Institute of Soil Science and Plant Cultivation-
State Research Institute

An assessment of emission factors for various agricultural practices including typical crop rotation and modifications

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The Institute of Soil Science and Plant Cultivation is the largest and the oldest research-development centre in Poland (1862), conducting agricultural studies under the supervision of the Ministry of Agriculture and Rural Development.

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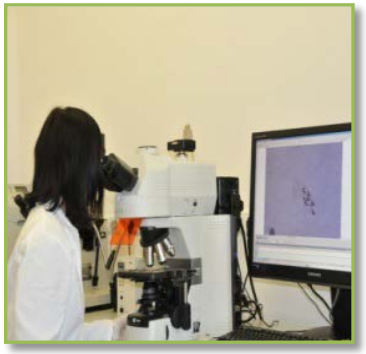
The main research topics of IUNG

- Soil science and the assessment of natural agricultural production conditions;
- Fertilisation management of soil fertility and fertiliser use;
- Soil tillage and crop rotation management;
- Production of cereals and fodder crops;
- Analysis of various types of agricultural farming systems;
- Aspects of agriculture biotechnology, microbiology and plant photochemistry;
- The impact of farming on the environment;
- Adaptation of agriculture to climate change;
- Development of knowledge and technologies for reducing atmospheric greenhouse gas concentrations through the management of agricultural emissions and carbon sequestration.







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Strengthen IUNG's proficiency on **"Managing the Production of Food and Feedstuff, their Safety and Quality under Global Climatic Change" ProFiCienCy**

The main objective of the *PROFICIENCY* project is to strengthen IUNG's excellence in fostering technological, human and partnership capacities. IUNG ambitions are to adopt a totally integrated interdisciplinary approach in around four main research areas related to agriculture, which are defined as priorities by the Institute as:

1) Land Use.
2) Soil Quality.
3) Production Systems and Techniques.
4) Plant Products Quality and Safety.

The Common Agricultural Policy (CAP) of European Union after 2013, is going to be an instrument to reduce the impact of climate change on agriculture (climate change mitigation) and at the same time have to give the opportunity to support farm production in adaptation to the climate change (adaptation to projected climate changes).

Rural Development Programme (RDP) is to provide programs for mitigation and adaptation activities beyond the requirements under so-called "Greening"

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Polish agricultural land is representing approximately 50% (15.5 million hectares) of the country:

69% (10.5 million hectares) -arable crops,
21% (3.2 million hectares) -permanent grassland,
2.3% (0.3 million hectares) -orchards.

The largest area of field crops -winter wheat (2 million hectares),
- triticale (1.5 million ha),
-rye (1.4 million ha),
-spring cereals (1.3 million ha),
-spring barley (0, 9 million hectares),
-rape seed (0.8 million ha)
-maize (0.7 million).

