Acta Agrophysica, 2008, 11(1), 101-116

CZECH AGRICULTURE IN THE PERIOD OF TRANSFORMATION*

Jan Křen[1,2], *Soňa Valtýniová*[1]

[1]Department of Agrosystems and Bioclimatology, Faculty of Agronomy,
Mendel University of Agriculture and Forestry in Brno,
Zemedelska 1, 61300 Brno, Czech Republic
e-mail: kren@mendelu.cz
[2]Agrotest fyto, Ltd., Havlickova 2787, 76701 Kromeriz, Czech Republic

Abstract. The paper gives an analysis of the state and problems of agrosystems under conditions of the Czech Republic, which can be characterized by:

- larger size of agricultural enterprises and farms,
- low inputs in soil and crop management for a long time (since 1990),
- decrease in livestock population, particularly in cattle, after 1990,
- big part of the managed soil is rented, which destabilizes agricultural enterprises and often leads to worse soil care,
- omitting fixed crop rotations, decrease in areas of good preceding crops (sugar beet, potatoes, legumes and perennial forage crops), considerable enlargement of areas planted with oil crops (rapeseed and poppy),
- higher variation in yield and production of main crops in recent years, which is likely to be caused by climatic changes that are emphasized by the mentioned problems.

This indicates that sustainability of the current agrosystems can be problematic in the future due to low inputs, inappropriate structure of grown crops and breaking of the rules of crop rotation. The farming systems applied increase rather than compensate for impact of climatic changes on production of field crops. Possibilities of improving this state are discussed.

Keywords: Czech Republic, arable farming, agrosystems development, sustainability of current agrosystems, yield stability of field crops

INTRODUCTION

The Czech Republic (CR) is a small country in the middle of Europe. The present state of its agriculture has resulted from a number of factors under given

*The study was supported by research plan No. MSM6215648905, and project No. 2B06101, both financed by the Ministry of Education, Youth and Sports of the Czech Republic.

soil and climatic conditions. The soil conditions are rather heterogeneous in the CR. Locations at altitudes of 150-650 m above sea level with various soils are used for agriculture – from fertile chernozems to less fertile light, gravelly or water-logged soils. Since the CR is located on the boundary of the continental and maritime climate, the weather course, including the winter time, is very different in particular years, with adverse impacts on agriculture, particularly on arable farming.

The current state is a result of the earlier historical evolution that has been influenced by:

- collectivization after World War II,
- extensive subsidies in the period of normalization (in the 1970s and 1980s),
- restriction of these subsidies and strong decrease in the number of workers in agricultural primary production mostly during the first half of the 1990s.

Basic data on the Czech agriculture are given in Table 1 and maps in Figures 1 and 2.

Table 1. Basic information about the Czech agriculture (source: Czech Statistical Office, adapted)

Area of the Czech Republic (km²)	78 886
Area of farm land in the Czech Republic (ha)	4 259 480
Number of inhabitants	10 287 189
Area of farm land per capita (ha)	0.41
Arable land (ha)	3 047 249
Grassland (ha)	974 000
Proportion of arable land (%)	71.5
Proportion of less favoured areas (LFA) (%)	50.2
Vulnerable areas according to Nitrate Directive (% of farm land)	44
Livestock units per ha (cattle)	0.32
Proportion of land under organic management (% of farm land)	6.6
of which: - arable land (%) - grassland (%)	 8.1 82.4
Area under minimum soil tillage (% of arable land)	ca 30
Area under precision farming (% of arable land)	ca 10

