Inputs, yields and economic parameters of three farming systems compared at Burgrain (Switzerland).

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Introduction

During the late 1980ies there was growing evidence that Swiss agriculture needs to comply better with the principles of sustainability and the market demands. Therefore, in 1991 a group of researchers and extensionists started a long-term trial on the experimental farm Burgrain to compare agronomic, economic and some environmental effects of three arable farming systems. Conversion of a previous low-input systems to an organic system was completed in 1997. This paper presents the results of the years 1997 to 1999.

Material and methods

The experimental farm Burgrain is situated in central Switzerland close to Lucerne 520 meters above sea level. Average rainfall is 1200 mm per year and mean temperature is about 9.8°C. The mixed farm covers 44 hectares including 23 hectares of arable fields. Its main activities are dairy cows, some pigs, poultry and arable crops. In 1990 the number of livestock units per hectare was reduced from 2.8 to 2.2. According to different soil types of the plots, two crop rotations of six years are carried out. On mineral soils the arable crop rotation consists of 1. potatoes followed by white mustard, 2. winter wheat followed by clover grass, 3. maize for corn production, 4. spring barley, 5. and 6. clover grass. On heterogeneous partly organic soils the crop rotation is 1. maize for silage, 2. spring oats, 3. winter barley, 4. and 5. and 6. clover grass. In order to compare the three arable farming systems side by side all 12 plots were divided in 1991 into three strips of 0,7 hectare each. The three farming system compared are:

- **(IS)** medium intensive farming system reflecting a local farming system with 2,4 livestock units per hectare and maximising yields on the short term.
- **(IP)** integrated farming system following the guidelines of SVIAL (Niklaus et al. 1992) for a rather extensive integrated farming. It intends to optimise the use of farmyard manure and slurry of 1,8 livestock units per hectare in meadows as well as in arable crops, complemented with mineral fertilisers. It applies, if possible mechanical weed control and participates in the Extenso-program for cereal cultivation (subsidies for renunciation on fungicides, insecticides and growth regulators).
- **(O)** organic farming system at plot level. This system uses farmyard manure and slurry exclusively (1,8 livestock units/ha) as fertilisers and the only products applied for direct plant protection were copper and B. thuringiensis-products. From 1992 to 1996 this system was a low-input system with minimal input of synthetic products for plant protection and no mineral fertilisers.

The three farming systems at Burgrain, therefore, differ mainly in amount and form of fertilisation and plant protection whereas crop rotation, soil cultivation and crop varieties are almost the same.

Results

The farming systems compared at Burgrain showed clear differences in the amount or form of the inputs used for production.

Input of readily available nitrogen (nitrate and ammonia) per crop and year (Tab. 1) was 39 % lower in the organic (O) and 30 % lower in the integrated system (IP) than in the local intensive system (IS). This was due to the lower number of livestock units /ha in these systems and the limited use of synthetic fertiliser-N per crop and year (0 kg in O, 30 kg in IP and 69 kg in IS).

Table 1. Mean annual input of nitrate and ammonia nitrogen (kg N /ha) per crop in the farming systems at Burgrain.

	arable crops			clover grass		
	IS	**IP**	**O**	**IS**	**IP**	**O**
synthetic fertilizer	69	30	0	0	0	0
organic fertilizer	38	47	65	184	118	118
total input per crop	**107**	**77**	**65**	**184**	**118**	**118**

In the systems O and IP farmyard slurry was distributed on almost every plot including cereals. In contrast, IS applied slurry only in meadows and used higher quantities of manure in the row crops than the other systems.

Plant protection in IS strongly relied on synthetic pesticides. The organic system O made only a few applications of copper and *Bacillus thuringiensis* in potatoes (Tab. 1). IP also worked with a reduced number of applications but used mainly synthetic products.

Table 2. Mean annual number of applications of plant protection products or mechanical passages per crop in the farming systems at Burgrain 1997-1999.

	number of applications			number of mechanical passages		
	IS	**IP**	**O**	**IS**	**IP**	**O**
potatoes	8.7	4.7	4.0	1.3	3.7	3.7
corn	1.0	0.3	0	0	1.7	2.7
cereals	3.0	0.5	0	0	0.75	1.35
mean of 7 arable crops	**3.2**	**1.0**	**0.6**	**0.19**	**1.44**	**2.07**

The reduction of herbicide applications in O and IP was partly compensated by a higher number of passages for mechanical weed control. In clover grass plots of the organic system high densities of *Rumex obtusifolius* emerged. This caused several hours of hand weeding in contrast to IS and IP, where one herbicide treatment was done in the year of meadow sowing.

