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"Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation"
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Importance of crop residue management in Conservation Agriculture

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Presentation structure:

- What we know about soil degradation?
- Facts about Intensive conventional agriculture – in short!
- …and what we do about that?
- Something about Conservation Agriculture [CA]
- Crop residues [CR] – what we know about it?
- What we do and what do we have to do with CR?
- Methods for measuring/assessment crop residues

What we know about soil degradation?

- Water shortages and higher temperatures, which increase evaporation, combined with soil erosion intensified by extreme weather events, with application of inappropriate soil and crop management (soil tillage, mineral nutrition, crop protection etc.) increase risks for soil degradation





Soil erosion

Watter logging

Decreasing root elongation

Loss of fertile top soil

Nutrients depletion

Tillage pan

Soil acidification

SOM decreasing

Soil compaction

Decreasing humus content

OM decreasing

Reduction of microbial activity

Increasing bulk density

Soil alkalinization / salinization

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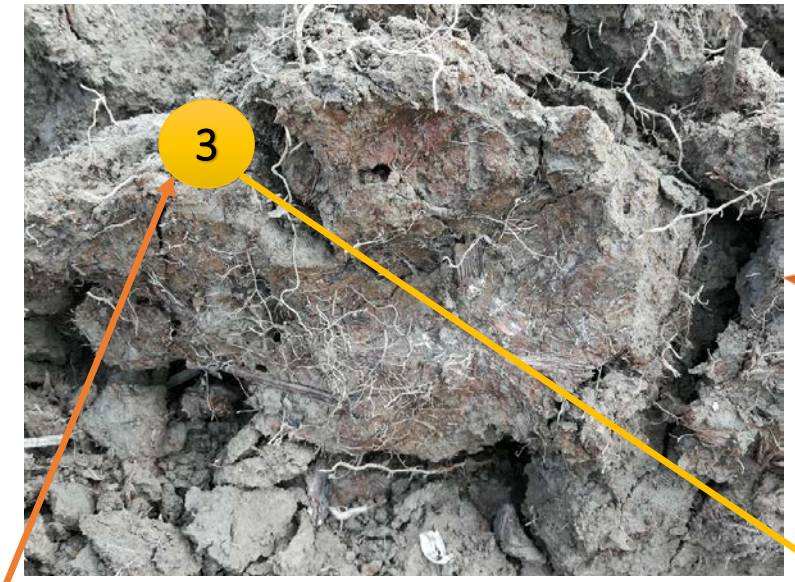
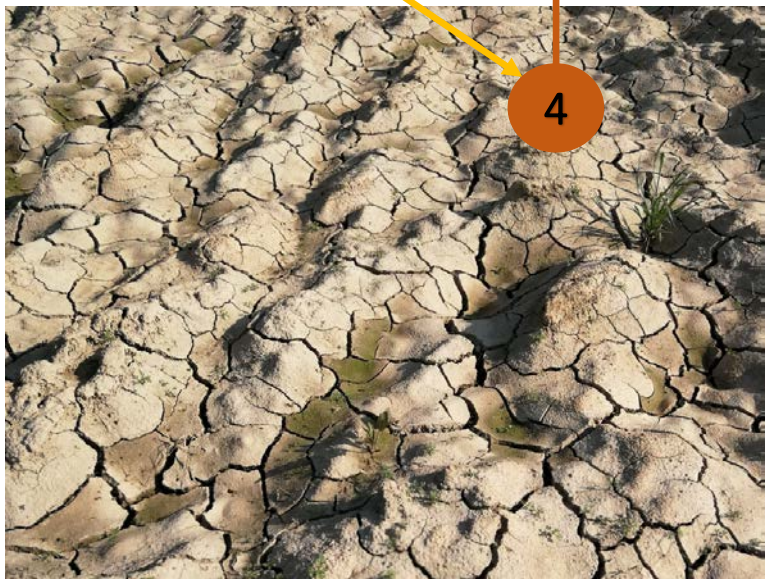
Schematic example



Soil degradation

Plowing



Inappropriate soil management – pathways to soil degradation

Facts about Intensive conventional agriculture – in short!