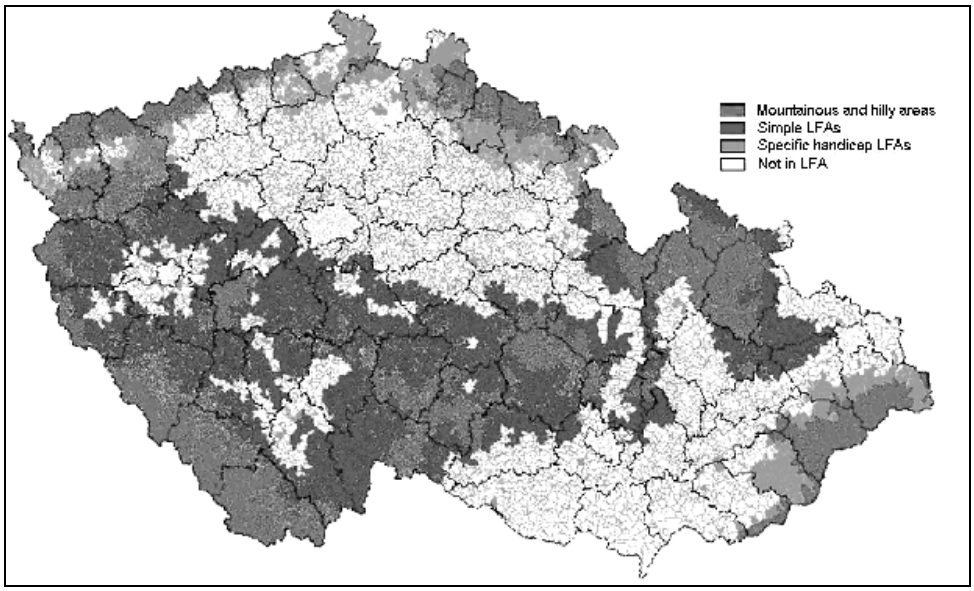

Fig. 1. Map of less favoured areas (LFA) in the Czech Republic (MOA CR 2007)

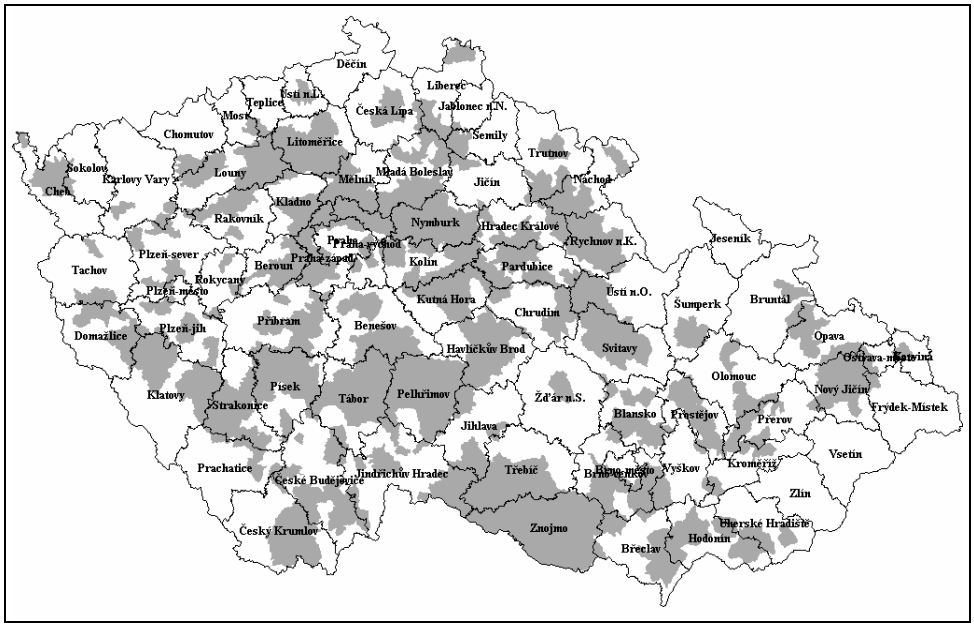

Fig. 2. Map of vulnerable areas according to the Nitrate Directive in the Czech Republic (MOA CR 2007)

RESULTS AND DISCUSSION

The present situation can be characterized by:

a) **Larger size of agricultural enterprises and farms.** Table 2 shows that ca. 88 % of farm land is managed by farms larger than 100 ha, and ca. 74% by enterprises larger than 500 ha. The present state is a result of agriculture collectivization after World War II during the period of socialism. After the political system changed in the 1990s, the restitution of collectivized property gathered in cooperative farms took place. Also, the government supported establishing family farms. Since the interest in such farming was small, various forms of big agricultural enterprises dominate now, such as original transformed cooperatives, Ltd. companies, share companies, business companies, etc. An advantage is the possibility of using high-performance machines and advanced technologies, above all in crop growing. A disadvantage is that the enterprises use rented land, which generates economic problems and destabilizes them, and often leads to worse soil care because farmers are not owners. The rented land accounts for 85.7% of private and almost 100% of state farm land, agricultural companies manage 94.8% and family farms 63.7% of rented farm land (Anonym 2007).

Table 2. Agrarian structure of the Czech Republic in 2005 (MOA CR 2006)

	Agricultural enterprises		Area of managed farm land	
Size (ha)	numbers	%	ha	%
0-5	24 171	53.9	37 099	1.0
5-10	5 163	11.5	35 813	1.0
10-50	9 148	20.4	205 027	5.7
50-100	2 096	4.7	146 423	4.1
100-500	2 391	5.3	516 956	14.4
500-1000	800	1.8	582 866	16.3
1000-2000	695	1.6	981 179	27.4
> 2000	362	0.8	1 080 360	30.1
Total	44 826	100	3 585 723	100.0

b) **Decrease in workers in agricultural primary production** (Fig. 3) that took place after social changes in the early 1990s. At that time, the situation in agriculture began to change. The agriculture - of a strategic importance during the socialist period - has been converted to market economy with 5 to 6-fold lower state subsidies as compared with those in the late 1980s. Also, the unfavour-

able conditions in agriculture settled for the accession to the EU played a certain role. In the period of three years (1991-1993), 270 300 workers left primary agricultural production for other sections of the national economy, which accounts for 48.9 % of the original status in 1990 (553 300). The decrease in agricultural workers has been continuing, even though at a slighter rate. In 2005, the percentage of people employed in agriculture sunk to 27.2 % of that of 1990 (Fig. 3). At present, less than 150 000 people are employed in the Czech agricultural primary production, which is a decrease by ¾ in comparison with the state at the end of the socialist period. In spite of this decline, production of a number of agricultural commodities surpasses domestic consumption (milk, cereals) and some of them are produced for export (malting barley, rapeseed, poppy seeds).

