Sustainability assessment of different cropping systems

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Agrosystem and its interactions

Soil and its fertility should be one of the **main concerns** of the farmer as it is the basic internal part of an agrosystem and resource for field production. However, there are **many other influences** and connections in the system. And all of them **influence the soil too**.
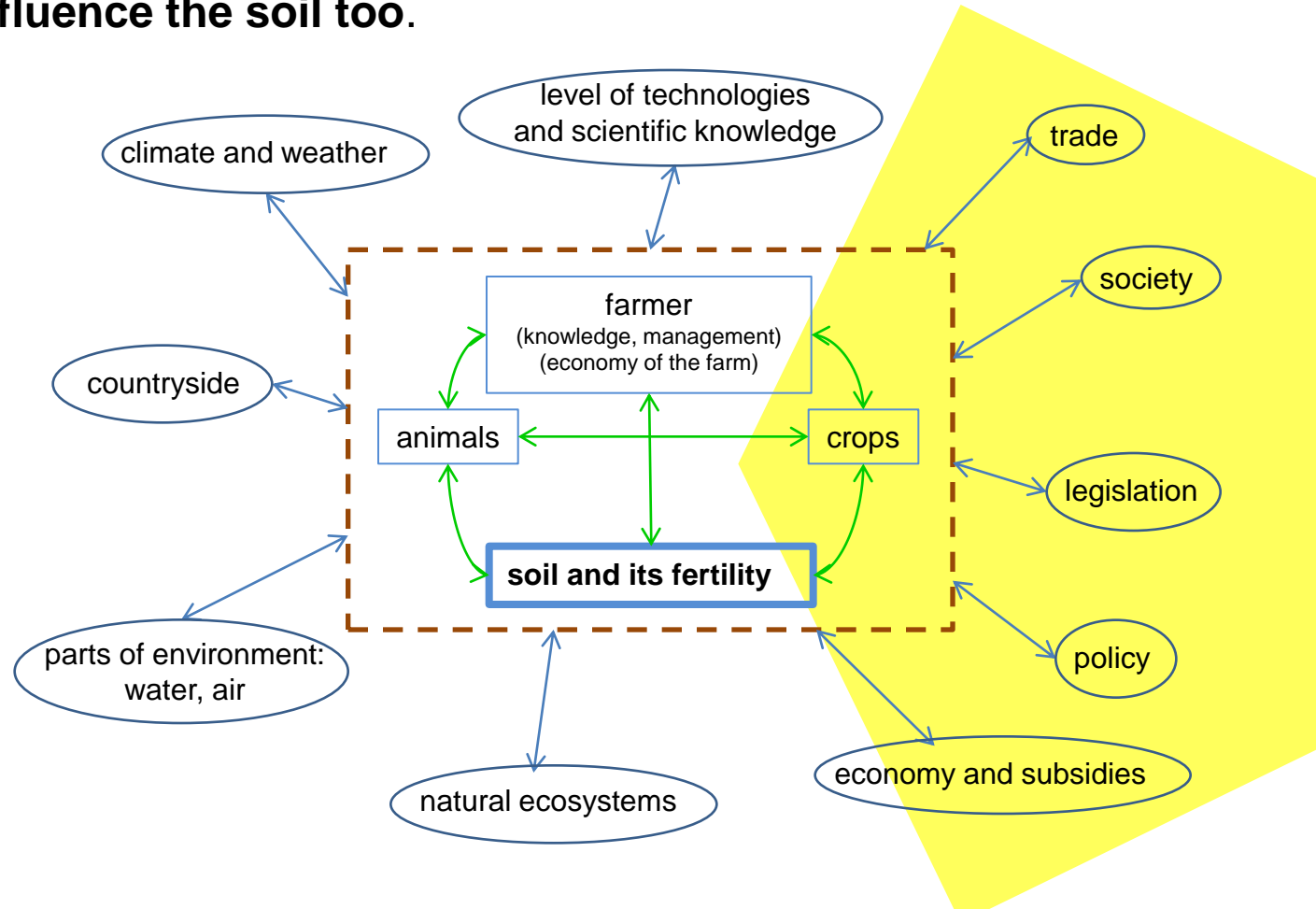
Main trends in the Czech agriculture

- **low inputs** in soil and crop management for a long time (since 1990),

- the **decrease in livestock** population after 1990, followed by lack of farmyard manures,

- a large part of the managed **land is rented**,

- a **larger size** of agricultural enterprises,

- **omitting fixed crop rotations**, decrease in areas of good preceding crops (sugar beet, potatoes, legumes and perennial forage crops), a considerable enlargement of areas planted with oil crops (rapeseed and poppy),

- higher **variation in yield** and production of the major crops in recent years
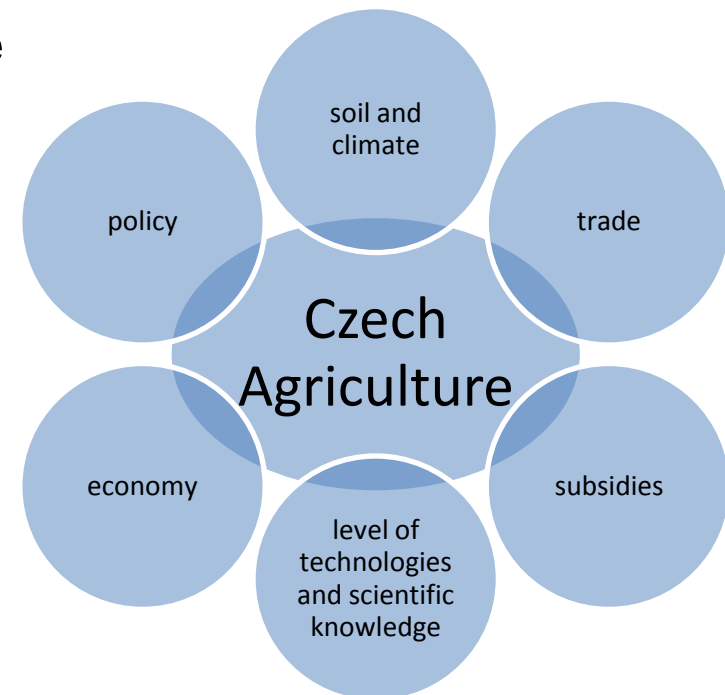
Consequent problems

