An agro-economic analysis of grain production in Estonia after its transition to market economy

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Abstract. For analysing agronomic efficiency and economic criteria, the results of variety comparison tests of cereals, performed in Estonia during twenty years, national statistics and the data of the survey of the Farm Accountancy Data Network (FADN) for 2000–2003 were summarised. Farms whose grain production contributed more than 75% to total output were selected for analysis. At present only ~40–50% of the real yield potential of cereals is realised. In case of oilseed rape the utilisation of the yield potential is 60–65%. Among the cereals, the largest share is accounted for by barley with 25–43% and wheat with 15–29%. During four years (2000–2003), total inputs increased 21%. Total inputs were the highest in large farms. As an average for 2000–2003 FADN grain producers were profitable in all size groups but consideration of total labour costs indicates that small grain farms were unprofitable. Average farm family income was 1,376 EEK ha^{-1}. There is a non-linear relationship between farm size and economic indicators. Farm family income increases up to ~400 ha. The increase is most significant in the size range 40–200 ha where the increase in farm size by one hectare increases profit by 7.6 EEK ha^{-1}. Further increase will decelerate profit and the most efficient use of labour occurs in this size range as well. Cost benefit is the highest for farm size ranging from ~150 to 400 ha. Profit decreases with the increase in one annual work unit by 508 EEK ha^{-1} and production becomes unprofitable in case a grain farm employs more than 2.6 workers per 100 ha.

Key words: grain farms, profitability, yield potential, fertilisers, FADN

INTRODUCTION

The total production of Estonian agriculture has decreased more than two times in the period following the regaining of independence. The proportions of agriculture, hunting industry and forestry in the gross domestic product have decreased 2.5 times. The growth area of field crops has decreased 350 thousand hectares, among which the area of fodder crops has decreased 200 thousand hectares, the area of cereal crops 123 thousand hectares and the area of potato 23 thousand hectares. The area of arable land per animal unit is 2.6 hectares and the average yield of fodder crops per hectare of arable area is 23.6 GJ. The total yield of cereals has decreased on average 22.5 Mg per year, which accounts for 3% of initial production. The most drastic decline has occurred in the cultivation of rye and barley, 9.1 Mg or 7% and 23.3 Mg or 4.9% per year, respectively. The growth area has increased for wheat, rape and legumes. In 2000–2003 the total production of cereals was 571.4 Mg; domestic use was 740.5 Mg, from which import accounted for 26%. The role of import was particularly significant in case of wheat. Considering the yield and its stability, Estonia ranks among the last countries in Europe.

The drastic decrease in crop production is caused by the soaring prices of machinery, fuel, fertilisers and plant pesticides as well as by the instable and low market prices of agricultural products. Also the national ultra-liberal agricultural policy and a rigid foreign exchange rate may have intensified the decline (Yao, 2005). Agricultural production has become more environment friendly but proportionately less effective. Agricultural production must be both agronomically and economically efficient and environment friendly. The agronomical efficiency of grain production is important in view of both local and global food demand. Considering available biophysical resources, Estonia is capable of at least recovering the average level of self-sufficiency for cereals. Dobermann and Cassmann (2002) have estimated that farm yields must account for 70–80% of the yield potential to cover increasing world food demand. During the last decade, Estonia has been not able to ensure agricultural self-sufficiency.

The competitive ability and profitability of Estonian agriculture have been explored at the state level (Alanen, 1999; Roostalu, 2000; Yao, 2005; Swinnen et al., 2005) and at the regional level (Maidre & Lilover, 2003). Although studies have been made of profitability calculations for grain production (Möller et al., 1998; Vassiliev & Ellermäe 2002; Loko et al., 2005), analysis of the real situation in farms specialising in grain production has been lacking. The aim of the present study was to assess the production potential of Estonian grain production and to analyse agro-economic indicators in test farms in 2000–2003. Estimation of agronomic efficiency of grain production was based on the realisation of yield potential in actual production. The analysis of agronomic efficiency and economic indicators allows assessing the sustainability of grain producers.