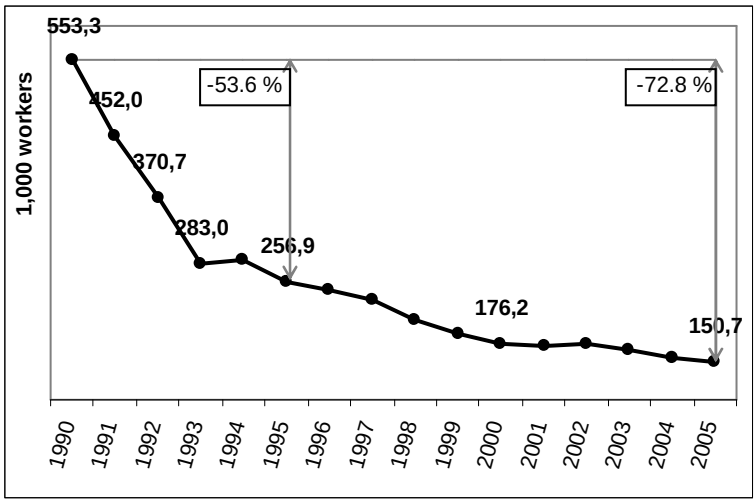

Fig. 3. Number of workers in the Czech agriculture (in 1,000; source: Czech Statistical Office, adapted)

It should be noticed that labour productivity has considerably risen in the agriculture after 1990, which is not, however, recognized in the society. The wages of agricultural workers rank among the lowest ones in the CR in comparison with the other sectors. The average wage in the agricultural primary production is 67 % of the national average (Vertelar 2007). Due to quitting the agricultural primary production by numerous academically educated personnel, the specialist level of agronomic services has decreased in many agricultural enterprises and requirements for advisory services have been increasing.

c) **Decrease in the livestock population** (Fig. 4). After 1990, the highest decrease has been recorded in cattle. The number of livestock units per hectare reduced from 0.66 in 1990 to ca. 0.32 at present. Likewise, pig and poultry stocks have fallen down. Particularly, the decrease in cattle and, in relation with it, the area under perennial forage crops has been negatively reflected in soil organic matter balance and quality of organic matter incorporated into the soil and in maintenance of soil fertility, particularly in lighter soils at higher altitudes.

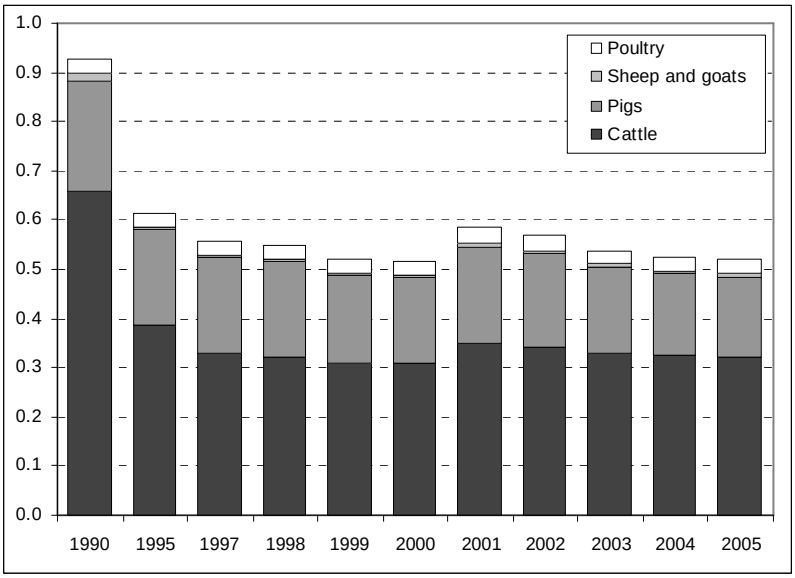

Fig. 4. Livestock farming intensity and livestock population structure (livestock units; source: Czech Statistical Office, adapted)