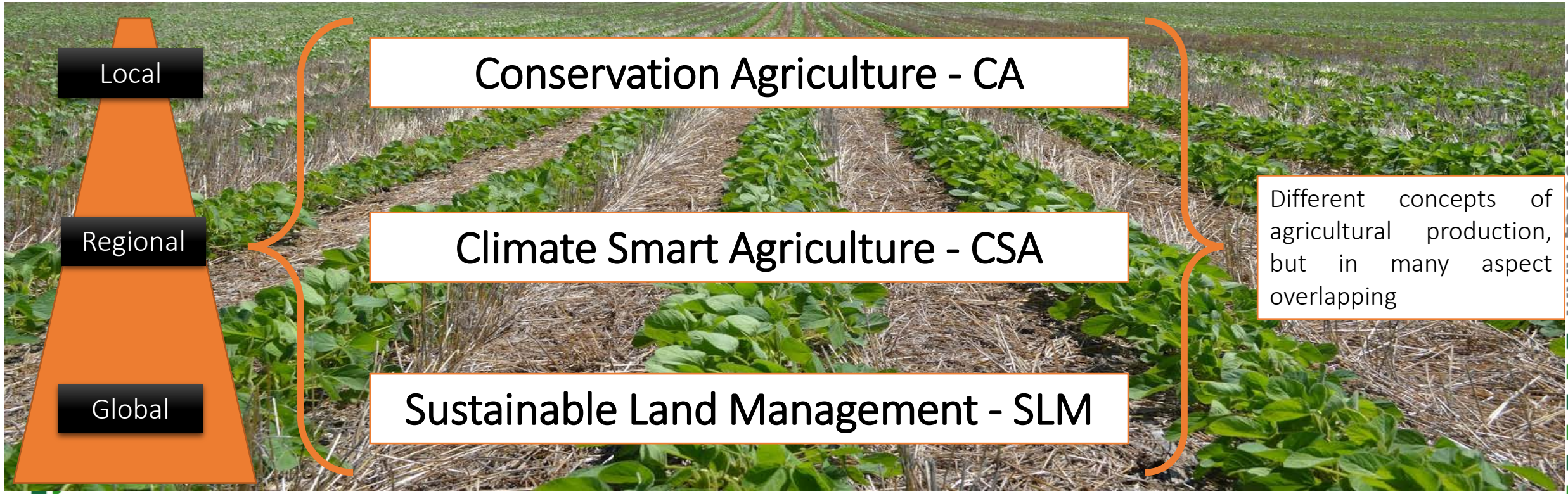
- Intensive conventional agriculture lead to soil quality degradation
- Degraded soil quality lead to reduction of soil production potential
- Decreased soil productivity potential decrease quality and quantity of food and feed production
- Decreased amount of food and feed production lead to another intensification of crop management (soil tillage, fertilizers…)

Intensive conventional agriculture = only conditionally and only temporary increase soil production potential !!!

...and what we do about that?

→ **Adaptation of crop production systems - strategy selection**

- The EU does not have a one unique dedicated strategy or a specific legal framework for soil degradation
- Aspects of soil degradation are addressed under various strategies, action plans and policies
- The economic cost of soil degradation is estimated by the EC to be in the order of tens of billions of €



Something about Conservation Agriculture [CA]

- (CA) is one of the best possible and one of the most effective way for prevention of soil degradation

CA includes three interrelated main principles as bases for successful agriculture production in relation to agro-ecological conditions (www.fao.org/ag/ca):

- minimal set of soil tillage treatments (minimal soil disturbance)
- permanent soil cover (with crops or crop residues)
- diversification in crop production (predominantly crop rotation)

CA also uses or promotes where possible or needed various management practices listed below:

- utilization of green manures/cover crops to produce the residue cover,
- no burning of crop residues,
- integrated disease and pest management,
- controlled/limited human and mechanical traffic over agricultural soils

Reasons for Conservation soil tillage - CST (main benefits):

- reduced wind erosion
- reduced water erosion
- erodible land brought into production
- increased options for multiple cropping
- improved soil moisture management (conserves)
- flexible timing for field operations
- improved soil structure
- better humus management
- carbon sequestration (increase OM)
- moderation of soil temperature
- saves fuel and labor
- changes weed dynamics
- improved soil biogenity
- generally: improved physical – chemical – biological properties of soil

Some negative effects of crop residues on soil surface (Conservation agriculture)