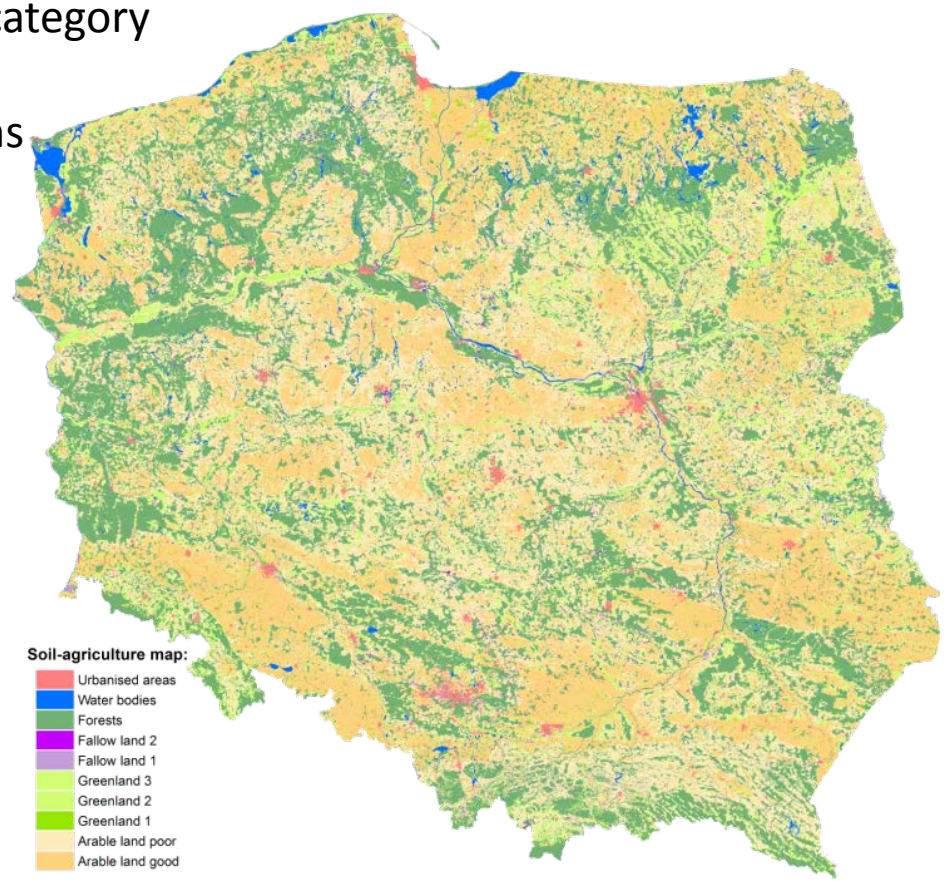
In the past decade have significantly increased the acreage of **rape**, **triticale** and **corn**, and decreased surface of **potatoes, wheat** and **sugar beet**.

The most important livestock is **beef and dairy** (46%), **pigs** (39%) and **poultry** (22%).

As a variables digital version of the agricultural soil map and meteorological data were used.

The agricultural soil map

Based on information about a particle size of soil, reclassification of map was done in four categories of agronomic soils: heavy, medium, light and very light. Knowledge of the contribution of each soil category in the regions allowed the development of scenarios to support the agronomic solutions that deliver environmental benefits in the region of use.



Meteorological data:

20 years of meteorological data series (T min, T max, precipitation, radiation). Daily weather data came from a database JRC-EC Ispra and represented centrally located grid node in each region.

The crop rotation and field management models were developed by taking into account the specificity of the standard crop rotation structure described by the Central Statistical Office - Statistical Yearbook of Agriculture 2010.

Crop rotation A – as a standard rotations with full tillage, mineral nitrogen fertilisation incorporation of crop residues but only those that are not collected from the field. This option is specific to arable farms, which are estimated for approximately 40% of all farms

Crop rotation B - standard rotation with winter catch crop which is introduced once a rotation and mineral fertilisation

Crop rotation C - standard rotation with winter catch crop with mineral fertilisation. plus all crop residues left on the field and reduced tillage (10 cm disc harrow)

Crop rotation D - standard rotation with ploughing with mineral fertilisation and the use of 25 Mg ha^{-1} manure once at crop rotation (about 170 kg N ha^{-1}). This option is specific to farms with livestock production

Crop rotation and fertilizer doses (kg ha^{-1})

Soil category	1	2	3	4	5
	Dolnoslaskie region				
Light	Oat (70)	Rye (70)	Rye (70)	-	-
Medium	Maize (140)	Spring barley (60)	Rapeseed (140)	Winter wheat (90)	Winter wheat (90)
Heavy	Sugar beet(120)	Spring wheat (70)	Rapeseed (140)	Winter wheat (120)	-
	Kujawsko-pomorskie region				
Very light	Potato (120)	Triticale (90)	Rye (70)	-	-
Light	Maize (120)	Spring barley (70)	Triticale (90)	Corn mix (70)	-
Medium	Rapeseed (140)	Wheat (90)	Wheat (90)	-	-
	Lubelskie region				
Very light	Potato (120)	Triticale (90)	Rye(70)	-	-
Light	Spring barley (70)	Triticale (90)	Corn mix (70)	-	-
Heavy	Sugar beet (120)	Maize (140)	Spring wheat (70)	Winter wheat (90)	Spring barley (70)