d) **Decrease in agrochemical inputs in crop growing.** The graph in Figure 5 illustrates the historical evolution (1920-2006) of cereal yields and consumption of main nutrients (NPK) in mineral fertilizers applied to 1 ha of farm land (1948-2006). The graph shows the relationship between the yields and supplied nutrients, which is confirmed by statistically significant correlations ($r = 0.48$ for NPK and 0.82 for N). Nutrient rates decreased from 272.6 kg NPK ha^{-1} in 1985 and have been stable on the level of ca. 90-100 kg NPK ha^{-1} since the early 1990 s. In 2005, 73.2 kg N, 11.7 kg P_2O_5 and 7.7 kg K_2O in mineral fertilizers were applied to 1 ha of farm land. The graph also indicates stagnation of cereal yields in the 1990s and their considerable variation over the last years. The yield stagnation can also be caused by low nutrient rates in combination with

minimized soil tillage management practices and establishment of crop stands. Such practices are used on about 30% of arable land. Interesting information is presented in Figure 6, demonstrating changes in emissions of acidifying gases since 1990. A considerable decrease in emissions is apparent, particularly in SO_2 during the 1990 s, resulting from sulphur removal in coal power stations (owing to changes in coal combustion procedures). Because of extensive increase in the rapeseed area (requiring more sulphur), some locations are in need of sulphur fertilization. The consumption of pesticides and their active ingredients for individual crop categories is given in Table 3. Decrease in the consumption of pesticides, above all herbicides and desiccants, was also recorded in the early 1990s (Fig. 7). Similarly to trends in agrarian advanced countries, proportions of individual groups of pesticides have been changing during the recent years tending to a slight increase in fungicides consumption, including seed protection agents and growth regulators. However, their consumption is still lower than that in Western Europe.

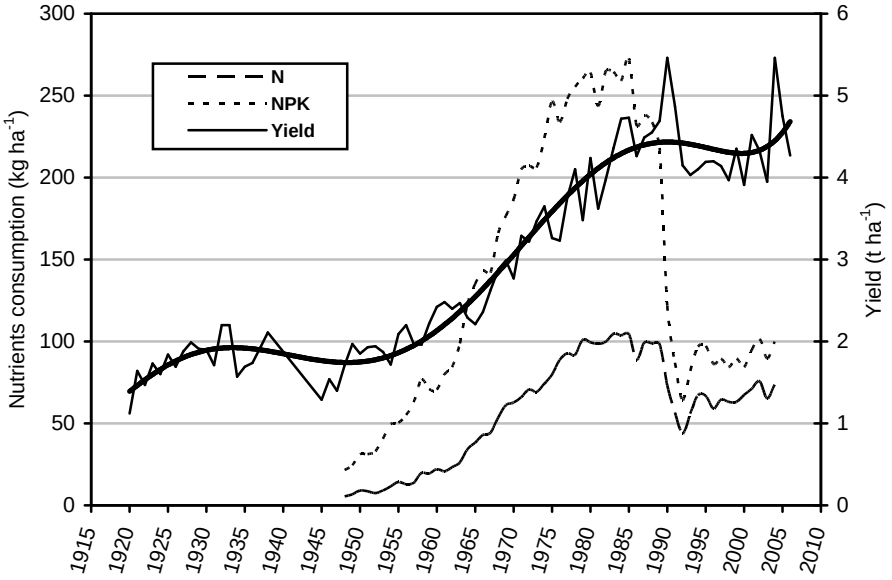

Fig. 5. Applied amount of fertilizers (kg ha^{-1}) and yield of cereals (t ha^{-1}) (source: Czech Statistical Office)

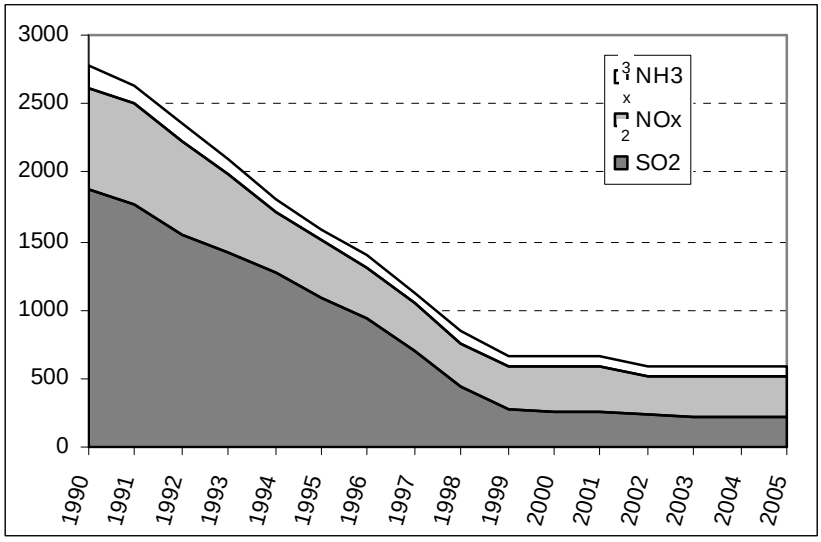

Fig. 6. Emissions of acidifying gases (1,000 t; ME CR 2007)