- intensified development of disease
- intensified development of pests
- potential difficulties in application of manure
- potential difficulties in application mineral fertilizers
- potential difficulties in soil preparation
- potential difficulties in sowing
- slower soil surface heating

Reasons for CST - modern principles of soil tillage imply as main:

- excluding mouldboard ploughing as necessary
- less soil tillage trafficking
- better organic matter (residue) management
- prevention to soil degradation (primarily soil erosion)
- shallow residue incorporation or their leaving on soil surface

Residue remains amount and permanent coverage with crop residues are very important and represent key question in CA

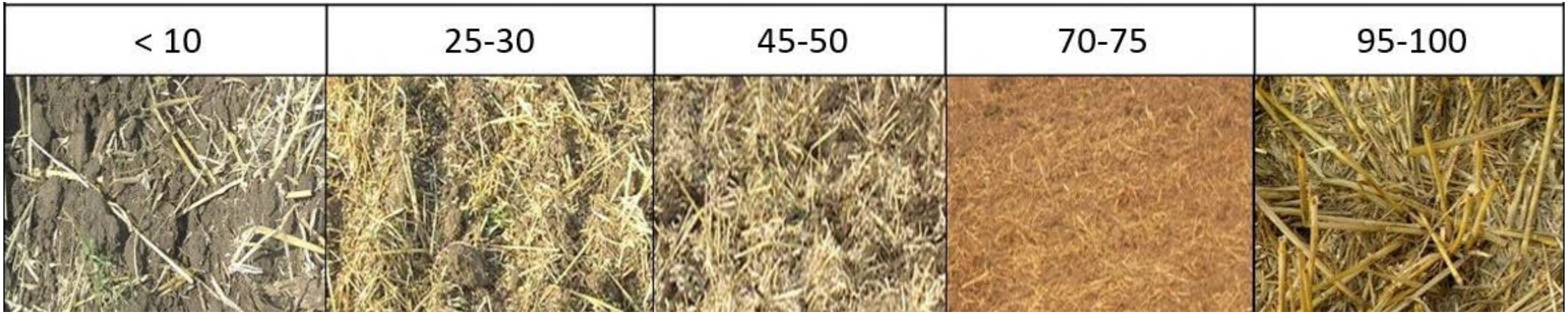
Best soil tillage systems in practice is tillage which provide the best (optimal) conditions for crop production with minimum of negative influence on soil state (conditions) adhering to the principles of sustainability

- **Conventional (intensive) tillage systems**
  - leave less than 15% crop residue cover or less than 550 kg/ha of small grain residue

- **Reduced tillage systems**
  - leave between 15 and 30% residue cover on the soil surface or 550 to 1100 kg/ha of small grain residue

- **Conservation tillage systems**
  - leave a minimum of 30% up to 100% of crop residue on the soil surface or at least 1100 kg/ha of small grain residue on the surface

% of crop residue on the soil surface - after tillage preparation for the next crops



Crop residues [CR] – what we know about it?

Crop residues: all mature plant residues after harvesting, including parts of plants above the ground and roots that remain in the soil:

- field crops (stems, leaves, spikes, pods)
- orchards
- vineyards

Historical (traditional) aspect: plant residues represent all useless agricultural plant waste that disturbs agricultural areas and prevents the smooth implementation of agricultural field works

Contemporary (modern) aspect: crop residues represent all agricultural high-value plant material, with potential economic and agroecological value

Competitiveness in the use of crop residues:

- bioethanol
- biogas
- industrial products
- fodder
- stable bedding
- carbon sequestration
- soil health and productivity

Crop residues - solution for healthier and more productive soils

Benefits for the soil

- increases soil productivity (higher yields)
- maintains the level of organic matter in the soil
- improves soil structure
- mitigates water and wind soil erosion
- increases water infiltration
- conserves soil moisture
- "recycles" plant nutrients
- provides habitat and food for micro- and macro-organisms

Benefits for the environment

- mitigates the conditions of over wetting (flooding) of the soil (preventing its runoff into watershed, i.e. loss)
- reduces surface runoff (and sediments loss)
- increases water quality by decomposition and filtering sediments
- reduces non-point pollution
- reduces the risk of hypoxia and anoxia (positive influence on living organisms)