Mean yields over the two crop rotations were 12 % lower in O and 8 % lower in IP than in IS (Fig. 1). Differences between the systems were smallest in the clover grass meadows (-5% in O) that produce high dry matter yields of 157 dt /ha in the area of Burgrain. For arable crops, mean yields were 17 % lower in O than in IS. Biggest yield reductions were observed in cereals. This was probably due to the high disease incidence observed in the rainy climate at this site. The same occurred in IP as this system participated in a program to obtain subsidies for pesticide-free cereal growing. Surprisingly, the yield reductions in organic potato cultivation at Burgrain during 1997-99 were only 12 % of IS.

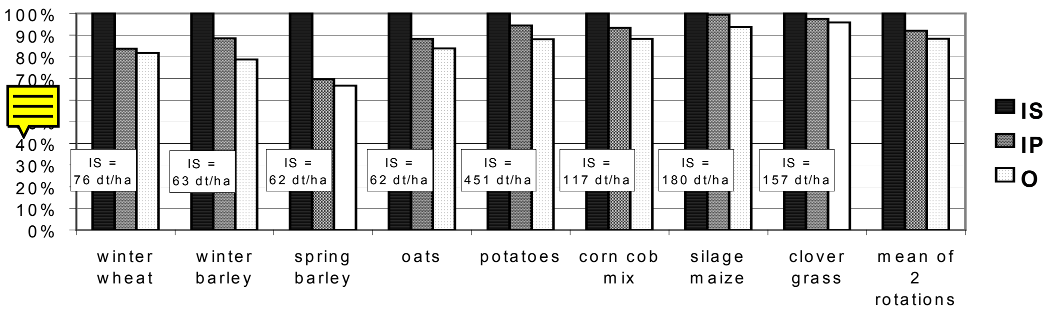

Figure 1. Mean relative yields of different crops of the farming systems at Burgrain (IS = 100%) in 1997-1999.

Mean costs of production per arable crop in O were almost the same as in IS (Tab. 3). The savings in direct costs

Table 3. Mean crop value, production costs and net profit for arable crops without any subsidies in the farming systems, Burgrain 1997-1999.

	units	**IS**	**IP**	**O**
I: crop value at conventional price	SFr./ha	5951	5345	5162
II: total costs of production	SFr./ha	-3513	-3330	-3571
direct costs of production	SFr./ha	-1532	-1319	-1380
labour costs of production	SFr./ha	-991	-1038	-1152
machine costs of production	SFr./ha	-990	-973	-1039
I-II = net profit II	**SFr./ha**	**2438**	**2014**	**1591**

of production were spent by the higher labour input. Due to lower yields the net profit II of the system O was 847 SFr. lower per hectare and year when calculated without any subsidies for organic farming and at conventional product price.

Table 4. Differences in net profit of arable crops of the systems IP and O at Burgrain in comparison to IS including subsidies and direct payments 1997-1999.

	units	IP	O
difference in net profit II to IS without any subsidies	SFr./ha	-424	-847
subsidies for pesticide-free cereal growing	SFr./ha	+ 266	+266
direct payments for environmental friendly farming systems	SFr./ha	+800	+1400
difference in net profit II to IS with subsidies and direct paym	SFr./ha	+642	+819

In Table 4 the subsidies paid by the government for less extensive cultivation of arable crops are added (pesticide-free cereal growing 400 to 500 SFr./ha per year, whole farm integrated production 800 SFr./ha, whole farm organic production 1400 SFr./ha per year). Taking these payments into consideration, the systems IP and O reach a higher net profit II of 642 or 819 SFr./ha per year than IS. In addition, organic products of the system O can reach significantly better economic results than IS or IP if the products can be placed in the corresponding marketing channel.

The influence of farming systems on soil aggregate stability was small and not consistent over the 6 plots studied (Fig. 3). This could be partly explained by the similar type of soil cultivation in all three systems. Lowest values for all farming systems were observed in the soil of plot 1 that contains a slightly lower clay and C-content than the other plots. Also for soil pore volume, no differences between the farming systems were observed (Zihlmann et al., 1999) but the crucial role of the skill of the farmer to cultivate the soil at the right time and in an adequate way became evident.

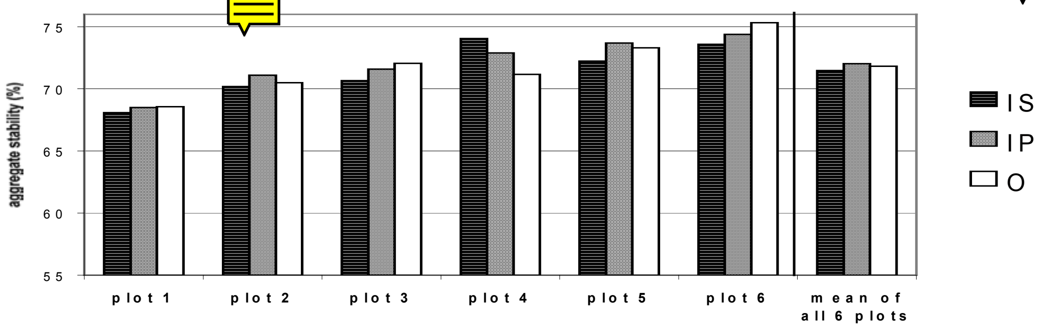

Figure 2. Mean soil aggregate stability of the farming systems in 6 plots of the arable crop rotation 1997 –1999.