MATERIALS AND METHODS

For analysing agronomic efficiency and economic criteria, the results of variety comparison tests of cereals, performed in Estonia during twenty years, national statistics and the data of the survey of the Farm Accountancy Data Network (FADN) for 2000–2003 were summarised. FADN has been under-utilised but it is more capable than presumed (Vrolijk et al., 2004). The yield potential of cereals and oilseed rape was provisionally equalled with the yield obtained in variety comparison tests. The data of the agricultural subsidies for grain production were obtained from the Agricultural Registers and Information Board.

The methodology of FADN enables to extrapolate the data of economic results for the agricultural holdings included in the sample to the agricultural sector as a whole. The Jäneda Training and Advisory Centre is responsible for a FADN survey in Estonia. The current paper uses the FADN terminology.

According to the FADN database, the farms whose grain production (cereals, legumes and oilseed crops) contributed more than 75% to total output were selected. The whole analysed sample consisted of 287 observations. This approach enabled to analyse the agro-economic parameters of specialised grain producing farms, for which correlation analyses were applied. The average size of the farms in the sample was 262 ha. As this figure is markedly higher than the national average, the assessment of economic indicators had to proceed from the difference in the size groups. The grouping of the farms is based on the size of the utilised agricultural area. In some studies (Judez et al., 2001; Judez & Chaya, 1999; Rezitis et al., 2002), the grouping of the FADN farms is based on the European Size Units (ESU). Economic size of the farm in ESUs is obtained by dividing the total standard gross margin of the holding by EUR 1,200. As farm size in hectares and farm size in ESUs were significantly linearly correlated (r = 0.95; P < 0.01), it was possible to carry out grouping on the basis of area.

RESULTS AND DISCUSSION

Yield potential and its utilisation

The many-year average yields of winter cereals in the case of a near optimum agricultural background are 3.5 Mg ha^{-1} (Fig. 1). In unfavourable years, with a probability of one year out of ten, the yield of rye and winter wheat can be less than 2 Mg ha^{-1}. However, in favourable years, with a similar probability, the yield of winter cereals can be 5.5 Mg ha^{-1}. In case of extremely severe frost damage, the yield of winter cereals can be even lower than 1 Mg ha^{-1}.

Among the studied varieties, the real yield potential of winter wheat in the pedo-climatic conditions of Estonia and with the agro-technology used to date is 7.0 Mg ha^{-1} and the maximum yield of rye in favourable years has been as much as 8.0 Mg ha^{-1}. According to the results of variety comparison tests, the yield of spring cereals has been somewhat higher compared with winter cereals. The average yield potential of spring wheat is more than 4 Mg ha^{-1}, the yield of oats 4.5 Mg ha^{-1} and the yield of barley up to 5.0 Mg ha^{-1}. A maximum yield among the studied varieties, obtained in variety comparison tests, was 6.5 Mg ha^{-1} for spring wheat, 7.5 Mg ha^{-1} for oats and more than 8.0 Mg ha^{-1} for barley. At the same time, in case of an extremely droughty summer, the yield of spring cereals can be only 1 Mg ha^{-1}. The average yield of oilseed rape is 2.0 Mg ha^{-1} and the maximum yield has reached 3–3.5 Mg ha^{-1}; however, the risk of yield failure due to plant pests is relatively high. Taking into account the existing level of production and weighing it against the level estimated from variety comparison tests, it appears that only ~40–50% of the real yield potential of cereals is realised at present. In case of oilseed rape, the utilisation of the yield potential is 60–65%.

At the same time, the analysis shows that cereal cultivation is related to extremely high risk due to natural factors, as pedo-climatic conditions affect not only the yield but also its quality. Climatic conditions influence 1,000 kernel mass to a great degree and the other indicators of yield quality which determine the selling price of a grain crop as well as its suitability for use.