*manure at 25 tonnes per hectare was used in the first year of crop rotation.
*winter catch crops were planted in the final rotation year, sown before 15.09 and fertilised with 30 kg of N per hectare;
*an additional dose of N for winter catch crop as well as for cereal staw - 60 kg N was ploughed in;
*rape straw, corn, leaf sugar beet and potato haulm, no additional nitrogen fertiliser was applied

The study was performed by using a simulation DNDC model.
4 rotation x 3-soil types x 16 regions x 20 years= 3840
The emphasis has been put on the arable farm, due to the fact that they generally have a negative balance of organic matter in the soil and apply the rules fairly intensively for nitrogen fertilisation, which can lead to increased N leaching and higher N_2O emissions.

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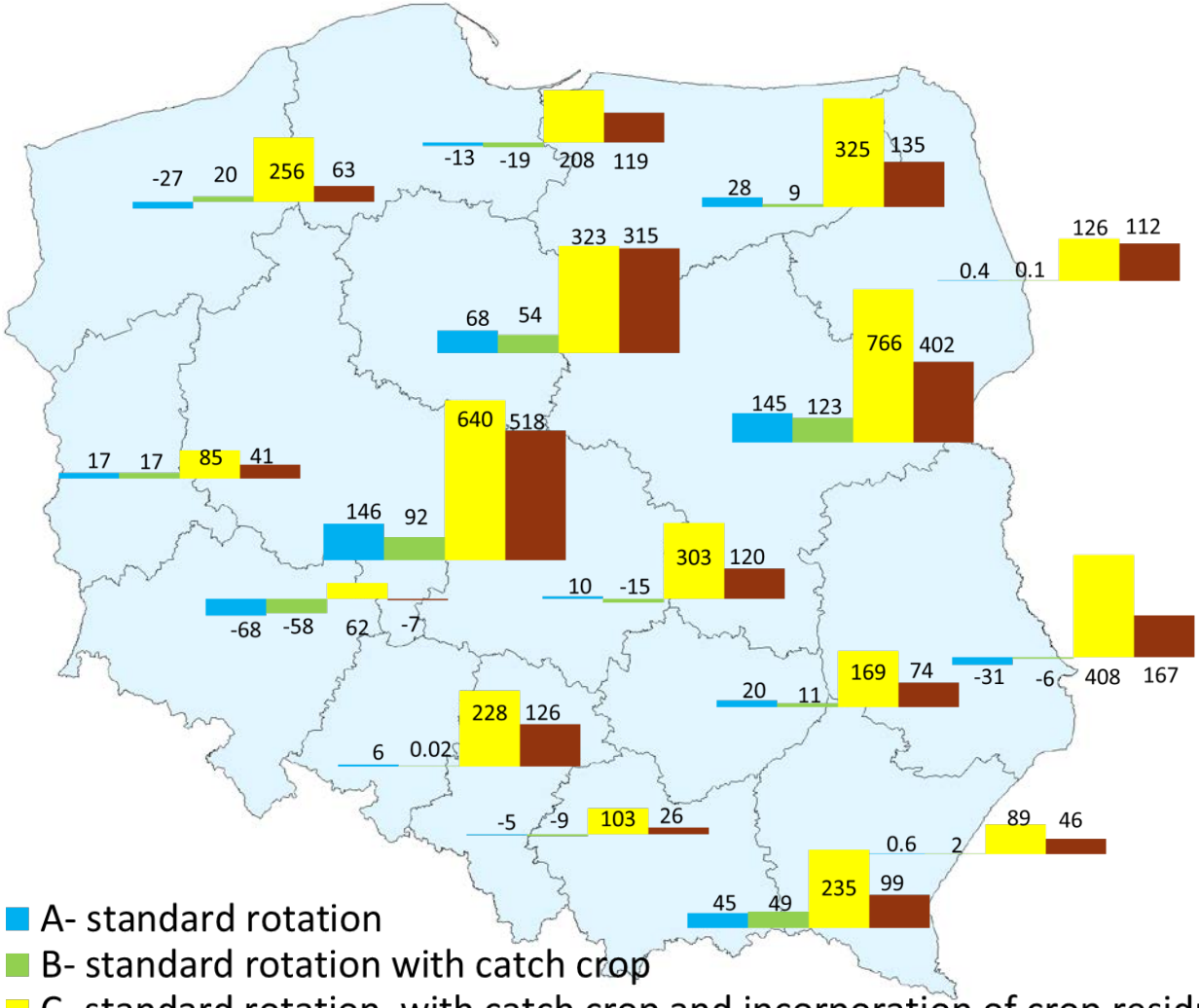
Results