In most assessments the plots of O showed the same or a slightly higher earth worm biomass than IS. For the group of endogaeic earth worms this difference was statistically (P= 0,05) significant (Fig. 3). In previous years the chemical haulm destruction of potatoes in IS showed clear negative effect on earth worm population.

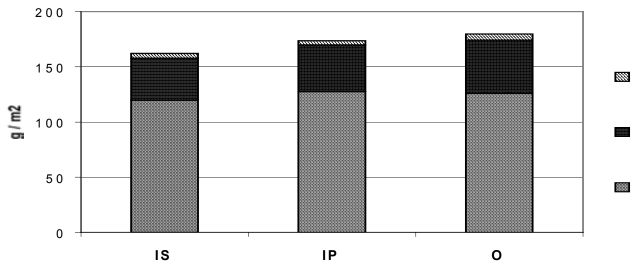

Figure 3. Mean earth worm biomass in plots of the farming systems at Burgrain (1997-1999, 1. rotation)

Soil content of mineral nitrogen (N_{min}) in november was measured in all plots of the first crop rotation to estimate the nitrate leaching risk. In general the N_{min}-values analysed at Burgrain (Fig. 4) were rather high. The amount of mineral nitrogen remaining at the end of the growing season in the soil (0 to 100cm) was strongly influenced by the crop. After potatoes mean N_{min}–values of up to 120 kg N/ha were measured. However, the farming systems compared at Burgrain showed only small differences in the nitrate leaching risk when the whole crop rotation is compared.

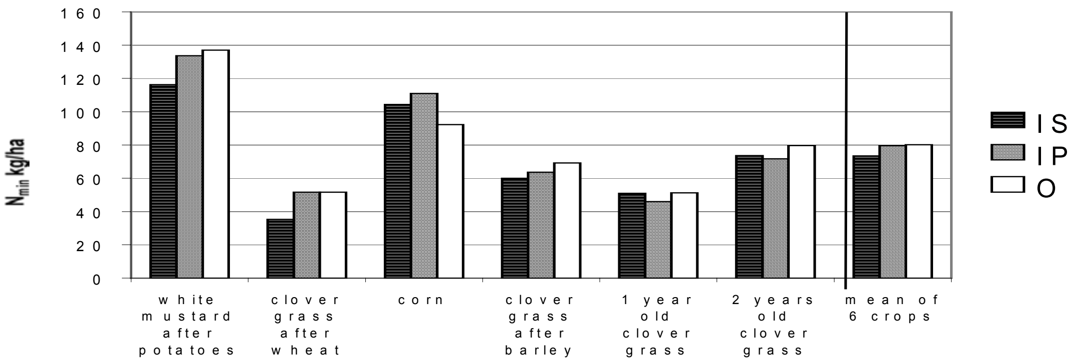

Figure 4. Mean soil content of mineral nitrogen of the farming systems in november in six crops 1997-1999.

Discussion

The farming system comparison at Burgrain clearly demonstrates the feasability of the conversion of an arable crop rotation to organic cultivation on a mixed farm. Yield reduction of the organic system over all crops was only 12 % in comparison to the local medium intensive system. Clover grass meadows with only 5 % yield reduction partly balanced the higher yield losses in the arable crops. Surprisingly, potato yields of O reached 88% of IS at Burgrain with 4 kg /ha copper per year in comparison to only 70% in an other system comparison in Switzerland (Dubois et al. 2000). Utilisation of slurry as well as mechanical weed control in arable crops including cereals gave good results in O and IP after some experience had been obtained. In contrast, in clover grass the control of dock (*Rumex obtusifolius*) that emerged from the seed bank accumulated during previous years caused problems after conversion to organic farming.

According to the economic appraisal the savings in direct production costs of O only compensate its higher labour and slightly higher machine costs, in comparison to IS, in arable crops. Due to lower yields the systems O and IP produces a lower net profit II (Tab. 3) than IS assuming the same product price. Only by the governmental subsidies for less intensive farming activities these systems obtain a slightly better net profit than IS. For the system O this economic result can be improved even more if the full price for organic products is obtained on the market.

For the environmental parameters assessed only small differences were observed yet between the three farming systems. More parameters need to be analysed and during a longer time period, bearing in mind that the difference in farming activities between types of farming systems on a medium intensive mixed farm in central Switzerland as Burgrain, are not as big as say on a more specialised farm or in a region with traditionally intensive agriculture. The trial at Burgrain also points out the importance of the skill of the farmer for the agronomic, economic as well as environmental impact of his activities.

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