The yield of cereals depends mainly on soil fertility, climatic conditions and use of fertilisers (Fig. 2). Increase in the yield of cereals at the expense of soil fertility is about 36–40 kg per point of soil quality. The effect of climatic conditions on the yield of cereals depends on the soil, the species and the variety as well as on fertilisation. Considering different years, climatic conditions in the intensive growth period of plants in Estonia are unstable. The difference in rainfall is up to 3–4-fold and the difference in average air temperatures in the growth period of spring cereals is up to 4°C. Depending on the soil, the yield of cereals can increase on average 10–99% at the expense of fertilisers. Yet the variation in yields, related to climatic conditions, is 2–4 times higher compared with yield increase at the expense of fertilisation. The low realisation of yield potential is certainly caused by insufficient fertilisation of crops. Of the cereals, 76% were fertilised in 2001–2003, while the average rate of mineral nitrogen was 45 kg ha^{-1} (Table 1). Fertilisation was more intensive in case of oilseed rape, which has ensured much higher realisation of the yield potential in the current production conditions.

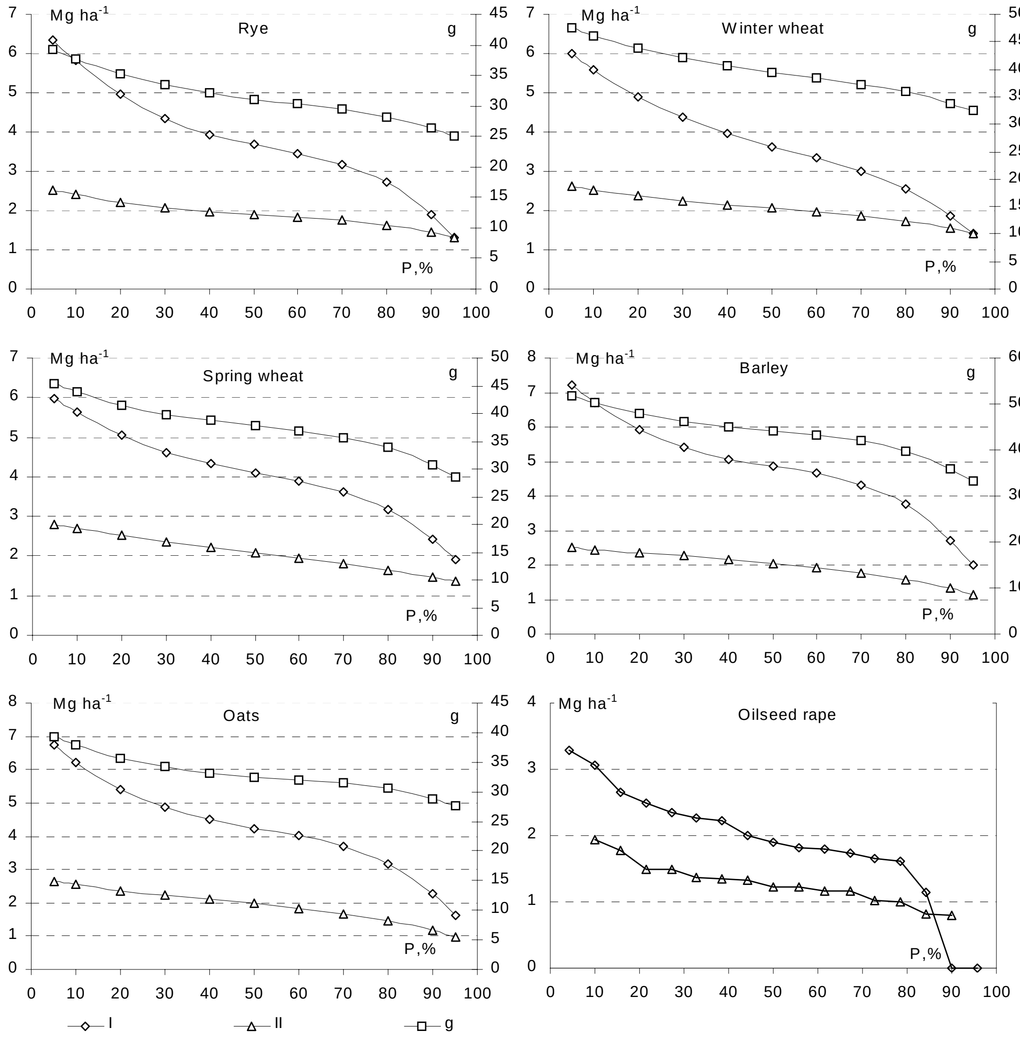

Fig. 1. Probability (P, %) of the yield and 1,000 kernel weight of cereals in variety comparison tests (I) and in farming (II) conditions (national average).

