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Use of Agrochemicals – Environmental, Social and Economic Impacts of Alternative Farming Strategies: Precision Weed Management

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Abstract: In sustainable agriculture it is getting more important the need of reducing environmental burden duo to agrochemical use. To carry out environmental protection, the responsible use of natural resources and keeping rural development for the future generation is our task. The term "sustainable development" includes the current and long-run sustainable *production* and the controversies of environmental protection that ensure the right quality of life, and hard-preventable, but rather tolerated conflicts. Sustainability must include the farming that allows for easy reproduction the assets needed for production not only at business management level, but also on a national level management irrespectively of the source of capital necessary for farming. It is also important for the maintenance of rural areas. Precision farming is one of the farming strategies in crop production which can increase farmer's efficiency and can reduce the chemical use – especially in plant protection – and also the burden of environment. In the present research we have examined the economic relations between potential savings in chemicals on EU level and in Hungary by analyzing scenarios for implementing the site-specific technology in weed management. In this paper we summarize our former research studies, published in publications listed in references. It has been found that after switching to precision farming, the active ingredient savings in herbicide use can be 30 thousand tons (calculating with the current dose-level) in EU-27. If approximately 30% of the crop producing and mixed farms over 16 ESU adopt this new technology, this will diminish environmental loads by up to 10-35%. In Hungary the expected area on which precision plant protection can be used is about 400 000 ha if 25 % of the farms operating over 16 ESU apply the technology. That means 229-587 to pesticide savings per year depending on the savings in dose of pesticide per hectare (that were: 25-30-50%), assuming the current pesticide usage. The majority of farms characterized by greater output and size can be based on their own equipment but it might as well be presumed that smaller farms can turn to precision farming not based on their own investment, buying the technical service or establishing machinery rings. At a certain farm size and farming intensity precision crop production is a real, environmentally friendly farming strategy, with the help of which the farm can reach earnings that cover at least the economic conditions of simple reproduction.

Keywords: environmental burden, chemical use reduction, potential savings, EU.

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1. Introduction

The term "sustainable development" includes the current and long-run sustainable *production* and the controversies of environmental protection that ensures the right quality of life, and hard-preventable, but rather tolerated conflicts. In the realization serious regional, national, social (and of course, political) interests, momentary, short and long-run visions clash, they often confront. The interpretation of sustainability is extended by Chilinsky and his colleagues in 1998 that the production must be sustainable in economic sense. [7] According to Jørgensen (2000) sustainability must include farming that allows the easy reproduction of assets needed for production not only at business management level, but also at national level management irrespectively of the source of capital necessary for farming. [16] It is also important for the maintenance of rural areas. [25]

Sustainable development, however, has not only ecological but also economic aspects, which means that direct and indirect impacts should also be considered in the implementation of a technology and in determining the appropriate farming strategy. All those farming methods can have place and roles in the changing world which help to meet the above outlined requirements and contribute to the adequate individual decision making in farming. Precision crop production meets or is able to meet the requirements of sustainability.

Sustainability can be described by a lot of definitions in regards to agriculture and environmental economy, defining also the possible strategies. „Sustainable nature protection strategy should include resource management in order to meet the needs of the present generation without reducing the possibilities of the future generation". [NRC Board on Agriculture. 11 p. 175.]. The reduction of pesticide use has an important role in it [20]. Pearce and Atkinson (1995) defines sustainability as follows: since natural resources and the capital produced by the men closely complement each other in the production process, the natural resources provide the limits for increasing production and should be used rationally during production. [31]