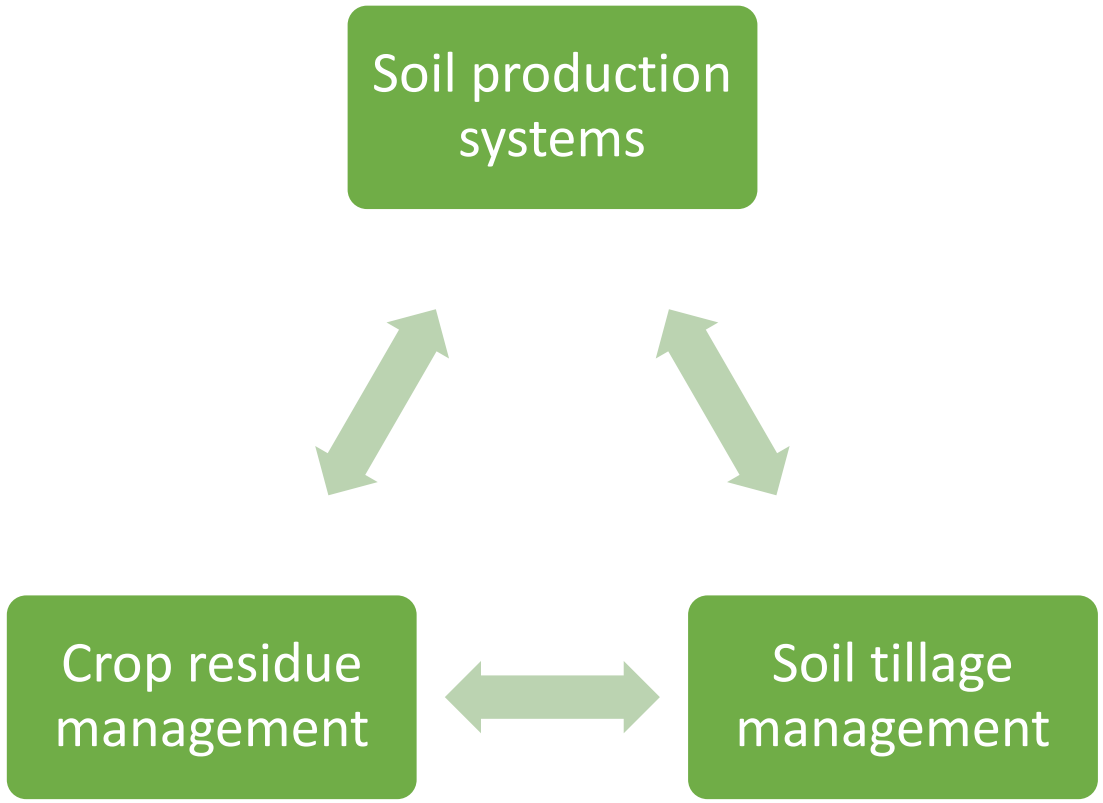
What we do and what do we have to do with CR?

Crop residues, due to the lack of manure and the limited use of green manure, today represent the most important source for soil organic matter build up

Negative tendency → use of crop residues for obtaining energy and for industrial purposes

The negative effects of inadequate (e.g. industrial) use of crop residues are as follows:

- Loss of sources for the supply of organic matter in the soil
- Delay in stubble processing due to the time required for baling and removal of straw bales from the cultivated area
- Deeper warming, greater loss of water, drying, and weakening of biological activity and workability of the soil
- Due to the deterioration of the soil condition, more energy is needed for basic autumn cultivation
- Uncovered, bare soil is exposed to stronger surface heating, the impact of strong rain, and siltation
- More damage by soil compaction (during baling and removal of bales)
- Greater damage from weeds
- Nutrient loss
- Other losses (increased maintenance costs of machines, greater need for mineral fertilizers and reduction of yields)



Basic procedures / measures with crop residues (different approaches):

- incorporation
- soil covering
- mulching (*on site* or *off site*)
- burning on the field
- livestock needs (feed, litter, bedding)
- removal for biomass energy production
- …..