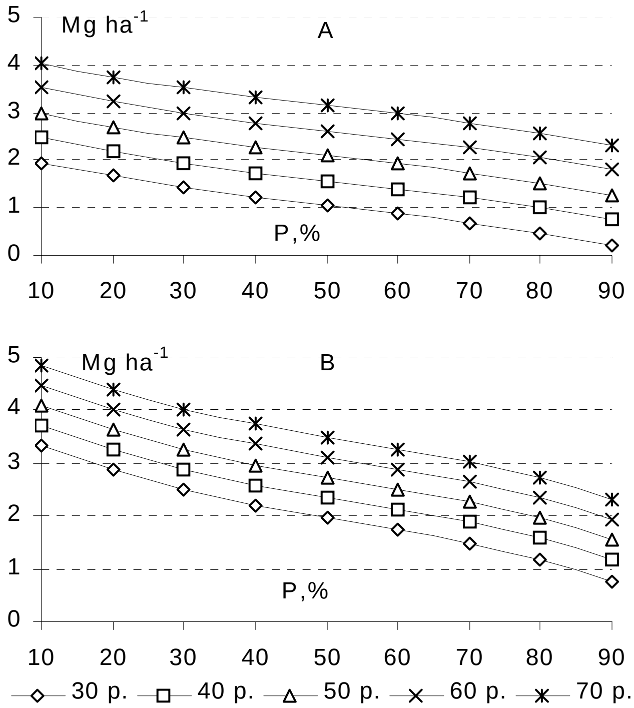

Fig. 2. Probability (P, %) of the barley yield depending on soil quality points without (A) and with agronomically effective (B) fertilisation.

Table 1. Use of mineral fertilisers in Estonia, 2001–2003.

Crop	Nutrient, kg ha^{-1}			Fertilised area, %
	N	P	K	
Cereals and grain legumes	45	5	14	76
Oilseed rape	66	10	30	85

At the same time, average fertiliser rates for oilseed rape are environment friendly and in concordance with legal restrictions. Use of inputs at an optimum level guarantees higher agronomic efficiency and minimises nutrient emission, calculated per unit yield, into the ambient environment (Kirchmann & Thordvaldsson, 2000). The consequence of the inadequate application of fertilisers was a negative soil nutrient balance in the last decade (Roostalu, 2001; Kärblane et al., 2002), which will result in a reduction in soil fertility and will also inhibit the efficiency of crop production in the long run.

As an average of the FADN farms, the yield of wheat in 2000–2003 was 2.3, the yield of barley 2.0, the yield of oats 1.9 and the yield of rape 1.7 Mg ha^{-1}. Compared with the national average, productivity was 15–20% higher for cereals and 6% higher for oilseed rape. Farm size and yield were not significantly correlated. Variability of the yield among different farms was extremely high (coefficient of variation 31–37%).

Table 2. Main indicators of FADN grain farms in different size groups, 2000–2003.