According to the energetical approach to sustainability, sustainable existence is when the produced energy is not created by increasing energy compared to the previous level. [27] As regards the interpretation of sustainability, the thermodynamic approach to natural and social processes is a new idea. The bounds of development can be explained by the generalization of the first and second main theorems of thermodynamics, according to which if we regard the ecological system of the Earth closed, the use of the limited available resources – when run out - will result growing entropy in the system. The natural state of the natural systems is disorder, and man interferes in it with its deliberate activities. Entropy growth also causes inner disorder in the system – the Earth. If the processes in this closed system are reversible, the entropy does not decrease so the state of the system does not change. Irreversible processes – presuming a closed system – result the growth of entropy. From thermodynamical aspects the changes of entropy in agro-ecosysems means the irreversible state changes in the crop and soil, as well as in biodiversity and also the entropy change between system and environment. Since most of the living environmental processes are irreversible, all the changes are paired with growing disorder, entropy. The bounds of sustainable development can lead back to quantity and quality limits. Entropy is regarded as the negative measure of utility by many authors who approach the subject from this side and declare that degradation of ecological environment can be characterized by the reduction of entropy. [9; 1; 17]. The entropy of natural habitat is maximal under given conditions because it can be characterized by diversity (disorder) close to the original state. As against to this, the entropy of agro-ecosystems is decreasing due to the deliberate human intervention – artificial energy input – at the degree of intervention. The more intensive is the agriculture, the lower is the entropy of the given agro-ecosystem. Owing to the technical development of agriculture, the adaptability of grown – bred – varieties is decreasing and thus both the chemical use and the mechanization requires extra energy input. The reduction of biodiversity means the „reduction of disorder” in the system.

Intensive agriculture means that „properly arranged conditions” are ensured for the crop with high energy input. Optimal circumstances are created targeting the restriction of maintenance, multiplication and economic damages of antagonist and competing organs. The question is how long can this be pursued. The basic principle is that the energy put into the agro-ecosystem by technological elements can be expanded until they increase the efficiency of solar-energy use. [16; 29; 30] As regards the energy balance of crop production Neményi (2009) raises another question: who can decide the value and proportion of energy need of technology development and the relations between ecological systems. [28] It should also be considered that 10-12% of the Earth’s crust is suitable for agricultural production, and intensified crop production is performed on almost half of this area. In Hungary, agricultural production is carried out on 54% of the total arable land area and forestry is on about 20%. As regards the degree of intensity we belong to the group of the world’s developed countries. That’s why the above questions should receive high priority.

The chemicals used in agricultural production, indispensable to the production level, that is needed for the world's population food supply, needed to produce raw material on the one hand, and mean the risk of human existence on the other hand. Appraising the crop production as a system in the course of finding the degree of intensity and form of business that eligible for the environment, must take into account the losses of the negative environmental and human consequences that harmful, pathogenic organisms may cause.

It should be noted that on the basis of various calculations the yield loss ascribed to the plant pest organisms (biotic stress) can be the 40% of the potential yield. The yield loss is 10-12% brought about by the weeds, 18-20% by pathogenic organisms, while the pests are responsible for 8-10%. This can also explain why producing the yield required 1.67 times higher area to grow crops, which is not possible due to land limitation. Its effect appears on the increase of production costs. In case of Hungary, assuming the loss values above, the potential area equivalent of plant protection is 1.2 to 1.4 million hectares of arable land, if does not happen preventive defense against biotic stress causing organisms. The society laid claim to reduce pesticide use (both the sent quantity and frequency relation) and this claim can be satisfied, partly by the agricultural technological development, mechanization, pesticide production, etc., and partly by the technology chosen by the farmer, and the variety breeding has an important role also. The use of weed, disease and insect-resistance varieties, as one of the indirect tools is applied in practice, the right combination of additional agro-technical tools may be one basis for resolving the contradiction mentioned above. The ecosystem and economic growth, the sustainability and consumption, the antagonistic contradictions between the developed and developing economies (social) require the development of agriculture and strategic management issues. The legitimacy of criticism is indisputable by the advocates of the organic revolution for today's global economy [21], however, by their estimation, the size of sustainable global system in the current system, about a third of the population could exist. A rational response cannot be given to this antagonism. However it would be expected that due to the dynamic economic development, Chinese and India population’s consumption increase, and the demand for food also increases. It is expected that the world’s food production is facing a new boom. Satisfying the dual requirement (the pursuit of ecosystem sustainability and the social demand), at the same time, through the technological development, the agro producers have to strive after. The common element of possible responses is the reduction of negative externalities, while focusing the well-groomed, preservative of natural resource productivity, through on remedial solutions the aim is the preservation and value increase of public goods.