Table 3. Consumption of plant protection products (in standard font) and active ingredient (in *italics*) in 2005 (kg, l ha^{-1}) (State Phytosanitary Administration 2007)

Category	**Total**	Cereals	Maize	Sugar beet	Potatoes	Rapeseed
Herbicides and desiccants	**1.253**	1.174	2.711	10.82	2.013	2.391
	0.564	*0.544*	*1.706*	*3.577*	*0.654*	*0.945*
Fungicides	**0.490**	0.705	0.000	0.631	4.730	0.483
	0.217	*0.264*	*0.000*	*0.237*	*3.287*	*0.099*
Zoocides	**0.101**	0.028	0.045	0.316	0.301	0.605
	0.035	*0.008*	*0.008*	*0.079*	*0.096*	*0.212*
Others	**0.407**	0.792	0.167	0.161	0.263	0.648
	0.194	*0.427*	*0.139*	*0.102*	*0.105*	*0.278*
Total	**2.250**	**2.698**	**2.918**	**11.93**	**7.308**	**4.126**
	1.009	***1.243***	***1.853***	***3.995***	***4.143***	***1.543***

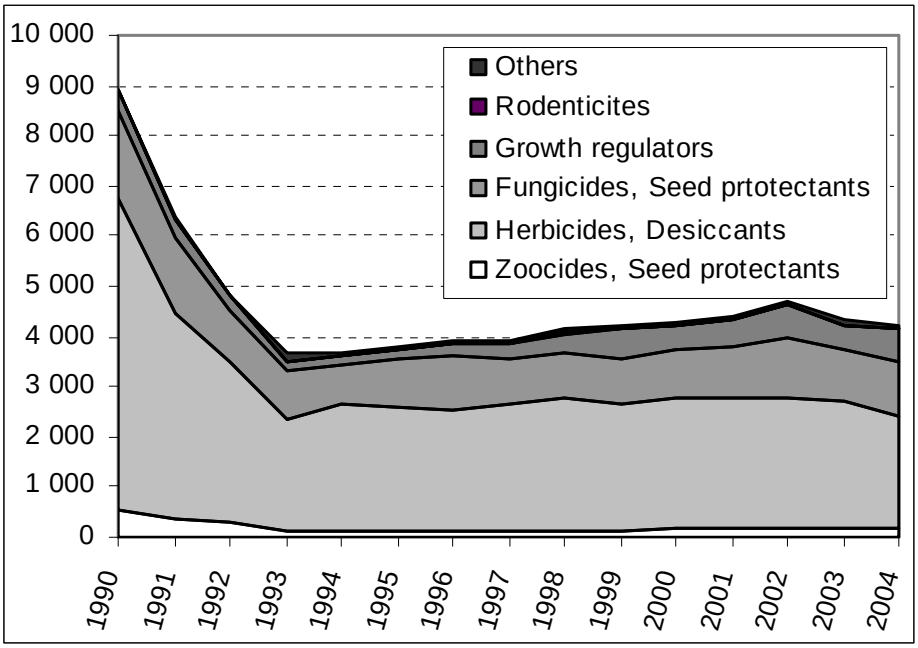

Fig. 7. Applied amount of pesticides (t of active ingredient; ME CR 2007)

e) **Increase in subsidies after the accession to the EU.** As mentioned above, the state subsidies in agriculture were restricted after 1989 and remained on a low level in the 1990s. They were substantially increased after the accession to the EU (1st May 2004), even though they accounted for only 25% of the level in West European countries. These changes in the total sum of subsidies and their structure are demonstrated in Figure 8. The planned development of the level of subsidies to Czech farmers in comparison with West European countries is presented in Figure 9. The graph shows that a comparable level with West European countries can be reached in 2010 (30% provided by the Czech government) and that provided directly from Brussels will be reached in 2013. It is interesting that the increase in subsidies was not reflected in higher yields of crops in 2005 and 2006. It was obviously due to the fact that these means were used to cover deficits in agricultural enterprises resulting from previous economic deprivation.