Farm management was strongly simplified (specialized). It enables good economic provision for a relatively small group of people, mainly managers of the large farms, but it has a negative effect on other parts of the national economics:

- increase of area with **low content of nutrients** (P, K, Ca and Mg) in soil and **acid pH**
- problems with **soil organic matter** balance
- decrease of the **employment** rate in agriculture and rural areas
- **unbalanced production** of the agricultural commodities, which leads to decrease in food self-sufficiency and negative balance of the agrarian trade

- This situation can be seen on individual farms to a different extent. But the **farm level is the appropriate one to work with to improve the situation**.
- As the consequence of the current situation given mainly by agricultural subsidies but also other influences, two main farm types aiming to profit from current conditions can be defined:
  - large cereal and rape seed farms on arable land without animal production,
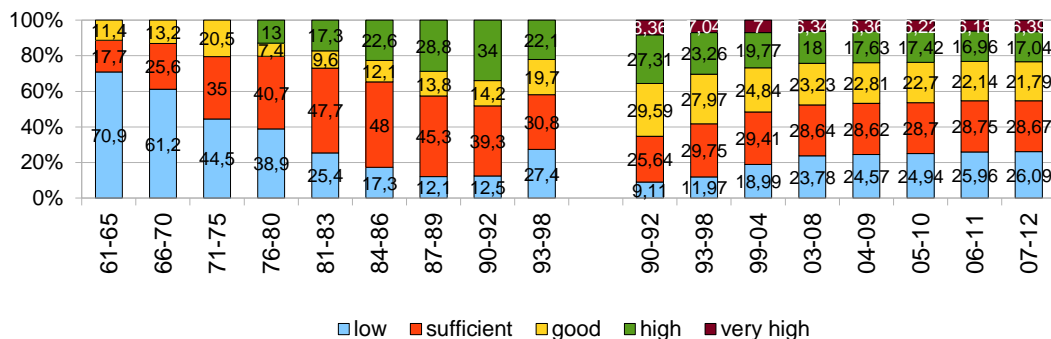 - large "range" farms on the grassland with beef cattle.

Average flow of nutrients (kg/ha) into soil by fertilization in the CR
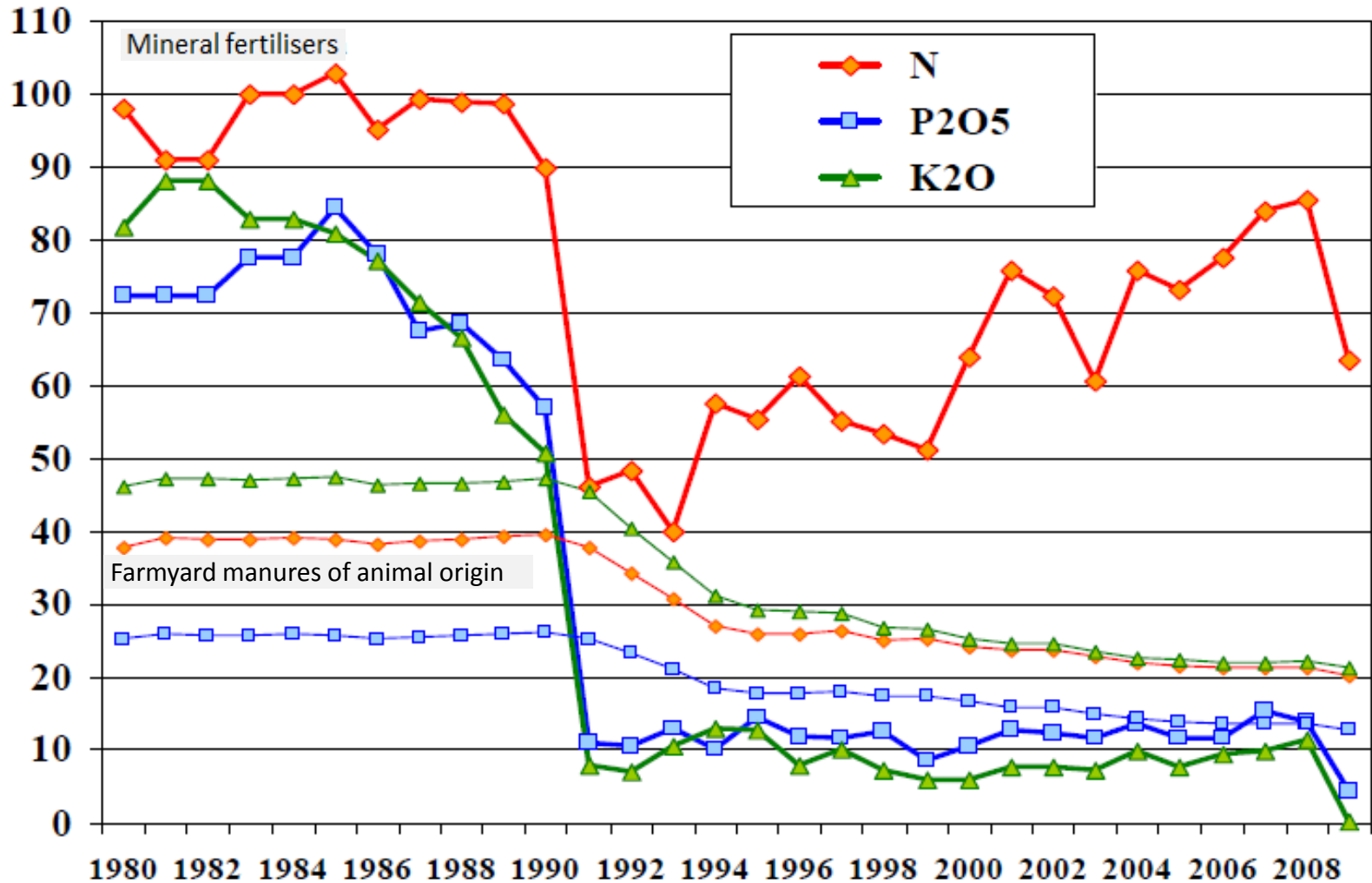
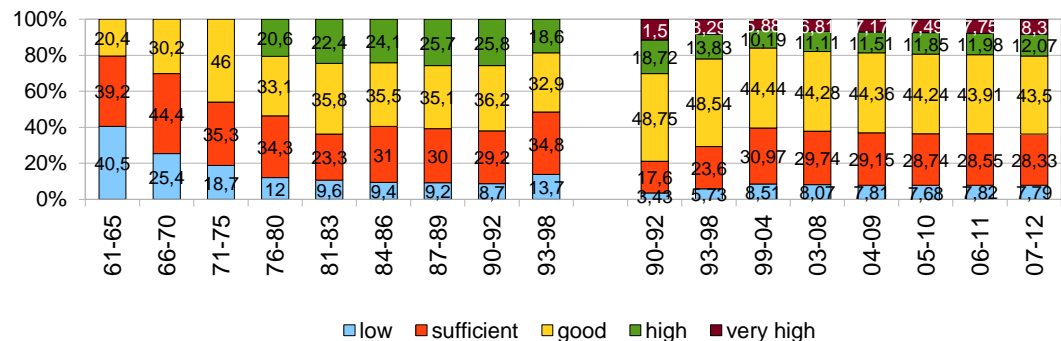Source: MZe (mineral fertilizers); CZSO (farmyard manures – in excrements)