Methods for measuring/assessment crop residues

Estimation of residue cover is primarily useful in planning field operations

Methods for estimation of residue cover need to be performed after all soil tillage operations and after sowing next crop or as for planning next cropping

Three basic methods for estimating percent of residue cover:

A. Line-transect method *[a]*
B. Photo-comparison method *[a]*
C. Calculation method *[b]*

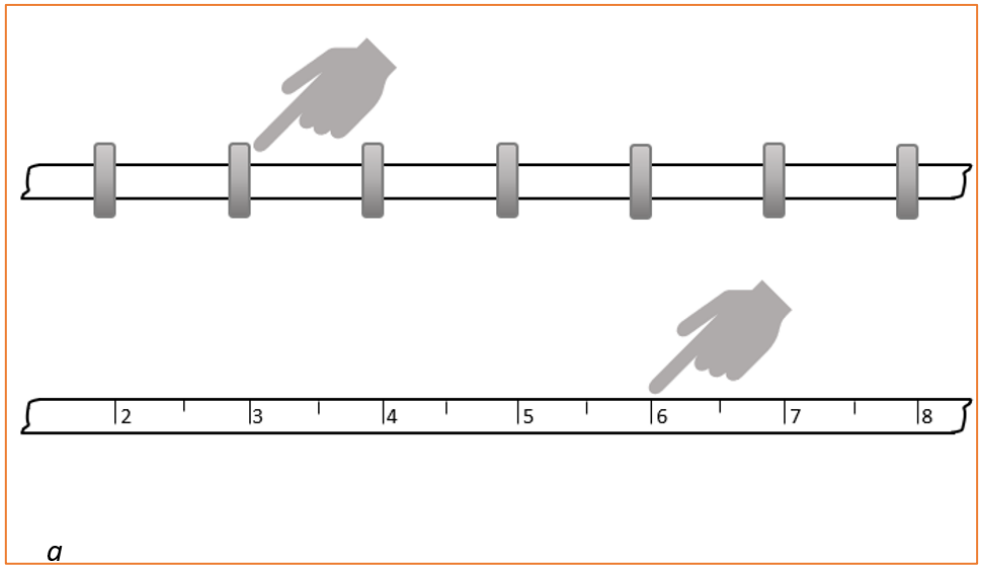
[a] include field observation, repeated measurements for the best averaged results

[b] requires generalizations and calculations, for conservation planning purposes

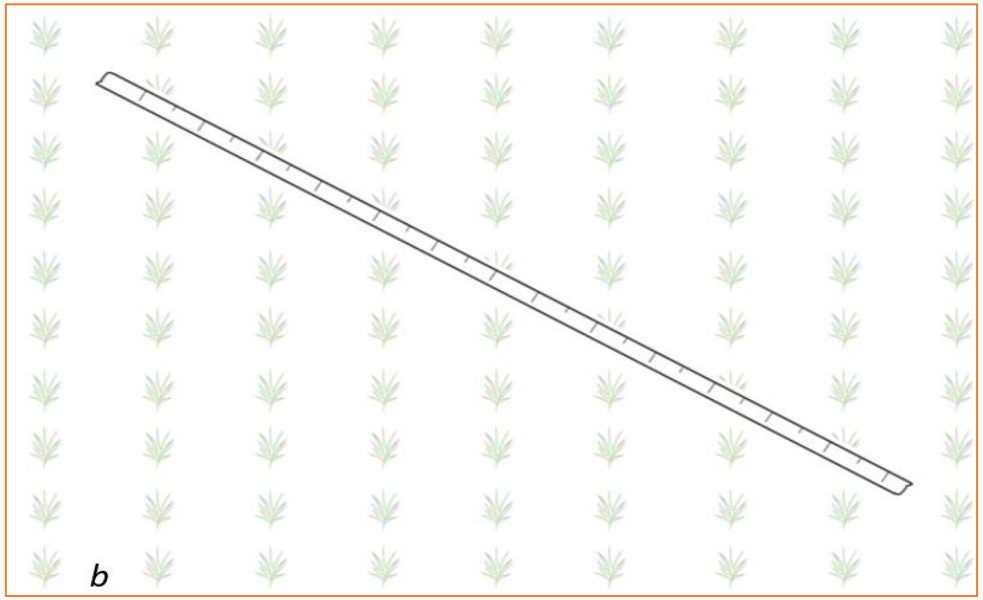
A. Line-transect method

Recommended procedure for using the line transect method:

