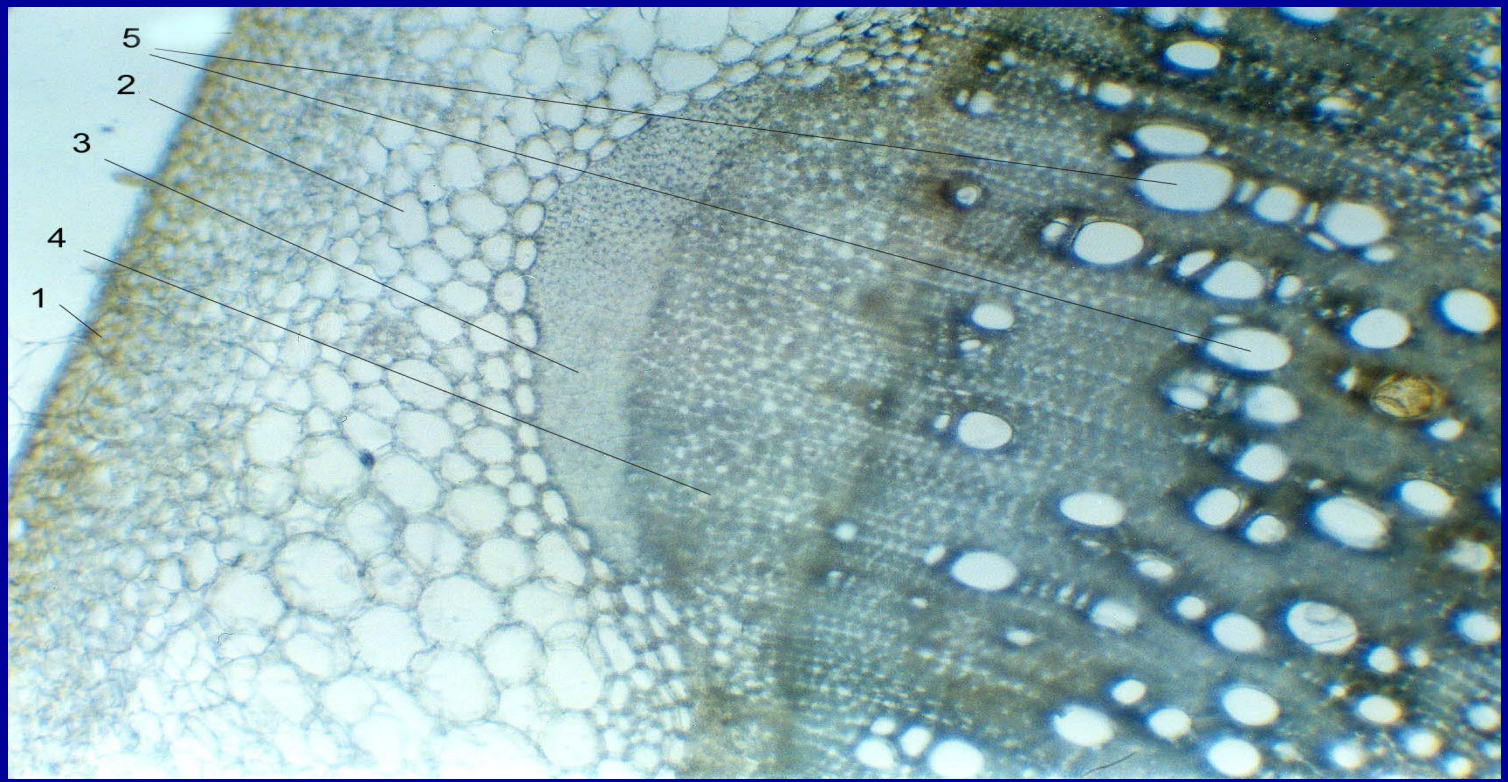
Species	Roots	Stem	Leaves
Xanthium strumarium	Parenchymatous cells and xylem walls	Xylem walls	Palisade mesophyll
Ambrosia artemisiafolia	Parenchymatous cells	Xylem walls	Palisade mesophyll
Erigeron canadensis	Parenchymatous cells and xylem walls	Xylem walls	Palisade mesophyll
Artemisia annua	Parenchymatous cells and xylem walls	Xylem walls	Mesophyllous cells around ploem bunches
Kochia scoparia	Parenchymatous cells and xylem walls	Xylem walls	Mesophyllous cells around ploem bunches
Barbarea vulgare	Parenchymatous cells and xylem walls	Xylem walls	Palisade mesophyll