Development of nutrients content in soil

Content of available P in soil
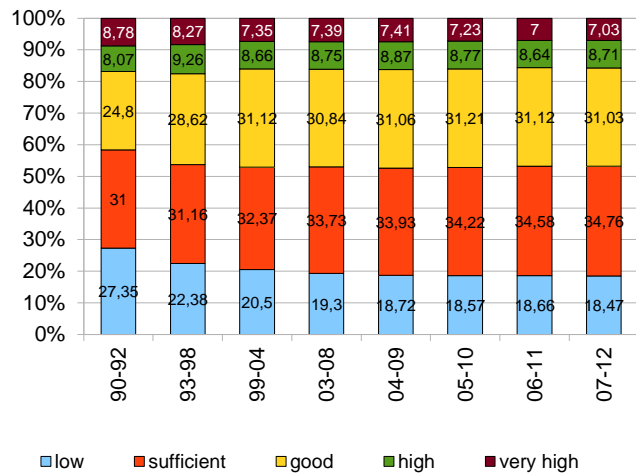

Content of available K in soil

Poznámka: Data jsou rozdělena na dvě části, protože se změnila metodika AZZP a kategorizace půd do skupin zásobenosti. Před mezerou jsou data dle staré metodiky a kategorií, za mezerou nová (současná).
Zdroj: Situační a výhledová zpráva Půda 12/2012, Výsledky arochemického zkoušení zemědělských půd
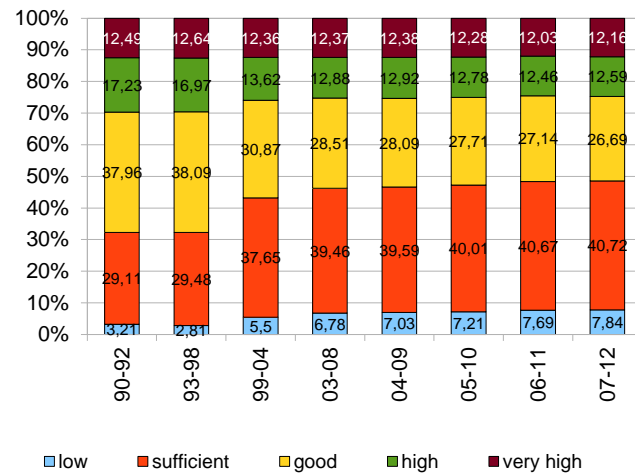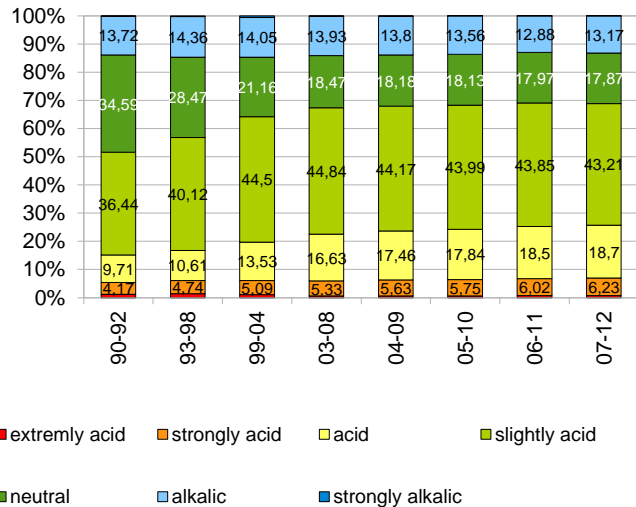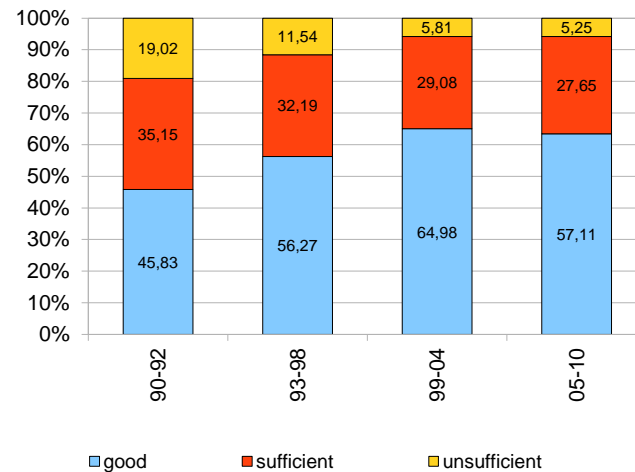
Content of available Mg in soil