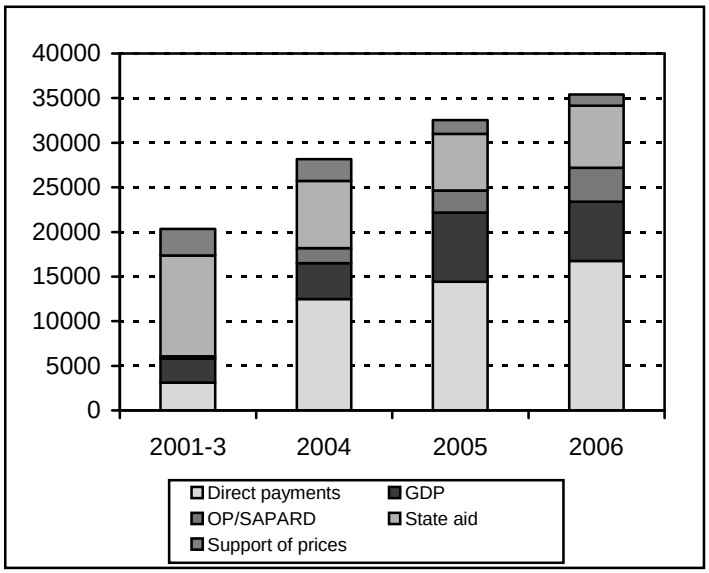

Fig. 8. Structure of subsidies to agriculture in the years 2001-2006 (mld. CZK; Doucha 2007)

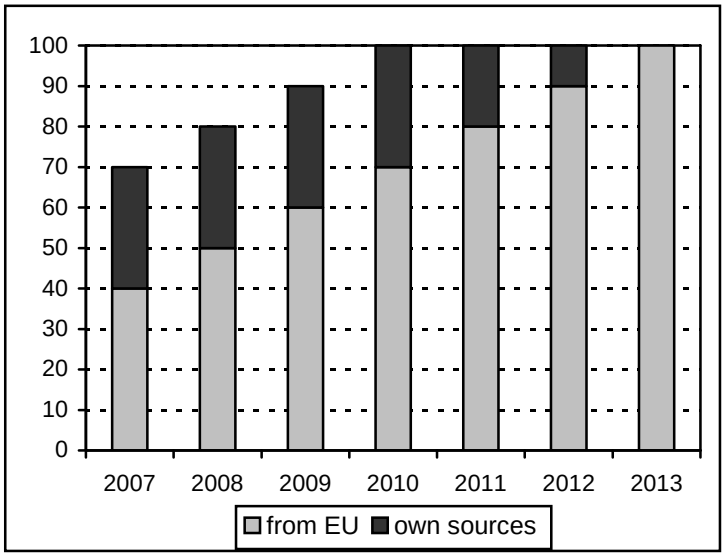

Fig. 9. Source of funding for subsidies to agriculture in the years 2007-2013 (%; Fajmon 2007)

f) **Change in the grown crop structure** caused by unfavourable economic situation of agricultural enterprises in the 1990s and possibilities to market the production. Figure 10 illustrates the reduction in the area under annual and perennial forage crops due to the decrease in cattle stock, the area planted to root crops (sugar beet and potatoes) and legumes. In cereals, the area of rye, oat and partly winter barley has declined and furthermore, the area of triticale increased, which has resulted in total slight reduction in the area of cereals. This decline was compensated for by larger areas of oil crops, particularly rapeseed and poppy and as well as maize for grain. At present, the main profitable crops in the CR are particularly malting barley, bread wheat, rapeseed and poppy, and in the case of sale contracts, also potatoes and sugar beet. In general, these changes have led toward a lower proportion of good preceding crops in crop rotations and decrease in agrosystem homeostasis.

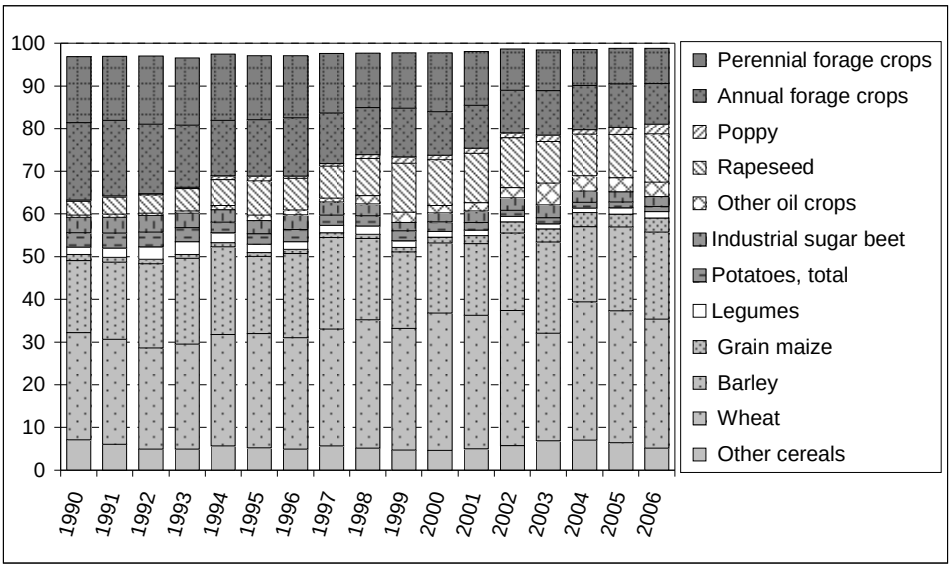

Fig. 10. Structure of crops (% of total sowing area; source: Czech Statistical Office, adapted)

g) **Higher variation in yields of crops during the last years.** The stagnation of yields in the period of 1992-2002 and increase in their variation over the last years are presented for cereals in Figure 11, and for root crops, oil crops and legumes in Figure 12. It can be assumed that low homeostasis and stability of agrosystems in the CR is a result of the factors applied for a long time (more than 10 years):