The environmental burden of agricultural chemicals appears in the following fields:

- the leakage and wash of fertilizer and pesticide into the soil, surface and ground water,
- other ingredients (regulators, desiccated drugs),
- the intensification of harmful effects on crop production influenced on soil structure,
- burden because of inaccurate spreads, overlap, wash water,
- risen and accumulation of toxic materials.

It is necessary to examine the tendencies of agrochemical use. In the past two decades in the developed countries and in the European Union and in Hungary, for different reasons, the use of artificial chemicals in agriculture showed a downward trend. The reasons include besides the intensification of environmental awareness and the reduction of environment burden, the previously measured but for nowadays the decreased headway of organic farming, the integrated crop production systems be converted into practice and the development of precision agriculture’s conditions. In respect of insecticides the required doses in grams per hectare, the technologies to spread in parallel with the appropriate expertise appeared through the innovation.

Applying technologies that based on the reduced chemical use, reported the formation of different tendencies besides the conventional farming, that its main economical features are summarized in table 1.

- the *reduction in pesticide use*, for the use of chemicals is the one way that result in persistent, curative effect and during the vegetation less treatment is needed, and the decrease of dose of ingredients takes effect in the direction of reducing the amount of Pesticide per area [24; 22] The primary condition is the (chemical) industrial R&D.
- *Trends* (kinds of organic farming) *are free from chemicals* (prohibiting the use of artificial chemicals) and the total prohibition of the use of chemicals from the point of view of environment. Each tendency goes with the decrease of environmental burden, however, the production structure, the resource needs, quality as well as the sales opportunities of farms should change. The common feature is the prohibition of artificial chemicals (fertilizers, pesticides, crop enhancer) and implementation of all those technologies, elements and procedures which can help to reduce the crop antagonists and enhance the maintenance of biodiversity at a higher degree. [23; 35] These tendencies presume that the sales of products produced this way is ensured at a price that covers the higher costs – composed of a bit different elements - of the different technology. [40] The rate of growth has slowed down because of the limitations of consumer demand for organic products, the market saturation is typical. [41; 12; 18; 13] The primary condition is the farm technology R&D.
- Application of the *integrated crop management systems* meaning rational production, which is reducing the environmental burden using the appropriate amount of pesticide. Integrated pest management (IPM), reasonable application of biological, biotechnological, chemical, production or plant breeding measures, in the course of pesticide use is strictly limited to the minimum level that will necessary to maintain below in an economically unacceptable level causing injury or loss of harmful population. [34] This systems are more important in the horticulture, especially in greenhouses from the point of view of sustainability. [10] Cost-efficient weed control is the basic factor of efficient and sustainable agriculture and at farm level it often goes together with the growth of farming size and concentration. [51] The practical implementation of damage-threshold principle meets all the criteria in making crop protection decisions by U.S. Environmental Protection Agency (1999). [32; 42]
- The *lane spraying*, complemented with other agro-technical means (lead cultivation) is a process by which the amount of chemical passed can be reduced by 30-70%. However, the energy of the land will increase because the use of surplus agro-technical element. [37; 5; 38; 45] At farm level Széll et al. could not reveal any significant differences with this technology regarding the yield. They have stated, however, that lane spraying complemented with lead cultivation can result an increasing income [4; 52; 19; 3] Tillet (2005) examined the impacts of lane spraying on yield and yield content in case of spring barley and stated that lane spraying resulted 18% yield surplus and 12-13% nitrogen surplus primarily due to the targeted spreading of nitrogen. Due to the lack of repetition, however, the results can be misleading. [50] Herbicide use can be reduced by 70% compared to the total surface treatment, if lead cultivation is done, because the combined treatment enables the spreading of the lowest

suggested level of the herbicide on the treated lane, of course in relation to the humus content and boundary of soil. [26; 33] Johnson et al. informed about another advantage of site-specific weed control: the development of weed resistance was slower. [15] The primary condition is the farm technology R&D.