	90-92	93-98	99-04	03-08	04-09	05-10	06-11	07-12
very high	8,78	8,27	7,35	7,39	7,41	7,23	7	7,03
high	8,07	9,26	8,66	8,75	8,87	8,77	8,64	8,71
good	24,8	28,62	31,12	30,84	31,06	31,21	31,12	31,03
sufficient	31	31,16	32,37	33,73	33,93	34,22	34,58	34,76
low	27,35	22,38	20,5	19,3	18,72	18,57	18,66	18,47

□ low ■ sufficient □ good ■ high ■ very high

Content of available Ca in soil

	90-92	93-98	99-04	03-08	04-09	05-10	06-11	07-12
very high	12,49	12,64	12,36	12,37	12,38	12,28	12,03	12,16
high	17,23	16,97	13,62	12,88	12,92	12,78	12,46	12,59
good	37,96	38,09	30,87	28,51	28,09	27,71	27,14	26,69
sufficient	29,11	29,48	37,65	39,46	39,59	40,01	40,67	40,72
low	3,21	2,81	5,5	6,78	7,03	7,21	7,69	7,84

□ low ■ sufficient □ good ■ high ■ very high

pH on arable land

	90-92	93-98	99-04	03-08	04-09	05-10	06-11	07-12
alkalic	13,72	14,36	14,05	13,93	13,8	13,56	12,88	13,17
neutral	34,59	28,47	21,16	18,47	18,18	18,13	17,97	17,87
slightly acid	36,44	40,12	44,5	44,84	44,17	43,99	43,85	43,21
acid	9,71	10,61	13,53	16,63	17,46	17,84	18,5	18,7
strongly acid	4,17	4,74	5,09	5,33	5,63	5,75	6,02	6,23

■ extremly acid ■ strongly acid □ acid ■ slightly acid
■ neutral □ alkalic ■ strongly alkalic

K:Mg ratio on arable land

	90-92	93-98	99-04	05-10
unsufficient	19,02	11,54	5,81	5,25
sufficient	35,15	32,19	29,08	27,65
good	45,83	56,27	64,98	57,11

□ good ■ sufficient □ unsufficient

Zdroj: Situační a výhledová zpráva Půda 12/2012 a Výsledky arochemického zkoušení zemědělských půd

Organic matter balance calculation
Average of Czech arable land

Source of OM	1991		2001		2011	
	t/ha	%	t/ha	%	t/ha	%
Crop residues	2.5	52	2.5	47	2.4	43
"Straw"	1.0	20	2.1	40	2.5	44
Manure	1.4	28	0.7	13	0.7	12
Total	4.9	100	5.3	100	5.6	100