- low rates of nutrients in mineral and organic fertilizers,

- relatively low rates of pesticides, particularly fungicides,
- omitting fixed crop rotations, decrease in areas of good preceding crops (sugar beet, potatoes, legumes and perennial forage crops),
- considerable enlargement of the area under oil crops (rapeseed and poppy).

The negative effects of these factors are strengthened by extreme weather changes (severe frosts, heat and drought, torrential rains) whose frequency has been increasing during the last years. An example can be:

- winter destruction of winter crops (rapeseed, winter barley and winter wheat) in 2003 due to severe frosts without a snow cover,
- heat and drought in July and August in 2006,
- irregular local torrential rains (thunderstorms with hails) that considerably damage crop stands.

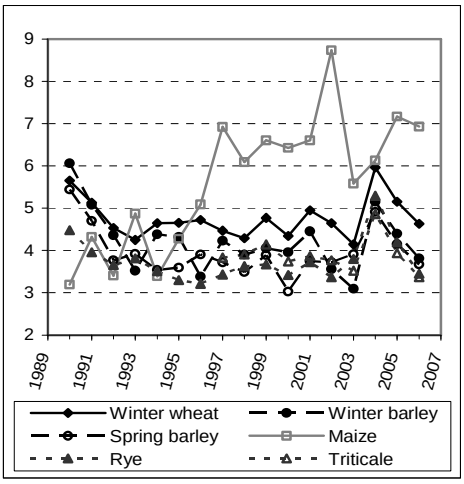

Fig. 11. Trends in yield of cereals (t ha^{-1})
(source: Czech Statistical Office, adapted)

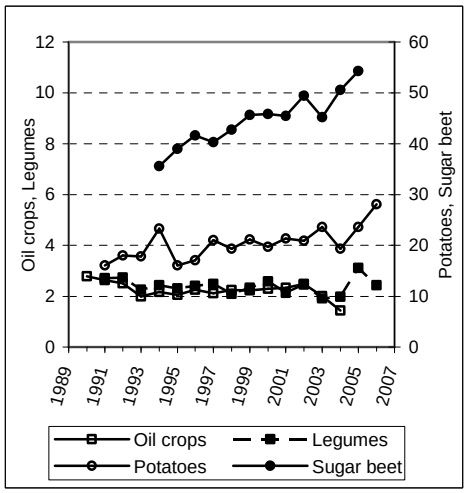

Fig. 12. Trends in yield of oil crops, legumes, potatoes and sugar beet (t ha^{-1})
(source: Czech Statistical Office, adapted)

Possibilities of solving the mentioned problems

The objective of EU conception is agriculture which is multifunctional, sustainable and competitive. That means that it has to ensure food production, but also landscape management, conservation of natural resources, sustaining of rural settlement, etc., and at the same time farming has to be economically viable.

The conception of sustainability broadens agronomical and ecological question with economical and social dimensions. Presented data indicate that keeping

sustainability of the current agrosystems in the CR can be problematic in the future due to low inputs, inappropriate structure of grown crops and breaking of the rules of crop rotation. The used farming systems increase rather than compensate for impacts of climatic changes on production of field crops.

In fact, agricultural enterprises and farmers have to solve problems resulting from the two basic controversial requirements:

a) to be flexible in responses to current market conditions,
b) to assure sustainability of farming systems.

Due to the large size of farms in the CR, evaluation of farming sustainability is of great importance. However, most ways of sustainability assessment continue, through various modifications, the methodology which was originally developed for conditions of West European countries, i.e. mostly for smaller farms with stable economic and possessive relationships (Hülsbergen 2003). The values of indicators are usually expressed by weighted mean on a farm level.

However, such an approach seems to be disputable in the CR due to larger farms and fields. If analyses are carried out on larger farms, some information on systems heterogeneity can be lost and results can be biased.

The needed assessment of heterogeneity in soil and crop characteristics within fields, which fulfils the idea of precision agriculture and allows site-specific application of cropping treatments and limitation of unfavourable impacts on the environment, is complicated in practice by special and interdisciplinary demands (it requires knowledge of agronomy, the latest technology and informatics). Information on internal heterogeneity of the soil-crop system within the field is usually provided to agricultural practice separately according to individual soil and crop characteristics, without sufficient interconnection, which affects effectiveness of practical use.