Increase of the aboveground and belowground total yield and weight in compare to the standard rotation A

NUTS-2 regions	Heavy soil				Medium soil				Light soil				Very light soil			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Dolnoslaskie	100	93	91	89	100	113	130	118	100	29	29	22				
Kujawsko-Pomorskie					100	100	104	108	100	100	102	98	100	110	110	122
Lubelskie					100	79	86	77	100	110	114	117	100	121	121	135
Lubuskie					100	103	128	120	100	149	152	143	100	61	61	48
Lodzkie					100	135	161	127	100	128	141	131	100	69	69	50
Malopolskie	100	130	147	120	100	109	124	113	100	98	99	111				
Mazowieckie					100	102	124	113	100	127	141	145	100	81	81	70
Opolskie	100	119	120	138	100	135	151	148	100	113	126	123				
Podkarpackie	100	118	138	129					100	136	145	162	100	96	96	77
Podlaskie	100	87	92	89					100	116	134	117	100	63	63	55
Pomorskie					100	108	126	114	100	120	131	131	100	85	85	68
Slaskie	100	112	127	113	100	145	172	140					100	75	75	67
Swietokrzyskie	100	107	109	117	100	143	165	138					100	244	260	255
Warminsko-Mazurskie					100	99	124	104	100	137	150	137	100	174	174	176
Wielkopolskie					100	89	112	110	100	120	122	119	100	145	145	147
Zachodniopomorskie					100	105	113	116	100	128	141	127	100	75	75	60
Poland	100	110	118	114	100	112	130	118	100	115	123	120	100	108	109	102

Average sequestration of organic carbon in the analysed crop rotations (kg C $ha^{-1}y^{-1}$)



- A- standard rotation
- B- standard rotation with catch crop
- C- standard rotation with catch crop and incorporation of crop residues
- D- standard rotation with manure fertilisation

Effective reduction of GHG crop production emissions can be achieved, by increasing the C seq. in soils.

Achieving this goal will require an increase in Polish conditions of nitrogen fertilization in order to increase the productivity of plants. Then more weight of crop and residues will remain on the field, and thus will increase C seq. However, the increase in fertilization and an additional amount of mineral N released from organic matter as a result of the mineralization will increase N_2O emissions. Therefore, it is necessary to analyze the balance of CO_2, CH_4 and N_2O.