- use line or tape with 100 points or marks
- stretch diagonally across the rows (representative area of the field)
- walk entire length of the line/tape
- count marks that intersect with residue
- use same point on each mark
- count only 3 mm and larger residue
- repeat at least four times
- average the count



a


b

Counting residue only on the same side of the point

Counting procedure:

- do not move the line while counting
- count residue only from the selected point at each mark
- count residue only from the one side of the line
- count only the large enough residue
- determine the percent residue cover

When using a line with 100 points, the percent residue cover is equal to the number of points under which residue is seen


7%


16%


21%


86%

B. Photo-comparison method

Possible ways to take a photo:

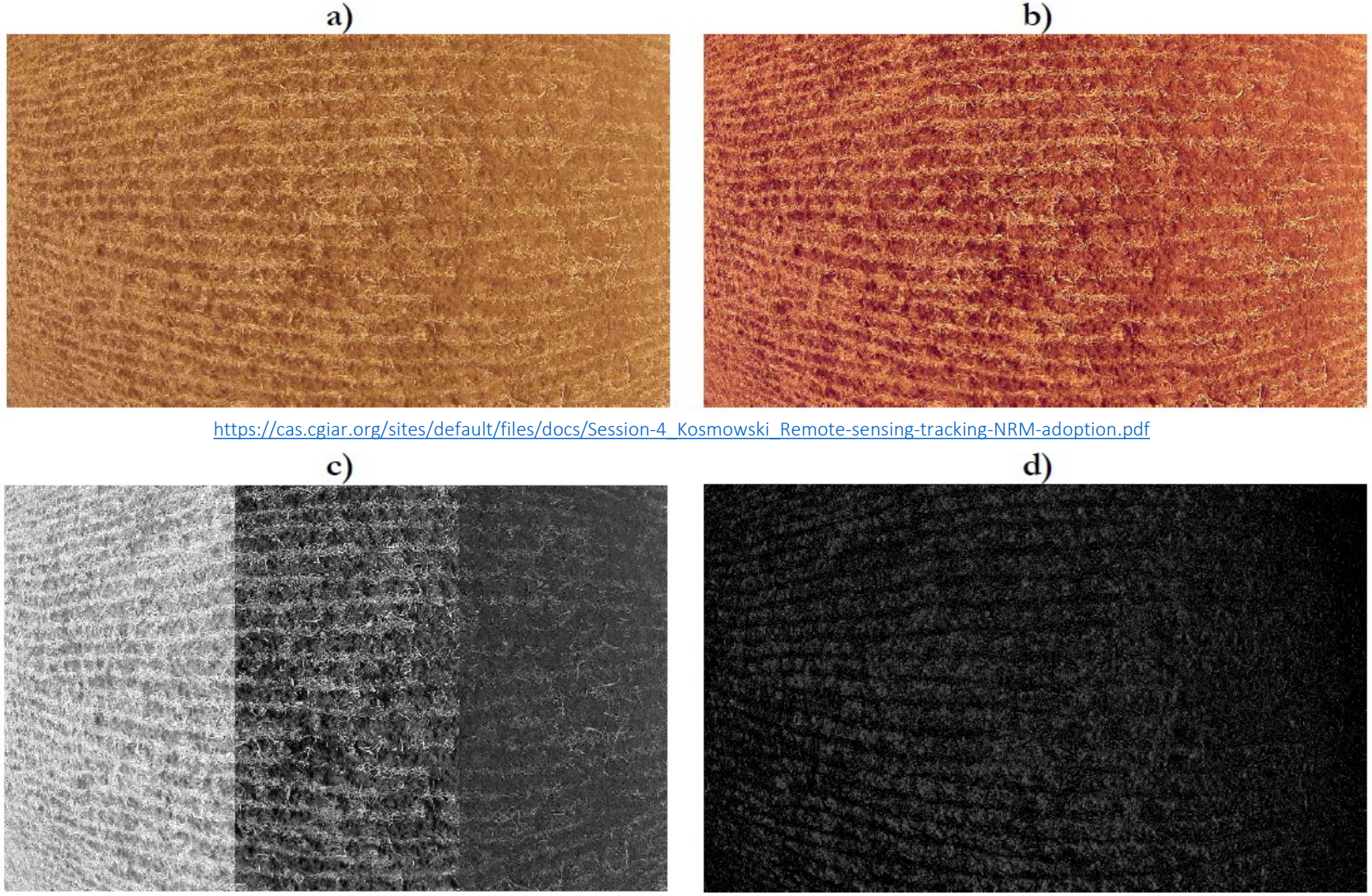
- geotagged photos (photo camera)
- spectral camera (drons)
- remote sensing (satelite high resolution images, radar polarimetry)

