1st World Sustainability Forum
1-30 November 2011

Use of agrochemicals – Environmental, social and economic impacts of alternative farming strategies: Precision weed management

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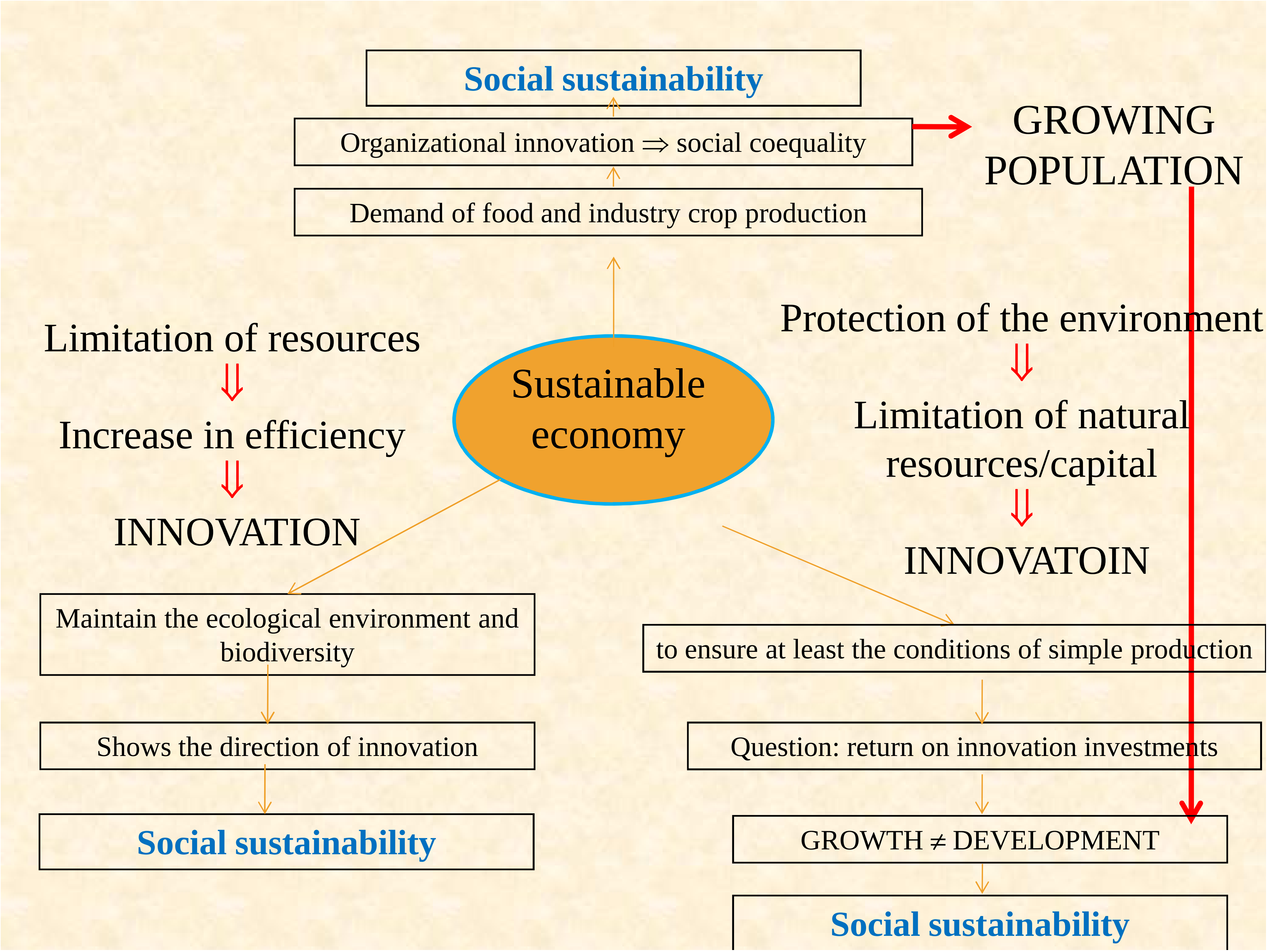
With the help of T-042503 OTKA project