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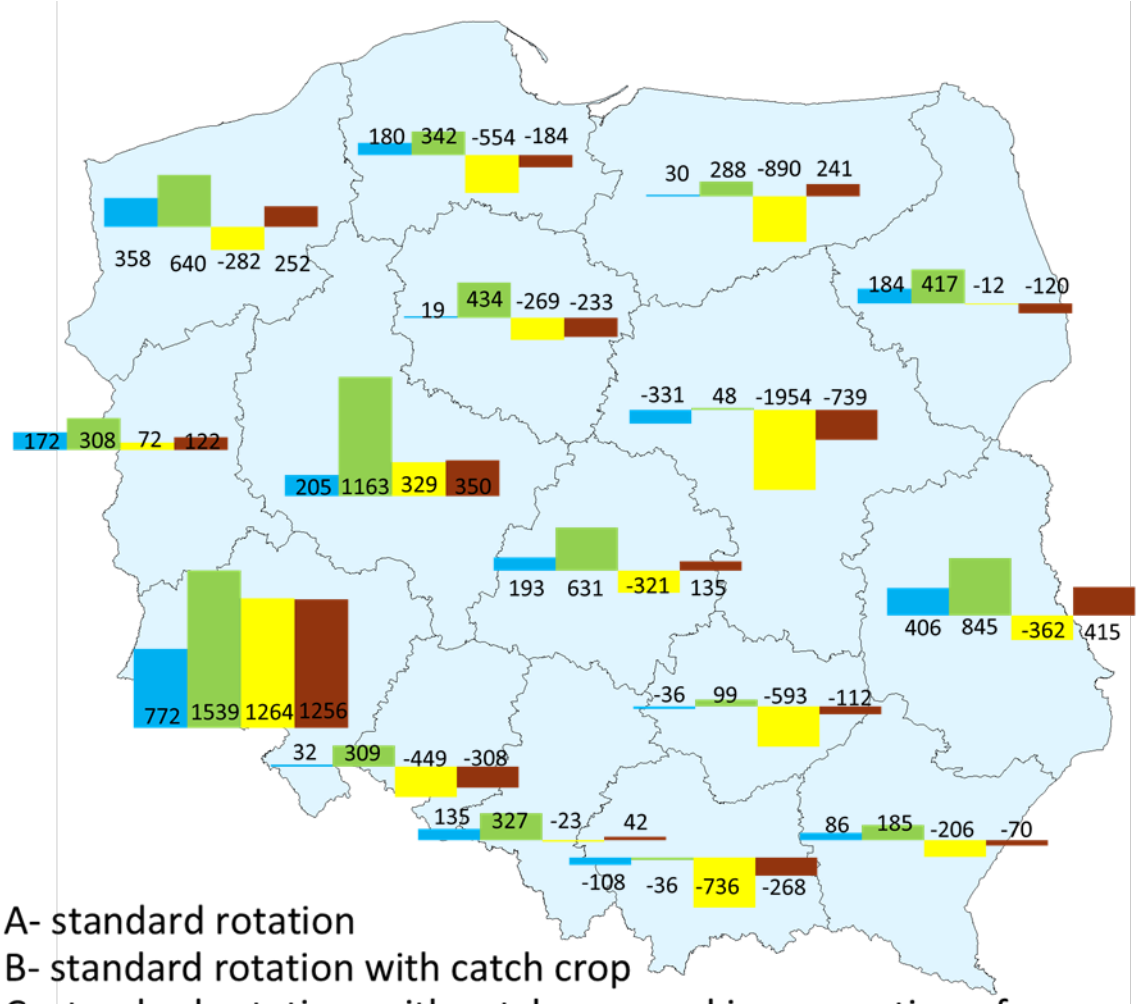
The balance of greenhouse gas emissions in the regional breakdown (thousand tonnes of CO_2 eq $ha^{-1}y^{-1}$)



Emissions and reduction of GHG were varied in the regions, due to climatic variability, soil variability and crop rotation.
The data may be useful for decision-making, where in the first place locate mitigation practices and which kind.

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Summary

- The introduction of winter catch crops into the crop rotation, where manure was not applied, has not been effective at a country level in the reduction of nitrate leaching from the soil, and did not limit the runoff from the fields of surface nitrates. These ratios have increased due to a need for adequate fertilisation of catch crops.
- Catch crops in the country have had a small positive or small negative impact on organic carbon sequestration in soils.
- Catch crops and incorporation of all crop residues into soil and tillage simplification leads to improved crop yields in a crop rotation - expressed as the amount of carbon in aboveground and belowground masses, but these practices reduce the yield of the main products.
- Catch crops used in rotations without manure, lower the yields of the main products and contribute to a relative increase in greenhouse gas emissions.
- Leaving the total amount of crop residue on the field and simplifying tillage practices, results in a relative reduction of greenhouse gas emissions on heavy soils, medium and light. The situation is similar in the case of manure.
- The mitigation practices do not lead to an effective reduction of GHG emissions in very light soils that were tested.

Thank you for your attention

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