Soil erosion

Water erosion threat	Very slight	Slight	Medium	Strong	Very strong	Extreme
Soil loss [t.ha^{-1}. year^{-1}]	> 1,5	1,6 - 3,0	3,1 - 4,5	4,6 - 6,0	6,1 - 7,5	7,5 <
Percent of agricultural land	3	26	25	17	11	18
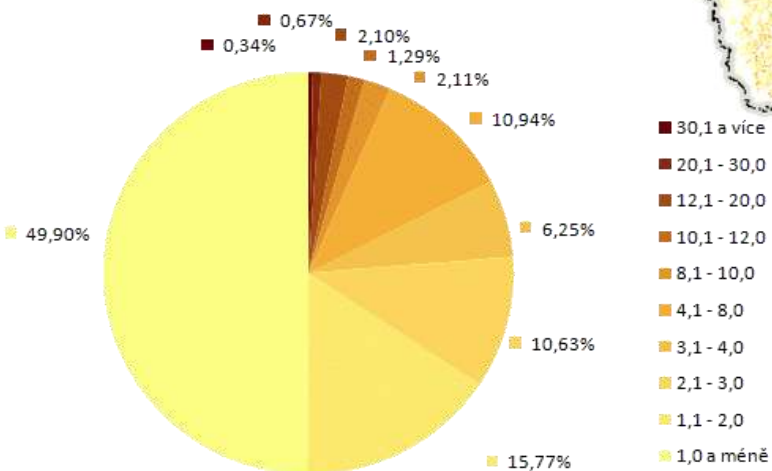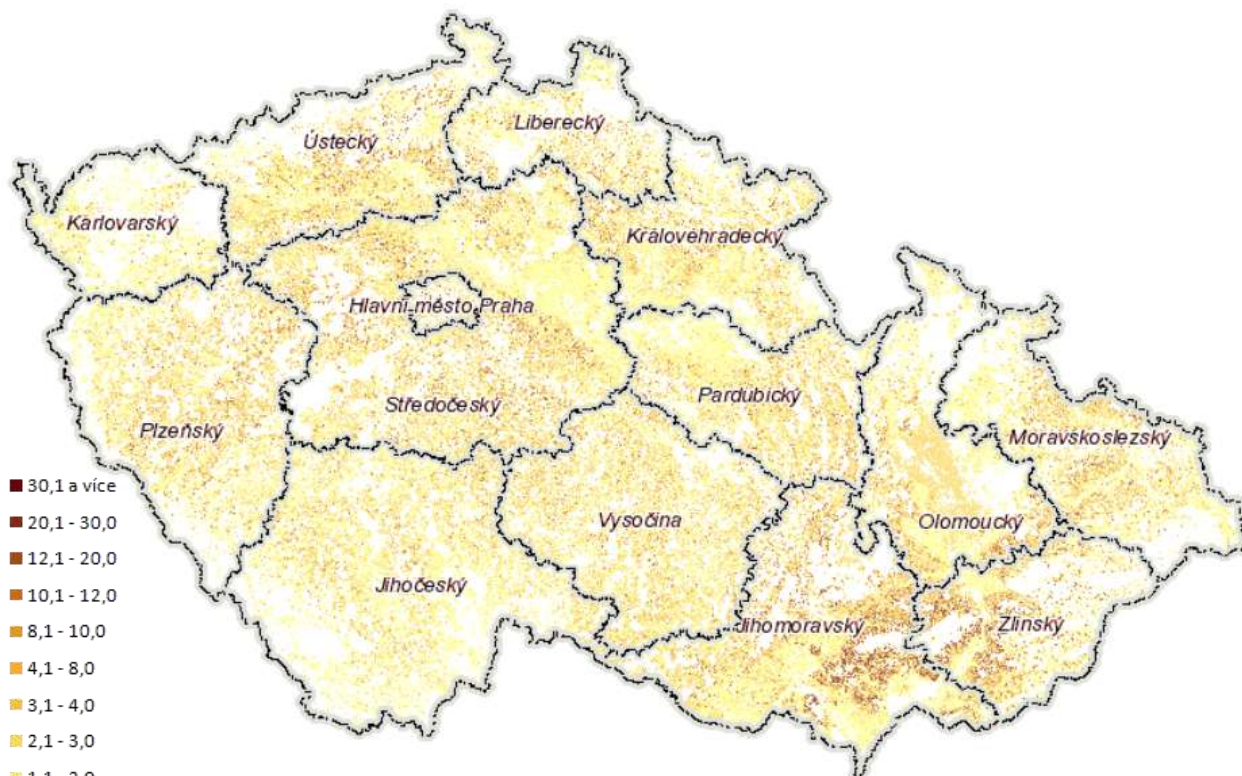
Development of the crop structure (% of total sowing area) 1920-2012