- introduction – sustainable agriculture
- why it is necessary to reduce chemicals
- alternatives for reduction of chemical use
- economical effects – modelling
- potential reduction of environmental burden
- conclusions


Social sustainability
Organizational innovation ⇒ social coequality
GROWING POPULATION
Demand of food and industry crop production
Limitation of resources
Increase in efficiency
INNOVATION
Sustainable economy
Protection of the environment
Limitation of natural resources/capital
INNOVATOIN
Maintain the ecological environment and biodiversity
to ensure at least the conditions of simple production
Shows the direction of innovation
Question: return on innovation investments
Social sustainability
GROWTH ≠ DEVELOPMENT
Social sustainability

Contradiction of sustainability

1. Economic growth ≠ Sustainability
2. Sustainability ≠ Consumption
3. Developed countries ≠ Developing Countries

SOCIAL SUSTAINABILTY?

↓

on organizational strategies

What kind of environmental burden we are speaking due to agricultural chemical use?

- penetration of fertilizer and pesticide and other chemicals into the soil and underground water
- strengthen of harmful effects of plant production on soil texture
- negligent dispersion, overlaps, burden of technical water etc
- occurrence, accumulation of toxins in yield / in environment

Considering the life cycle of synthetic nitrogen fertilizer, the following potentials for damage can be identified

- global warming due to the production of fertilizer;
- damages due to air pollutants emitted during the production of fertilizer;
- global warming due to the application of fertilizer;
- eutrophication due to leaching of applied fertilizer;
- pollution of drinking water due to leaching of applied fertilizer; and
- damages due to release of volatile substances (especially NH3) from applied fertilizer.

(Acidification of soils should not arise if good farming practices are followed.)

Why we use chemicals?
Aims of plant fertilization

- to give back the nutriment into the soil we took away by previous yield(s)
- to increase yield
- to compensate the differences in soil / micro-climatic conditions

Why we use chemicals?
Aims of plant protection

- to reduce the damage of harmful organizations (i. e. to keep the limit under this economic threshold with several technological elements)
- to stop their expansion
- to eliminate the toxic ingredients induction in the plants
- to reduce the yield uncertainty

Field equivalent of potential loss in yield due to the harmful organizations

the field (in hectare) what has not been necessary to seed to produce a certain yield we suffered as a loss due to the missed plant protection

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we have to use pesticides – but in what level and how?

Tools of adaptive – integrated – plant protection

Indirect methods		**Direct methods**
Technology	Weeds	**Chemicals (artificial)**
Resistant or tolerant species	Pathogenic organizations	Phisical and mechanical tools (grubber, weeding hoe)
Protection of useful organizations	Fungus	Biological and biotechnological tools
Without additional energy inputs	Insects	**With additional energy inputs**
⇑		⇑

Alternatives of reduction of pesticide use

- integrated crop production system
- organic farming
- outright ban of chemicals
- precision farming ⇒ reduction of the application of any chemicals
- potential role of GMO products

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role of crop protection should be highlighted

What are the factors of agricultural technical development?

- biological (resistance or drought tolerant plant breeding, genetics (GMT or GMO),
- chemical (new ingredients, smaller dose, durable actions, etc)
- technical (machinery, computerization, technology, etc)
- human (agrotechnical and managerial knowledge, positive attitude, etc)

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social pressure

Economical comparison of alternative strategies of chemical reduction (1)

Denomination	Reduced crop protection chemical use	Chemical-free production	Precision farming
Obtainable yield	almost same as conventional	-15-35%	almost same as conventional
Production costs	almost same as conventional	80-110% of conventional	higher due to extra investment
(Extra) Investment Need	none	none	significant
Sales price	same as conventional	possible to realize premium (0-30%)	same as conventional
Subsidy	same as conventional	special target support in addition to conventional	special target support in addition to conventional