At present, there is another handicap consisting in insufficient methodological interconnection between use of the information on heterogeneity in soil and crop characteristics within fields obtained from precision agriculture and generally employed methods for the assessment of farming sustainability that are mostly oriented to higher levels of agro-ecosystem (region, farm, field). Detailed analyses of several soil and crop stand characteristics and their variability within fields are not common, even though agricultural practice urgently calls for them. Here is a space for system research aimed at closer interconnection of sustainability conceptions and precision agriculture. It is also a field for application of information technologies and special models that enable the assessment of a huge amount of information of various characters.

CONCLUSIONS

1. The performed analysis showed the problems and factors of long-term effects (more than 10 years) in prevalent farming practices and agrosystems in the CR. These are particularly:

- low rates of nutrients in mineral and organic fertilizers,
- relatively low rates of pesticides, particularly fungicides,
- omitting fixed crop rotations, decrease in areas of good preceding crops (sugar beet, potatoes, legumes and perennial forage crops),
- considerable enlargement of the area under oil crops (rapeseed and poppy).

2. The cause was a long lasting unfavourable economic situation in 1990-2003. Its result was quitting the agricultural primary production by almost ¾ of workers and considerable increase in labour productivity. Negative implications are:

- stagnation of yields in most crops (except yields of root crops and maize for grain that are grown on rather small areas),
- higher variability in yields of crops in the last years, low homeostasis and stability of agrosystems (insufficient adaptation ability and higher vulnerability).

3. The negative effects of the above-mentioned factors are strengthened by extreme weather changes (severe frosts, heat and drought, torrential rains) whose frequency has been increasing during the last years. The used farming systems increase rather than compensate for impacts of climatic changes on production of field crops.

4. In reality agricultural enterprises and farmers have to solve problems resulting from the two basic controversial requirements:

a) to be flexible in responses to current market conditions,
b) to assure sustainability of farming systems.

5. Due to large farms in the CR, evaluation of farming sustainability is of great importance. Most methods for optimising and evaluating sustainability have been developed for conditions of West European countries, i.e. mostly for smaller farms with stable economic and possessive relationships. The values of indicators are usually expressed by weighted mean on a farm level. But such an approach seems to be disputable in the CR due to larger farms and fields. If analyses are carried out on larger farms, some information on systems heterogeneity can be lost and results can be biased. Here is a space for system research aiming at closer interconnection of sustainability conceptions and precision agriculture. It is also a field for application of information technologies and special models that enable the assessment of a huge amount of information of various characters.

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CZESKIE ROLNICTWO W OKRESIE TRANSFORMACJI

Jan Křen[1,2], Soňa Valtýniová[1]

[1]Katedra Agronomii, Wydział Agrosystemów i Bioklimatologii,
Uniwersytet Rolnictwa i Leśnictwa im. Mendela w Brnie,
ul. Zemedelska 1, 61300 Brno, Czeska Republika
e-mail: kren@mendelu.cz
[2]Agrotest fyto, Ltd., Havlickova 2787, 76701 Kromeriz, Czech Republic

S t r e s z c z e n i e. Praca przedstawia analizę aktualnego stanu i problemów dotyczących agrosystemów w warunkach Czeskiej Republiki, które można scharakteryzować poprzez:

– większe areały przedsiębiorstw i gospodarstw rolniczych,
– niskie nakłady na uprawę gleby i plonów przez długi okres czasu (od roku 1990),
– spadek populacji trzody, szczególnie bydła, po roku 1990,
– znaczna część uprawianych gleb jest dzierżawiona, co destabilizuje przedsiębiorstwa rolne i często powoduje obniżoną dbałość o gleby uprawne,
– rezygnacja z płodozmianu, ograniczenie areału dobrych przedplonów (buraka cukrowego, ziemniaka, roślin strączkowych i wieloletnich roślin pastewnych), znaczne zwiększenie areału pod roślinami oleistymi (rzepak i mak),

– wyższa zmienność plonowania i produkcji głównych plonów w ostatnich latach, co może być spowodowane zmianami klimatycznymi, których wpływ jest potęgowany przez wymienione problemy.

Wszystko to wskazuje, że utrzymanie zrównoważenia aktualnych agrosystemów może być w przyszłości problematyczne, z uwagi na niskie nakłady finansowe, niewłaściwą strukturę plonów oraz łamanie zasad płodozmianu. Stosowane systemy uprawy wzmacniają raczej niż kompensują wpływ zmian klimatycznych na produkcję rolną. Przedstawiona jest dyskusja dotycząca możliwości poprawy tego stanu rzeczy.

Słowa kluczowe: Czeska Republika, uprawa roli, rozwój agrosystemów, zrównoważenie aktualnych agrosystemów, stabilność plonowania upraw