Groups, ha	<= 50	50.1 - 75	75.1 - 100	100.1 - 125	125.1 - 150	150.1 - 175	175.1 - 200	200.1 - 225	225.1 - 250	250.1 - 300	300.1 - 400	400.1 - 500	500.1 - 600	> 600	Aver
Sample holdings	26	29	31	31	15	18	19	17	17	17	23	15	15	14	287*
ESU	4.0	6.2	8.5	10.3	13.8	16.6	19.0	20.6	25.4	24.3	34.1	42.3	62.4	85.5	22.6
UAA, ha	39.5	62.0	85.2	109.1	136.2	160.7	189.6	211.4	234.7	271.1	348.2	451.1	551.8	816.4	223.2
wheat, %	17.0	19.8	22.5	18.3	18.4	21.0	18.1	15.0	22.7	20.6	21.2	21.0	23.3	28.9	20.3
rye, %	6.0	8.1	1.8	4.0	2.7	2.5	1.0	2.6	0.2	2.6	2.1	4.5	3.4	5.3	3.5
barley, %	41.9	41.9	43.5	37.2	33.8	32.1	31.9	45.2	29.8	35.8	30.0	25.3	36.7	29.3	36.3
oats, %	5.0	2.6	3.4	2.4	6.9	5.4	7.7	2.6	5.5	6.1	7.0	2.5	0.9	3.0	4.3
oil crops, %	15.8	15.4	16.0	23.1	22.8	21.5	24.9	19.3	26.5	14.7	17.6	22.0	26.5	19.3	19.9
Total income, EEK ha^{-1}	3991	4373	4284	4855	4191	4675	4687	4214	4789	3694	4666	4356	5780	4619	4492
output, %	88.3	90.6	90.8	91.7	90.3	91.6	92.1	90.0	91.6	89.4	92.1	90.6	92.5	91.5	90.2
subsidies, %	11.7	9.4	9.2	8.3	9.7	8.4	7.9	10.0	8.4	10.6	7.9	9.4	7.5	8.5	9.8
Total inputs, EEK ha^{-1}	3392	3366	3291	3426	3231	3517	3282	3056	3992	2868	3729	3405	4494	4262	3487
total specific costs, %	44.6	48.0	50.3	51.4	54.4	48.3	39.8	48.8	44.9	41.4	44.5	44.5	49.5	44.6	47.1
seeds and plants, %	14.5	14.1	14.0	14.4	13.5	14.8	10.6	12.3	10.8	15.3	12.5	12.0	12.4	12.9	13.3
fertilisers, %	17.9	19.6	21.2	21.6	22.4	20.8	16.4	23.2	20.3	17.0	19.1	13.3	22.6	19.3	19.7
crop protection, %	9.0	9.4	9.7	10.9	12.1	9.9	9.0	10.1	9.0	8.2	8.4	10.6	10.9	9.5	9.7
farming overheads, %	31.7	30.1	32.9	28.2	27.8	28.4	33.4	26.7	30.9	34.0	30.2	30.0	27.6	28.3	30.2
depreciation, %	20.7	19.2	12.0	15.2	11.4	15.6	21.7	14.2	16.6	16.3	14.9	14.7	12.1	11.8	15.7
external factors, %	3.0	2.8	4.7	5.2	6.4	7.7	5.1	10.3	7.6	8.3	10.4	10.7	10.8	15.4	7.0
wages paid, %	1.5	1.6	0.5	1.6	3.7	4.2	1.0	4.6	4.1	4.2	6.1	7.4	7.6	12.5	3.7
FFI, EEK ha^{-1}	596	1016	1180	1543	1342	1896	1744	1356	1336	1521	1894	1289	1976	992	1376
FFI cond., EEK ha^{-1}	-476	224	617	1146	615	928	1257	987	592	702	811	800	1199	289	1074
AWU 100 ha^{-1}	3.4	2.3	1.3	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	0.9	1.1	1.4

This can be partly explained by the level of production costs. The yield of cereals and oilseed rape depends on the level of total and specific costs (r = 0.32–0.39; P < 0.01). Thus producers who use more inputs usually achieve higher agronomic efficiency. As the database of FADN lacks data of the quality of arable land, it does not allow assess the effect of soil fertility. For the study period inter-year differences in the yield were insignificant. Maximum yield was 5.6 for wheat, 5.1 for barley and 3.2 Mg ha^{-1} for oilseed rape. However, in case of only 10% of the producers, the yields of these crops were higher than 3.8, 3.5 and 2.3 Mg ha^{-1}, respectively. Higher yield ensures profit increase for producers (r = 0.33–0.37; P < 0.01).