Possible ways to photo processing:

- scanning
- different software solutions

Residue segmentation image processing:

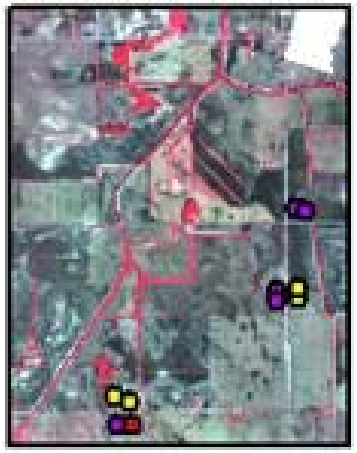
a) original field picture taken by a drone at a 25 feet altitude
b) color balance transformation
c) extraction of RGB components
d) segmentation result after application of the 2*G-R-B formula. Soil is represented in black pixels while residues are in white pixels



https://cas.cgiar.org/sites/default/files/docs/Session-4_Kosmowski_Remote-sensing-tracking-NRM-adoption.pdf

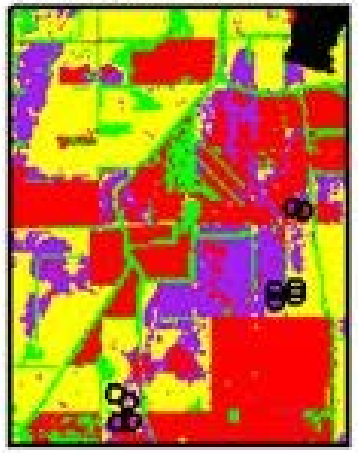
Examples of Spectral properties of soils and crop remains