- Use of *precision farming* that allows rational chemical pass by the spot treatment, results rational chemical use besides reducing chemicals. Precision farming means a new management strategy for the plant production, which allows the implementation of technology for the producers used in the micro-regions, primarily in relation to chemical use. Reducing the required quantity of herbicide, combined with a lower environmental burden, also offers more efficient production opportunity for the producer. [36; 53; 49; 14] Compared to the conventional technology, the extra income depends on the heterogeneity of the basic production conditions on the given farm. Many authors referred to the fact that precision farming in connection with yield uncertainty can be defined as a tool of reducing risks and also as an actual tool of reducing environmental damages. The yield uncertainties can be reduced and the safe income can be increased by the proper use or combination of technological elements in crop production. [2; 8; 43; 6] Jolánkai and Németh (2007) complete this by adding that the essential element of precision farming is the pursuit for the most accurate adaptation of production technology adjusted to production site. [14] Primary conditions are the farm and engineering technology R&D and the R&D of geographic information system.
- It should be added that the coating of commercialized producing of plants that are created with the change of the genetic file hereby the application can be cancelled or reduced from its technology. Transgenic organism (TGO) developed through the transfer of the genetically modified organization (GMO), or the part of the genome of living organism transferred, have advantageous features by conventional varieties, they are not sensitive to certain technological elements. In economic sense, we can talk about the reduction of damage caused by harmful organisms, the avoid of yield reducing impact caused by individual elements applied in farm technology, and the cost reduction from other input savings for the prevention of the previously mentioned yield’s quantity and quality losses. The forthcoming cost savings within the certain elements of this technology is opposed to additional costs, during the production, as the adherence of isolation distance and the surpluses related to sales, besides the high seed cost of GMO’s, TGO’s varieties. Primary and necessary condition is the variety (biotechnology), R&D, but the operating level of technological R&D is also needed.

Table 1. Economical comparison of alternative strategies of chemical reduction.

Nomination	**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
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
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: Takács-György – Kis, 2007 [44]

2. Material and Methods

During the research, we had the following presumption: in EU-25 countries, the transition of a certain number of farms to precision crop production would result in saving a significant amount of active ingredients, particularly in the field of crop protection, which would reduce the environmental load as well. Using scenarios, we modeled the changes in the amount of the fertilizer and pesticide applied presuming crop producing and mixed farms adopt the new technology to different extents. The statistical data concerning farm structure were collected by EUROSTAT and the Central Statistical Office of Hungary, while those concerning chemical use were collected by the OECD (Table 2).

Table 2. Fertilizer and Pesticide-Herbicide Application, 2007

Country	Total arable land	Fertilizer	Pesticides
	thousand ha	kg/ha arable land	
OECD	350,960	22	0.70
EU-15	324,300	60	2.3
Hungary	9,300	58	1.7
Netherlands	4,200	134	4.1
Germany	35,700	105	1.7

Source: OECD in Figures 2008.

The European Size Unit, which categorizes farms according to their profitability (SGM output) and distinguishes 6 categories, served as a basis for identifying the farm size where the extra investment of adopting precision farming technologies pays off. Based on their size and farming standards, crop producing farms (cereals and other field crops, as well as fodder production) over 100 ESU were presumed to be able to adopt precision farming with the help of their own financial resources. I also presumed that farms of 16-40 and 40-100 ESU would be able to adopt precision crop production with the help of machinery rings [39]. In the EU, there are 240 thousand farms of 16-40 ESU, accounting for 4.2 million hectares of land. The number of farms of 40-100 ESU is 139 thousand, accounting for 5.9 million hectares, whereas the number of farms over 100 ESU is 77 thousand, and they account for 11.3 million hectares of land. The basis of the calculations at national level was also the above categorization. [47; 48]