Source: own construction

Economical comparison of alternative strategies of chemical reduction (2)

Denomination	Reduced crop protection chemical use	Chemical-free production	Precision farming
Profitability	almost same as conventional	higher than conventional in case of premium price and subsidies	depending on the size; in smaller farms it is less than conventional due to the big investment need; in middle-size farms it is the same as conventional; in bigger farms it is higher than in case of conventional farming

Source: own construction

Economical comparison of alternative strategies of chemical reduction (3)

Denomination	Reduced crop protection chemical use	Chemical-free production	Precision farming
Weed control	Based on herbicides	Physical, biological and agrotechnical means	Based on herbicides according to local/area (plot) features
Crop protection	Based on pesticides	Physical, biological and agrotechnical means	Based on pesticides according to local/area (plot) features
Nutrient supply	Based on fertilizers	Use of manure and organic materials	Based on fertilizers according to local/are (plot) features
Soil cultivation	Based on rotation and ploughing	Minimum soil cultivation	Based on rotation and ploughing

Source: own construction

What is the role of agricultural technical development in chemical use reduction?

resistance or drought tolerant plant breeding	⇒	less number of treatments
innovation in chemical industry	⇒	less dose of ingredient and carrier, less number of treatments due to durability
precision plant production	⇒	less number of treatments, less treated plots
human (capital)	⇒	more precise production – less environmental burden

Material and methods

⇒ analyses on potential crop land that could be conversed to precision farming depending on farm size

on the base of FADN data

- farm size (crop type) ≥ 100 ESU ⇒ based on own equipment
- farm size (crop type) 16 – 100 ESU ⇒ cooperation for machine use is required

assumptions

- ➢ savings of fertilizer:
  - ➢ pessimistic ⇒ 5 %
  - ➢ ignorant ⇒ 10 %
  - ➢ optimistic ⇒ 20 %
- ➢ savings of pesticides:
  - ➢ pessimistic ⇒ 5 %
  - ➢ ignorant ⇒ 10 %
  - ➢ optimistic ⇒ 20 %
- ➢ ratio of farms turning to precision farming
  - ➢ pessimistic ⇒ 15 %
  - ➢ ignorant ⇒ 250 %
  - ➢ optimistic ⇒ 40 %

Results (1)

Estimated savings in fertilizer application of farms introducing precision farming (EU-25)

Category			Farms applying precision technology		
			15%	25%	40%
16-100 ESU	Land using precision technology (ha)		103,559	172,598	276,157
	Savings in fertilizer active ingredient (t)	5%	535	892	1,426
		10%	1,070	1,783	2,853
		20%	2,140	3,566	5,706
>= 100	Land using precision technology (ha)		132,353	220,588	352,941
	Savings in fertilizer active ingredient (t)	5%	424	1,136	1,094
		10%	821	2,272	2,188
		20%	1,641	4,543	4,376
Total	Total size of land using precision technology (ha)		235,912	393,186	629,098
	Total savings in fertilizer active ingredient (t)	5%	959	2,027	2,521
		10%	1,890	4,055	5,041
		20%	3,781	8,109	10,082

Source: Author’s calculations, partly published by Takács-György, 2011

Results (2)

Savings in fertilizer costs

(Million EUROS)

Country	16-100 ESU farm group			>100 ESU farm group		
	5%	10%	20%	5%	10%	20%
Denmark	2.398	4.796	9.592	3.654	7.309	14.617
United Kingdom	9.982	19.964	39.928	25.585	51.169	102.338
France	48.870	97.739	195.478	50.547	101.094	202.189
Netherlands	1.349	2.698	5.397	2.052	4.105	8.210
Poland	12.927	25.855	51.709	9.185	18.369	36.738
Hungary	3.641	7.282	14.563	4.913	9.826	19.652
Germany	19.362	38.724	77.448	40.025	80.049	160.099
EU-25	156.259	312.519	625.037	170.815	341.629	683.258

Source: Author’s calculations, partly published by Takács-György, 2011

Results (3)