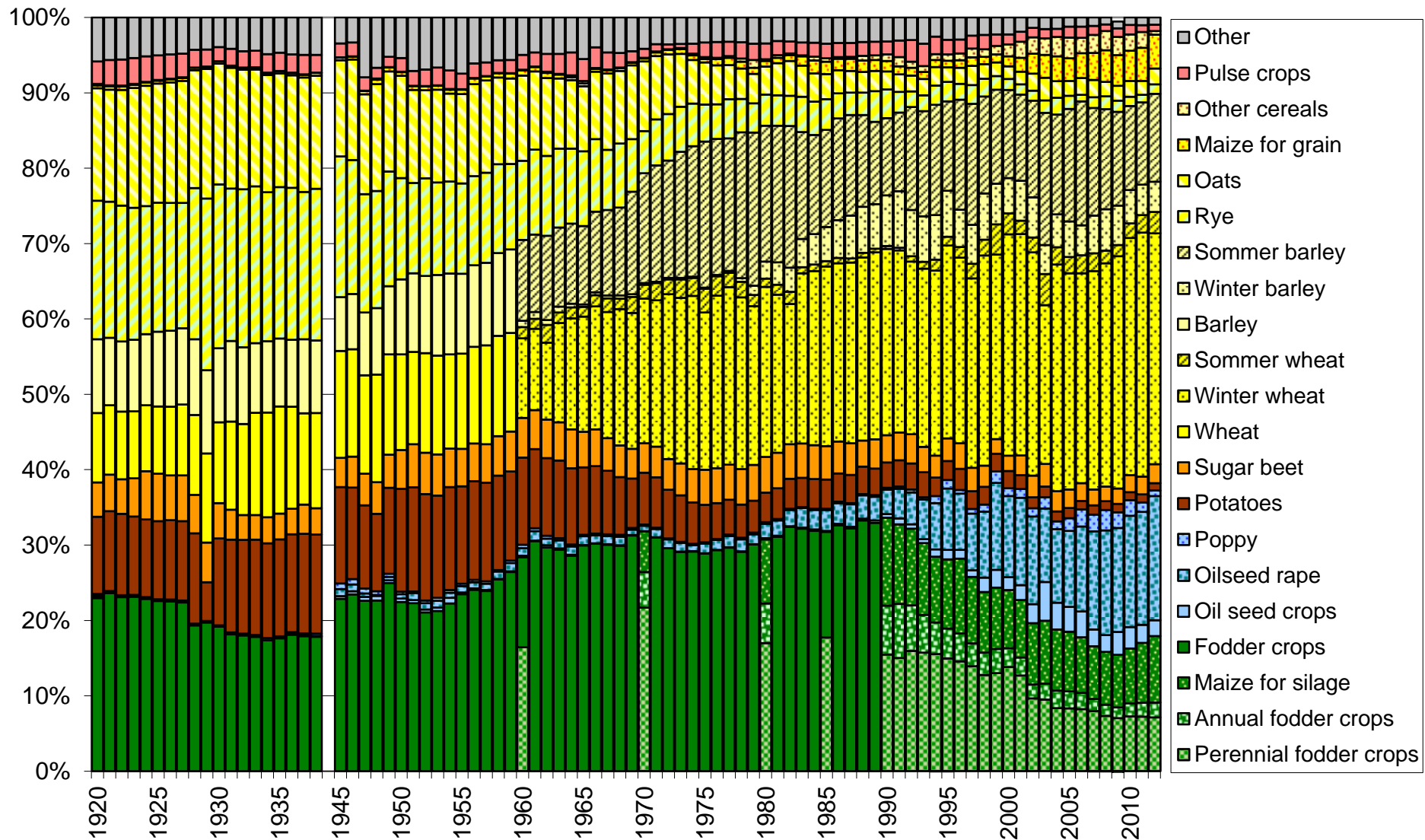
Development of production level
# of the Czech arable farming (cereal units / ha)
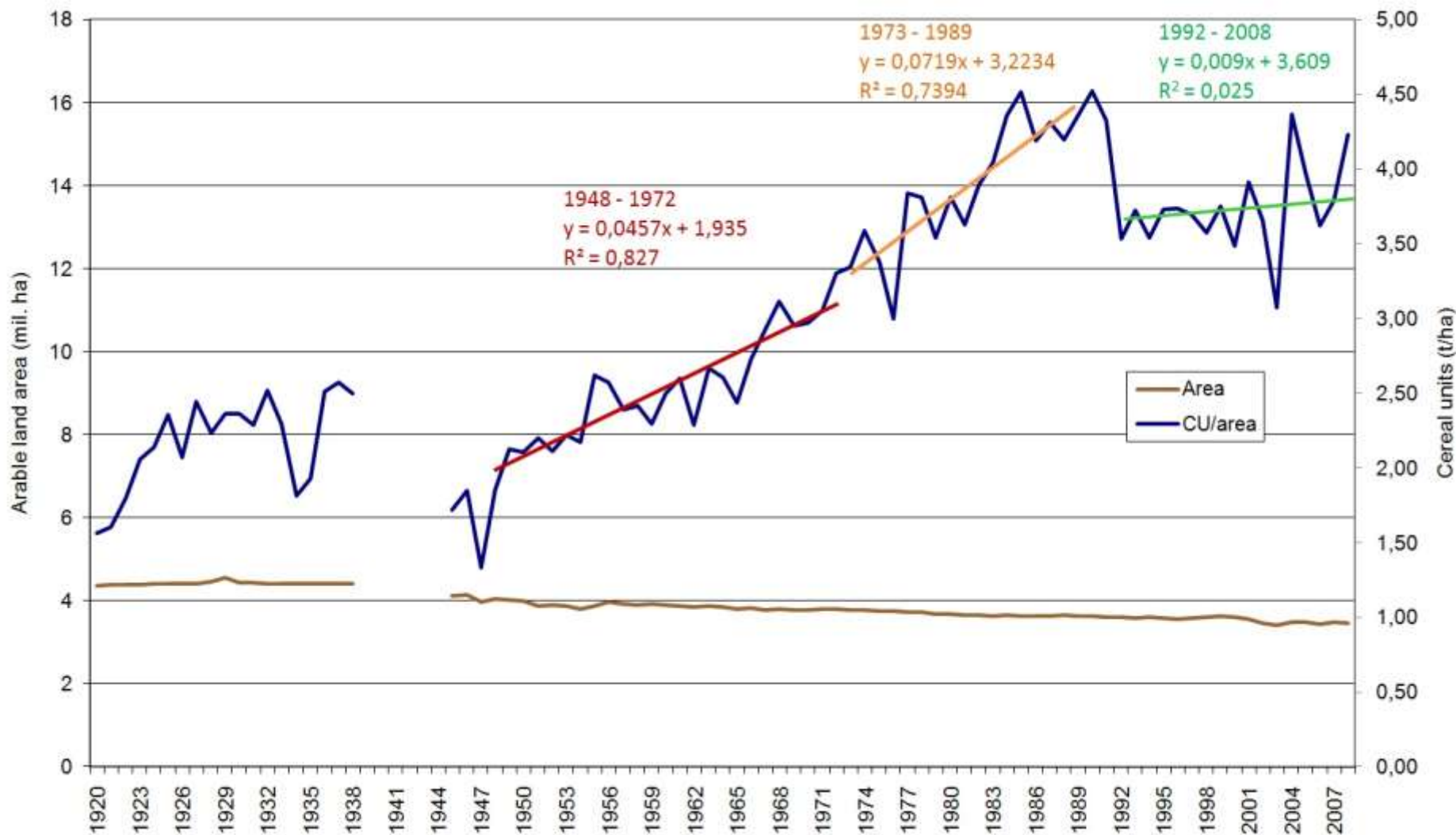
- Because behavior of farms is given by economic conditions and **economic optimization** is preferred to the agronomic one, it is **difficult to apply complex measures** to change the situation on farm level.