- The ratio of farms deciding on adopting the new technology is 15, 25 and 40%, in case of pessimistic, indifferent and optimistic scenarios, respectively.
- Savings for fertilizers are 5, 10 and 20%, while for pesticides they are 25, 35 and 50%. The values of OECD report of 2008 were used for determining the spread fertilizer and herbicide quantities, supposing that the value of EU-15 is the basis. In case of Hungary we calculated with the actual data of 2006.

In this paper we summarize our former research studies on economic consequences of chemical reduction, from the aspect of sustainability, published in publications listed in references.

3. Results and Discussion

Potential savings of chemicals using precision technology can also be interpreted as not required and not used by the plant, but at the same time chemicals that not allocated, the importance of technology is outstanding in reducing the environmental burden as well. The positive effects of technology are unquestionable, both on the farm and national levels. Previous studies have reported the cost efficiency on farm level, which is not examined because of space limitations.

Modeling the savings of active ingredients of fertilizers and those of costs in case of switching to precision technology showed the following results: on the level of EU-25 states, the widespread application of precision farming in crop production may save 959-10082 t of fertilizer active ingredient, amounting to €327.1-1308.3m, while the costs of pesticides saved may range between €1674.1-3348.1m (using 2006 price levels) (Tables 3 and 4).

Primarily, precision nutrient supply may be the method of using the yield potential of the field, thus it is not a constant amount, and can even mean higher fertilizer application in certain cases. Naturally, there is considerable fertilizer saving when planning the consolidated field-level yield. Precision farming has an even greater significance in reducing the amount of pesticide used.

Table 3. 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 [48].

Table 4. 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: FADN data base, edited by author, partly published by Takács-György, 2011 [48].

One of the main advantages of precision crop production is that 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. The 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 (Table 5).

Among the macro-level effects, the actual decrease in chemical use must be mentioned, that is a potential opportunity. The widespread use of precision agriculture in the EU-25 can result within the ingredients of fertilizer from 959 to 10,082 tons, while in the cost of 327.1 to 1,308.3 million Euro savings (at 2006 prices). Considering that the cost of fertilizer can represent the 8-12% of production costs, the cost savings have a positive impact on competitiveness, if the purpose of production to achieve the former yield. It should be noted that the application of precision nutrient supply, the producers apply as a tool for exploitation the potentialities lie behind the yield potential. In order to achieve higher yields increase the fertilizer, and it can result higher fertilizer use, however, through the spot treatment also comes to the plant, and do not burden the environment unnecessarily.

Table 5. 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 [48].

Considering the role of agricultural production in ensuring food safety, this amount cannot be ignored. It has great importance since the same effects of crop protection can be achieved with a significantly lower level of environmental load if precision crop production is applied (Table 6.).

As macro-level modeling calculations support, precision crop production plays a determining role in reducing the environmental load, along with the other agricultural technological innovations. However, precision farming has a greater importance in the reduction of the amount of pesticides used. On the level of farms, site-specific crop production leads to the reduction of material costs, as the necessary pesticide amount is 8-10% lower (calculated in active ingredient) than in case of traditional treatment Savings in pesticide use affect not only costs but also competitiveness, and have great importance in environmental protection as well.

Table 6. 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: FADN data base, edited by author, partly published by Takács-György, 2011 [48].