The yield affects not only the economic situation of an individual farm but also the national self-sufficiency for cereals. As grain deficit for 2000–2003 was 25%, and to compensate for this, the national average yield of cereals must increase up to ~2.5 Mg ha^{-1}. Considering the real yield potential, this would be feasible but only in case producers are economically motivated to intensify production to some degree.

Income and input structure

Output is directly related to land use structure in farms. Among the cereals, the largest share is accounted for by barley with 25–43% and wheat with 15–29% (Table 2). The share of oilseed rape is on average 20.4%. The share of oilseed rape is smaller in farms with an area less than 100 ha. Depending on the size of the farm, total output is in the range of 3,300–5,350 EEK ha^{-1}, from which the share of cereals forms 2,120–3,090 EEK ha^{-1} and the share of oil crops 800–1,760 EEK ha^{-1}. The share of oil crops is larger in farms with a larger output (r = 0.52; P < 0.01).

The proportion of subsidies in income made up on average 7.9–11% (Table 2). In Finland the share of subsidies in cereal farms varied from 35 to 53% (Kaljonen, 2006). As European Union Common Agricultural Policy (CAP) was implemented in Estonia as late as 2004, its effect is not reflected in the present results. Taking account of the general trend of the EU policy towards minimisation of subsidies and decoupling of production in the future, the low share of subsidies even gives a better overview of the sustainability of the agricultural sector. Changes in agricultural policy definitely affect grain producers (Ackrill et al., 2001; Fraser, 2003; Chatellier, 2004). Loko et al. (2005) have calculated that when the single area payment is equal for grain and grassland the trend will be to replace grain production with grassland.

As an optimal scale can be established practically over the all range for outputs and inputs, it is difficult determine an efficient scale (Forsund & Hjalmarsson 2004). During four years (2000–2003), total inputs increased 21%. Total inputs were the highest in large farms (Table 2). Average total input was 3,487 EEK ha^{-1}, and total specific costs varied between 40–55%, while the share of the former increased 6.8% during four years. Fertilisers accounted for an average of 19.7% and crop protection 9.7% of total inputs. The proportion of depreciation is the highest in small farms and that of wages by large-scale producers. There is strong correlation between the share of wages and farm size (r = 0.95; P < 0.01).

The efficiency of the use of labour depends strongly on farm size. In small farms it is more than two annual work units (AWU) per 100 ha. The most efficient use of labour (0.8–1.0 AWU 100 ha^{-1}) occurs in farms with a size range from 175 to 600 ha. Paid labour exceeds unpaid labour in farms with a size over 300 ha (Fig. 3). It is evident that still larger farms are not the so-called family farms any more.

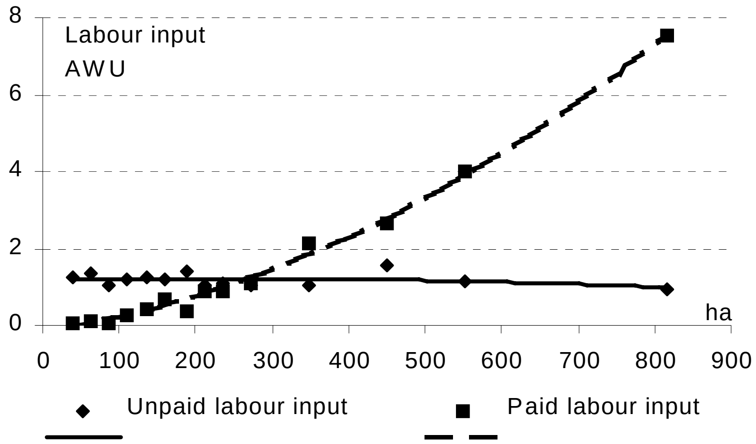

Fig. 3. Input of paid and unpaid labour in annual work units (AWU) depending on farm size (ha).