- **Single simple measures are more acceptable** for practice (soil cultivation technology, plant protection technique etc.). Lot of these single measures are **in conflict with each other** (incorporation of crop residues into the soil from the viewpoint of crop protection end erosion prevention).

Farm and cropping system assessment

- All the demonstrated trends and problems are in relation to the soil fertility and level of care it is provided by farmer.

- Soil fertility is result of whole complex of farming and cropping system applied on the farm.

- There is a tool to assess the cropping system as a whole using set of indicators (Sagros methodology).

Used indicators:

N balance (kg/ha)	0–50
P balance (kg/ha)	-5–5
K balance (kg/ha)	-20–20
OM balance (%)	-90–110
Crop diversity	1,5
Soil cover index	>0,6
System productivity (GU/ha)	
Energy intensity (MJ/GU)	<200
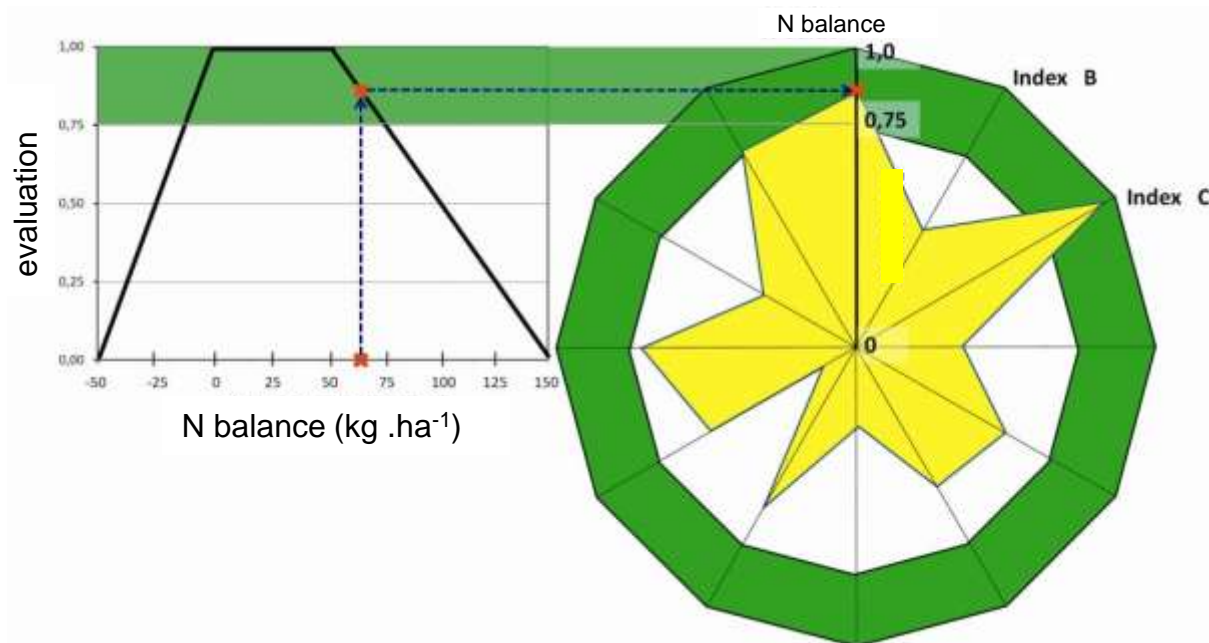
Intensive specialized arable farm

F1

- 492 ha
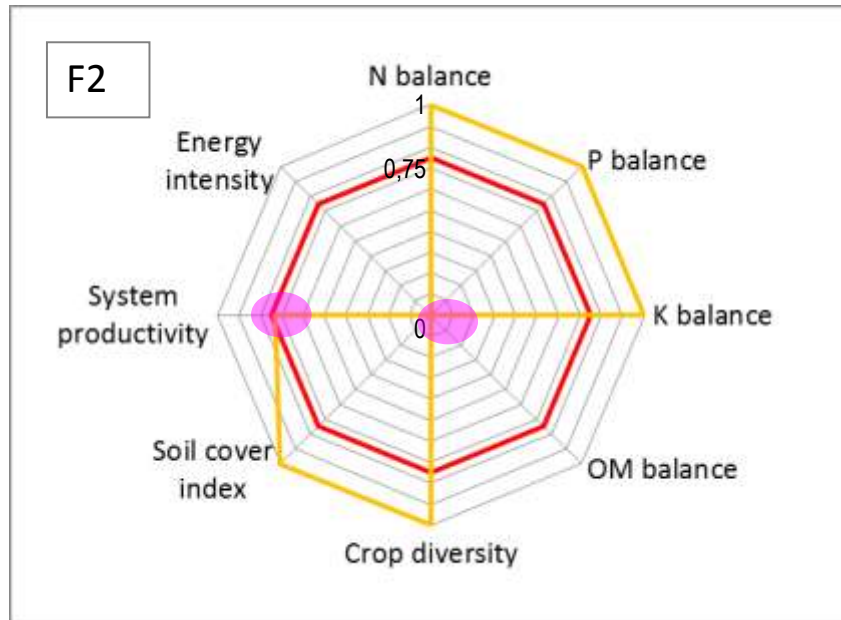- No animals
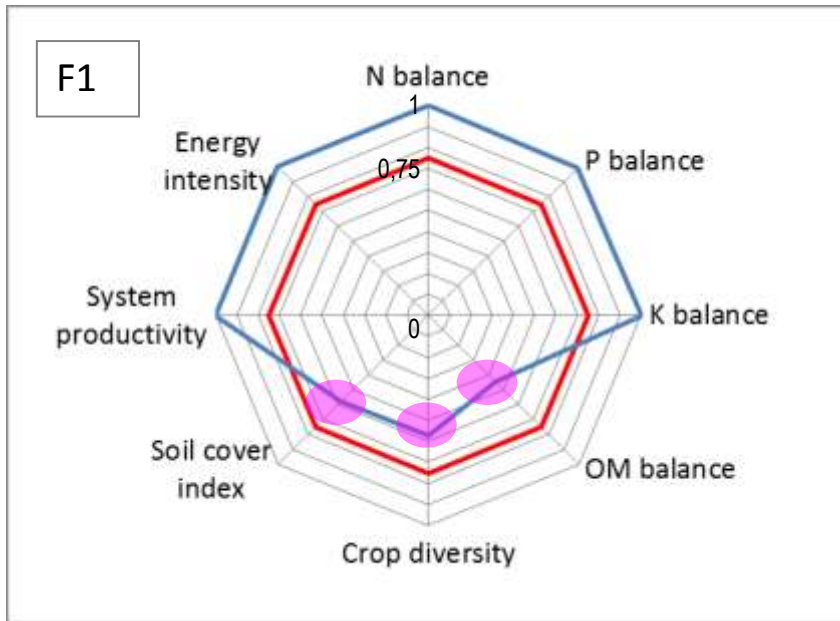
- This type of farming is common in productive regions of the CR. Because 78 % of the agricultural land is not owned by farmers who manage it, it is exploited without a proper care in many cases, and farming of this first type can have negative effects on soil fertility as well as on employment rate in rural areas.