Estimated savings in pesticide application of farms introducing precision farming (EU-25)

Category			Farms applying precision technology		
			15%	25%	40%
16-100 ESU	Land using precision technology (ha)		5,086,330	8,477,217	13,563,547
	Savings in pesticide (t)	25%	2,925	3,574	7,799
		30%	4,095	3,950	10,919
		50%	5,849	4,900	15,598
>= 100	Land using precision technology (ha)		4,818,598	8,030,997	12,849,595
	Savings in pesticide (t)	25%	2,771	4,618	7,389
		30%	4,095	6,465	10,344
		50%	8,190	9,235	14,777
Total	Total land using precision technology (ha)		9,904,928	16,508,214	26,413,142
	Total savings in pesticide (t)	25%	5,695	8,192	15,188
		30%	8,190	10,415	21,263
		50%	11,391	14,135	30,375

Source: Author’s calculations, partly published by Takács-György, 2011

Results (4)

Savings in pesticide costs

(Million EUROS)

Country	16-100 ESU farm group			>100 ESU farm group		
	25%	35%	50%	25%	35%	50%
Denmark	18.272	25.580	36.543	19.127	26.778	38.254
United Kingdom	127.923	179.092	255.845	139.921	195.889	279.841
France	252.736	353.830	505.471	239.276	334.987	478.552
Netherlands	10.262	14.367	20.524	26.884	37.637	53.767
Poland	45.923	64.292	91.846	31.010	43.414	62.020
Hungary	24.565	34.392	49.131	22.043	30.860	44.085
Germany	200.123	280.173	400.247	191.189	267.665	382.379
EU-25	854.073	1 195.702	1 708.146	820.023	1 148.032	1 640.046

Source: Author’s calculations, partly published by Takács-György, 2011

Results (5)

precision crop production

- by optimizing the fertilizer use helps to reach avaibality of farms ⇒ **economic sustainability**
- the site-specific treatment of lands with pesticides or herbicides may save a considerable amount of chemicals when only a small proportion of the land is infected
- estimated amount of pesticides saved in this way on the level of EU-25 countries is 5.7-11.4 thousand tons in case that 15% of farms apply precision farming, 9.5-13.1 thousand tons in case 25% of them introduce it, while in the most favorable case 15.2-30.4 thousand tons are spared ⇒ **reducing environment burden**

Conclusions (1)

three main alternatives

- precision plant protection ⇒ plots to be treated when it is reasonable ⇒ **reducing environment burden**
  - ✓investment – operation ⇒ size increase, concentration
- turning to organic farming ⇒ total chemical prohibition (philosophy) ⇒ **reducing environment burden**
  - ✓how long the extra price could be realized on the market?
  - ✓could the threshold size be reached? ⇒ size increase, concentration
- increase of extensive specialty of farming ⇒ delimitation of chemical use ⇒ **reducing environment burden**
  - ✓compensation of income loss (subsidy)
  - ✓is it reachable the viable size of farm? ⇒ size increase, concentration

Conclusions (2)

What is precision agriculture – from environmental aspect?

- „Precision agriculture" means that the farmer uses assets, varieties and technology of high technical level, possesses appropriate information about the environment
- utilizes all the elements of technical development of agriculture ⇒ allow targeted chemical applications matching site specific parameters
  - soil/nutrition
  - expected yield
  - occurrence of pests (weed, insects, plant sicknesses
- goal is
  - to utilize the area specific potential
  - to save active ingredient on the actual parcel
  - increase the production income on this way

Conclusions (3)

role of plant protection

- from the aspect of sustainability plant protection carried out in an environmental friendly way contributes to cover the forecasted food demand ⇒ SUSTAINABILITY (social expectations)
- role of switching to precision crop production: will reduce the effective chemical use ⇒ SUSTAINABILITY (environment protection
- precision farming can ensure the needed income to meet with the economic requirement of at least the simple reproduction at certain size and production level ⇒ SUSTAINABILITY (economic)

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We must to think on future!


Thank you for attention!