False-color NIR



SINDRI

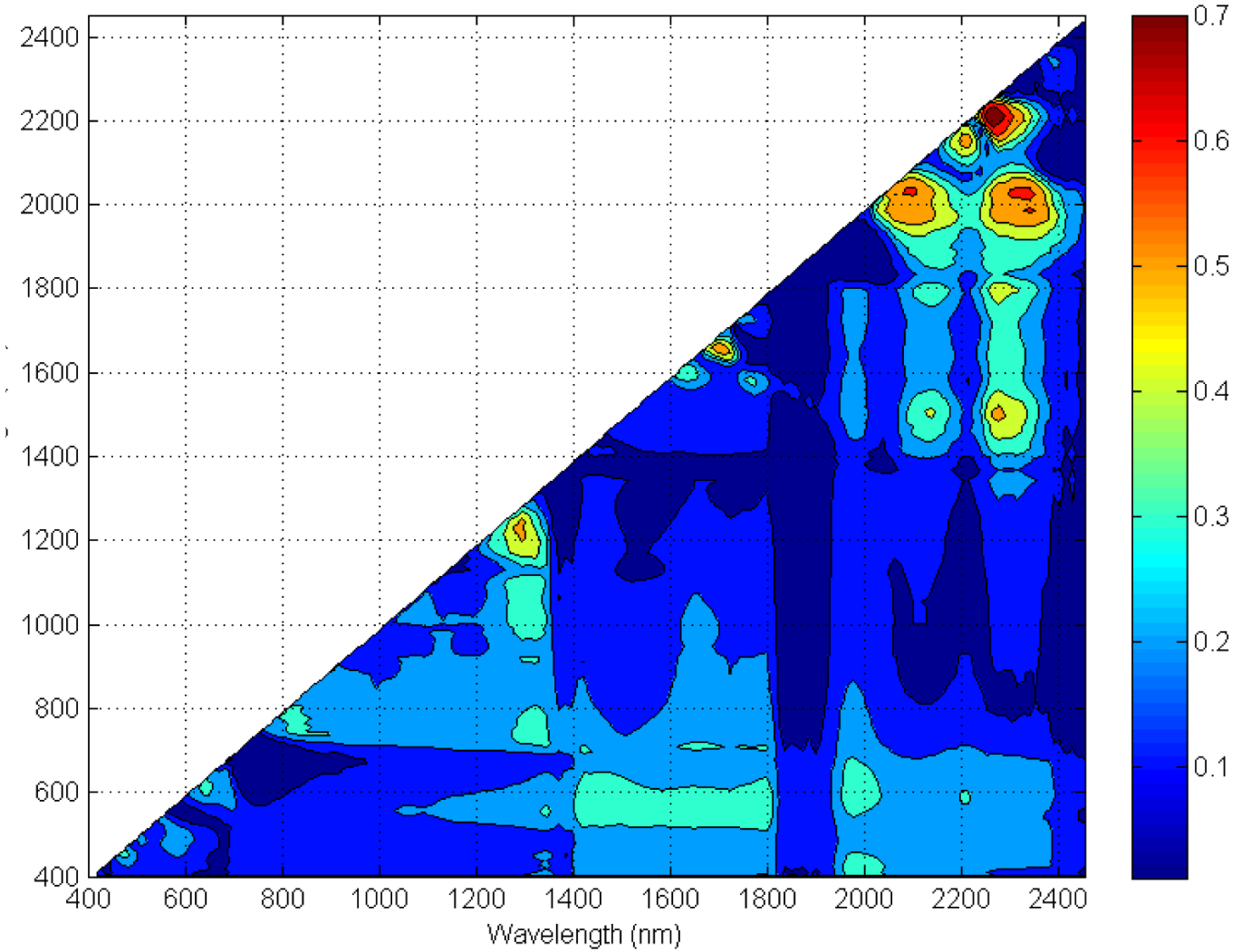
SINDRI classification



Legend

- No data
- Green vegetation
- Intensive-till
- Reduced-till
- No-till

0 700 1,400 2,800 Meters



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C. Calculation method

Influence of various field operations on surface residue cover remaining

Tillage and planting implements	Cover remaining after each operation
Moldboard plow	3 to 5%
Chisel plow	
Straight points	50 to 80%
Twisted points (disk chisel)	30 to 60%
Knife-type fertilizer applicator	50 to 80%
Disk (tandem or offset)	
7.5 cm deep	40 to 80%
15 cm deep	30 to 60%
Field cultivator	50 to 80%
Cultivator / disk combination tool	30 to 60%
Planter	
Smooth or no coulter	90 to 95%
Narrow ripple coulter (less than 3.5 cm flutes)	85 to 90%
Wide fluted coulter (greater than 3.5 cm flutes)	80 to 85%
Drills	
Disk openers	90 to 95%
Hoe openers	50 to 80%
Winter weathering	75 to 85%

Preconditions for application of Calculation method:

- calibration of every tillage operation according specific agroecological (site) conditions (type of machine, tillage technique, crop residue type)
- knowing the percentage of soil coverage with crop residues of pre-crops (using of other two methods)
- for the each tillage operation (Table) the lower percentage ranges should be used for fragile residues (e.g. soybeans), while the upper range corresponds to tougher residues (e.g. corn)

Example: To calculate final residue cover, multiply the associated percentages from Table

initial	x	weathering	x	chisel	x	disk	x	plant	=	final
90%		85%		80%		80%		90%		44%

Final remarks

- Soil tillage management (conventional, reduced or conservation) has direct and indirect effect on crop residue management
- Inadequate soil tillage approach (unsuitable technology) to crop production can resulted with many degradation processes
- Conservation soil tillage is one of the best possible solution to prevail many negative anthropogenic and natural influence of crop production on the soil
- Conservation soil tillage is most often defined as a crop production system where at least 30% of the soil is covered with crop residues
- Measuring/assessment of the amount of crop residue can be performed in several different ways, with prescribed appropriate methodology for each method
- There are three basic methods for measuring of crop residues: a) Line transect, b) Photo comparison and c) Calculation method, and a number of modifications and adaptations of these based methods
- Whichever method of measuring/assessment is used, it is essential for conservation soil tillage to ensure the best possible coverage of the soil surface with the crop residue

Thank you for your kind attention!!!

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