Mixed farm in medium conditions


F2

(Radar chart axes: N balance, P balance, K balance, OM balance, Crop diversity, Soil cover index, System productivity, Energy intensity; scale 0, 0.75, 1)

- 2200 ha (600 ha AL, 1600ha GL)
- 0.35 LU/ha

- The focus of production of this farm enables agrosystem simplification with low intensity of the animal production (0.35 LU/ha) and a low number of employees who are able to manage a relatively large area (2200 ha). The number of the cash products is relatively narrow (milk, beef, oilseed rape) and their production per hectare is low as well.

- The positive economic result is reached by receiving subsidies (direct payments) while employing a few workers and paying low rent for land.

Mixed farm in hills, organic
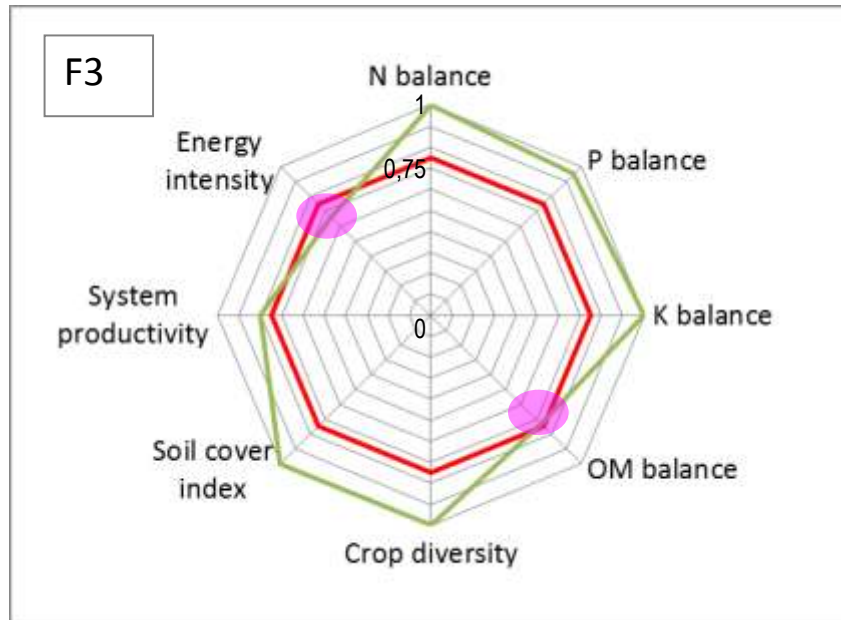
- 1817 ha (432 ha AL, 1385 ha GL)
- 0.34 LU/ha

- This farm is a good example of a farm in hills with lower intensity of production due to geographic conditions in the area.

- Current situation enables to combine subsidies for organic agriculture and grassland which is significant part of farm income. Lot of farms in the CR are of similar type but specialised solely to beef cattle on grassland. This even improves economic situation of such farms which have minimum costs and significant income from multiple subsidies. This results in the current situation when the CR has one of the highest proportions of the organic land (ca 12 %) but only very limited organic production on arable land. This again points to the simplified agrosystems which does not fulfil the declared benefits of organic farming (higher system heterogeneity, higher employment rate).

- Farm structures and their typical management is the result of the farmer's behavior under conditions given by the rules for subsidies and on mostly rented land.

- The presented analysis is the first step to work with the farms, basis for the optimisation process where the identified week points should be improved by changes in farm management.

- It is important to find such **modifications** of the management which are **economically sound** for the farmer and **find motivation** to improve the agrosystem not only in economic but also in agronomic, ecological and social indicators.

Conclusions

- On the background of the **economic and legal conditions** it is possible to identify **major cropping systems** utilized in the Czech republic and **their main problems regarding sustainability** of these managements.

- To improve situation, it is necessary to
  - search for solutions on the **farm level**
    in single parts of the system but keeping complexity and all the interactions in the mind
  - prepare appropriate **legal and subsidies rules** for right motivation of farmers

- Current problems of agriculture are more linked to the system of subsidies and management decision-making than to the level of the research and implementation of its results.

- Research evaluation system is not directly linked to the use of results in practice.

- Interconnection of applied research with practice is missing.

Acknowledgement

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Thank you for your attention.