Application of precision farming has more important role in the reduction of pesticide use than in reducing fertilizer use. The advantage of precision crop comes from the fact on the one hand that if the proportion of area is high, where the treatment of land protection can be left off, depending on the area infected and the heterogeneity of infection, the spot treatments can result fair material savings. At the EU-25 level, the estimated rate on pesticide savings is from 5.7 to 11.4 thousand tons, if 15% the plant is switched over, from 9.5 to 13.1 thousand tons at the switch over of 25%, while the most optimistic cases the savings are from 15.2 to 30.4 thousand tons. The savings of insecticide cost 1,674.1 to 3,348.1 million EUR (at 2006 prices). If the proportion of the switch over farms is between 30-60% of the total, compared to the quantity used in the surface treatment intensive technology average savings of 30-60% are estimated of a pesticide's ingredients per holdings. If the 10-35% ingredient reduction carried out by constant yield the environmental burden is reduced by 10-35% at the national level. In this case, the individual utility coincides with the social utility that serves the sustainability. [46; 47]

The valuation of economic impacts of precision agriculture, at farm level, cost-benefit analysis, return and gross margin analysis can be applied. The precision technology has a positive effect on ecological sustainability (reasonable chemical use), profitably can be achieved at farm level, ensuring the rate of return of the developments required for technology (economic efficiency). However, it should be noted in relation to the precision agriculture that it has dual positive effect connected with social sustainability. One is derived from the reduction of environmental burden; the other is contributing to the production of demanded food and industrial raw materials as well as energy basis.

4. Conclusions

Precision farming should receive high priority in sustainable agriculture in countries with developed agricultural activity. In this context, however, it should also be examined what are the conditions under which it means real alternative. We have stated earlier in connection with examining the risk of economic rationality of precision crop production that economic justification and risks of precision technology can be significantly affected by the soil parameters, heterogeneity of weed coverage and changes of sales prices. Active ingredients can be saved – depending on the aim - when precision nutrient supply is realized. When the aim is to reach homogenous yield at plot level, then actual active ingredient and cost savings can be realized by the site-specific dosage based on the nutrient content of the soil, thus improving the income position of crop production in addition to positive environmental impacts. In those cases when the site specific nutrient dosage goes together with different yield planning, the rational fertilizer use should also mean the optimization of income. If the sales conditions are good, the sales prices are expected to rise and further economic advantages are resulted by the implementation of the technology. In case of unfavourable sales conditions and low output prices, the shift to precision technology cannot be undertaken in economic sense.

Nevertheless, by applying precision technology, individual and societal benefits coincide, thus serving sustainability. In agriculture, the diffusion of every technological procedure that has a positive impact on conserving or re-producing natural resources and can be implemented in a profitable way on the level of farms (economic efficiency) supports sustainability. Furthermore, the proliferation of precision crop production promotes societal sustainability, together with the reduction of environmental pollution and the production of food, industrial raw materials and energy plantations.

Apart from economic arguments, precision technology can be supported by other factors as well. First and foremost, we must refer to its role in the reduction of the environmental load. However, it is not an important motivating factor for farmers, unlike for those who consider the transition to organic farming. Nevertheless, precision farming must be given outstanding attention in sustainable agriculture in developed countries. It must, however, be examined how it can be a real alternative in an economic respect. As it requires extra investment, expertise and accuracy, and its risks depend on a lot of unknown factors, farmers will not apply precision farming exclusively for 'philosophical' reasons.

It is necessary to find a balance between economy, environment and the social expectations. The goal from the perspective of the environment is to conserve and improve natural capital, the natural environment, while in terms of the economy to increase the efficiency of material goods' consumption. In terms of society it is necessary to ensure the creation and maintenance of equality. This can be done if production factors can be taken into account in wide range, realizing the causality. [2; 43]

In the agriculture at farm level, wide-spread of each technological process, which has positive effects on the preservation, "re-production" of natural resources, and can be achieved by the technology developments required for returns (economic efficiency) affect towards sustainability. In addition, the spreading of precision agriculture is to promote social sustainability with the reduction of environmental burden and the production of food and industrial raw materials, energetic objective raw materials. Creating the harmony between the individual and social utility, the triplet requirement of sustainability can meet within the plant production, applying this farming strategy in the long-run.

Conflict of Interest

The authors declare no conflict of interest.

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