Hystology of *Xanthium strumarium L* root



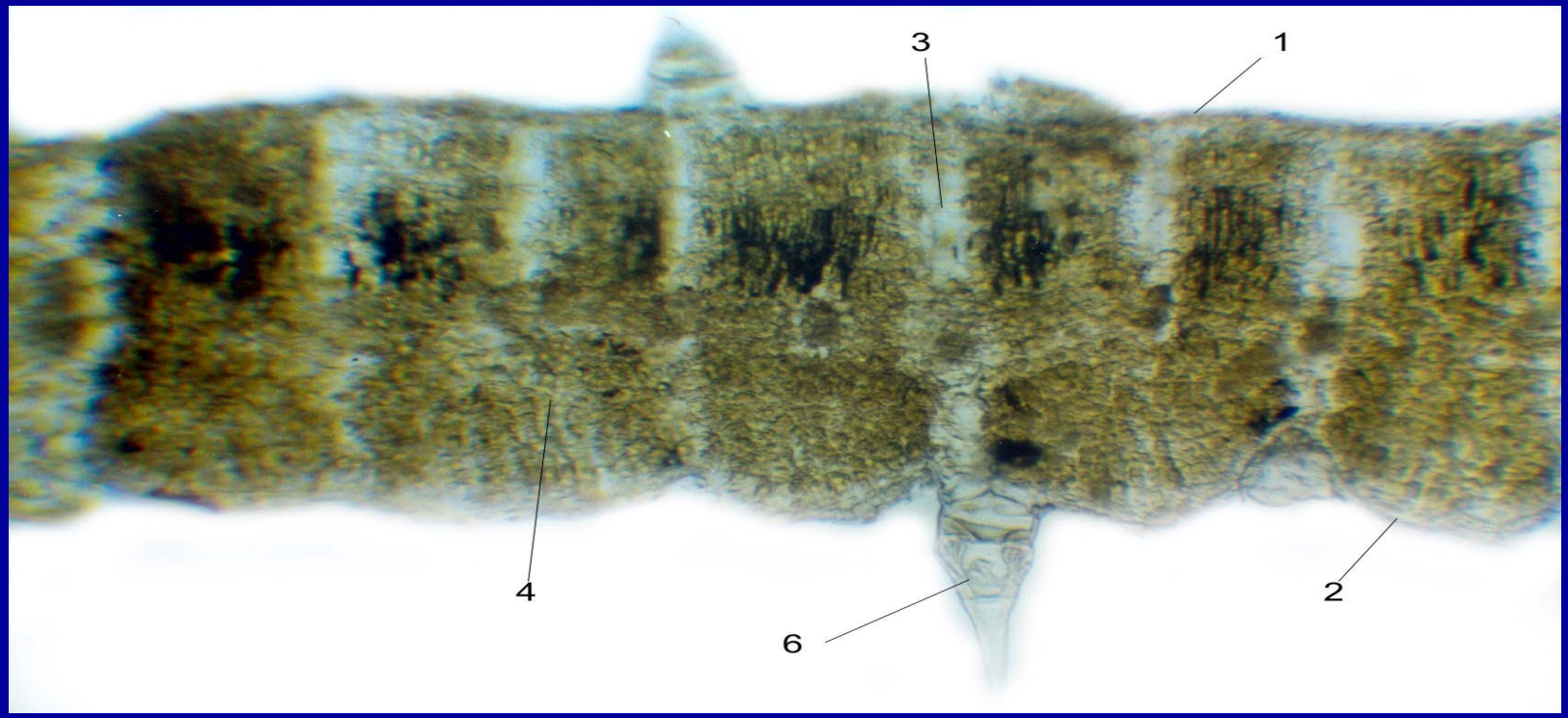
- 1 - epidermis, 2 - primary cortex, 3 – phloem, 4- medullary parenchyma, 5- xylem, 6- sclerenchyma strands

Hystology of *Xanthium strumarium L.* stem



- 1- epidermis, 2 – primary cortex, 3 – sclerenchyma jaws of conductive bundle, 4- phloem, 5- xylem

Hystology of *Xanthium strumarium L.* leave



- 1- upper epidermis, 2 - lower epidermis, 3 – palisade mesophyll, 4- spongy mesophyll, 5-conducting bundle, 6-trichome

Conclusions

- 17 of 123 plant species were pesticide tolerant.
  Predominant species were wild and weedy annuals and biannuals.

- We have shown that some of these tolerant species have the ability to accumulate chlororganic pesticides.

- Pesticide concentrations observed at field sites cause chromosome structure mutations in barley.

- Pesticides are located in particular plant tissues.

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