Profitability of grain production

The size of a farm is an important factor which determines its efficiency (Lund & Price 1998). Generally, profitability increases with farm size (Burger, 2001; Gorton et al., 2003). Farm size is often identified according to the area of agricultural land. Optimum farm size is a relative criterion as it is highly dependent on farm type, land use structure and the level of specialisation (Gorton and Davidova, 2004; Alvarez and Arias, 2004). The relationship between farm size and efficiency have been found to be positive (Hallam & Machado, 1996; Hadri & Whittaker, 1999), negative (O`Neill & Matthews, 2001) and also non-linear (Helfand, 2003). This indicates the complexity of identifying optimal farm size.

There were 36,859 operating farms in Estonia in 2003. The farms in possession of legal persons numbered 783. The average area of a farm was 21.5 hectares. Despite small average farm size, farms larger than 50 ha accounted for as much as 66% of all agricultural land. Grain producers of farms of this size use as much as 81% of all subsidised land. Grain production subsidies were applied by 4,284 producers for 286,619 ha; proceeding from these figures, average cereal growth area per farm is 68 ha. As an average for 2000–2003 and according to the FADN database, grain producers were profitable in all size groups (Table 1; Fig. 4A). Average farm family income (FFI) was 1,376 EEK ha^{-1}. There is a non-linear relationship between farm size and economic indicators. FFI increases up to ~400 ha. The increase is most significant in the size range 40–200 ha where the increase in farm size by one hectare increases FFI by 7.6 EEK ha^{-1}. Further increase will decelerate profit and the most efficient use of labour occurs in this size range as well. Cost benefit is the highest (>50%) for farm size ranging from ~150 to 400 ha. FFI is negatively correlated with the labour used per 100 ha (r = -0.27; P < 0.01) and with costs for wages (r = -0.30; P < 0.01) and positively correlated with the output of oil crops (r = 0.40; P < 0.01), which indicates higher profitability of rape production compared to cereal production. Use of labour and its estimation in a farm markedly affects the cost benefit of production.

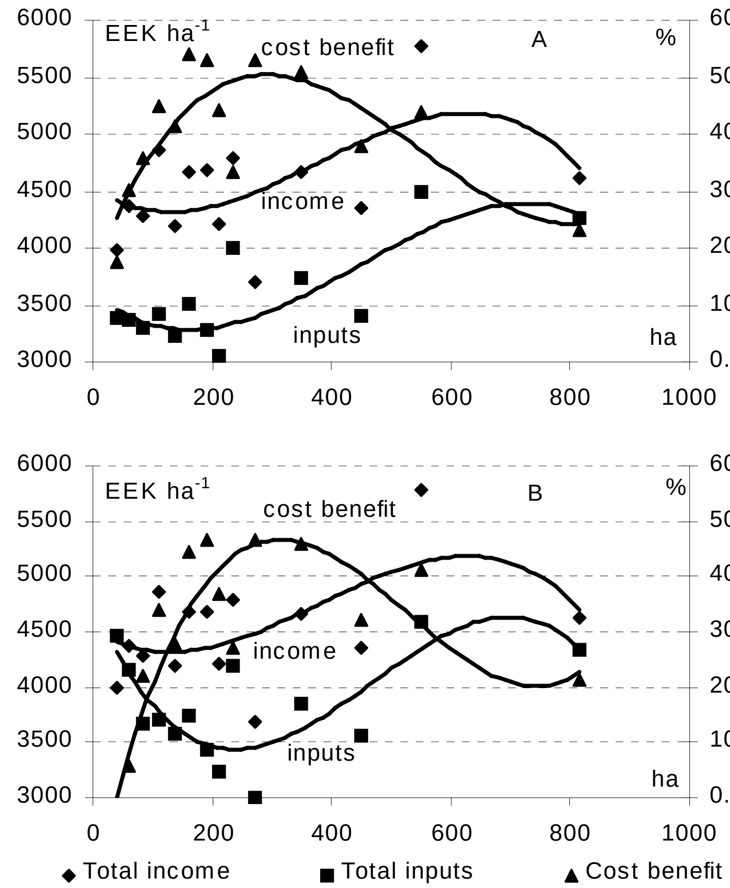

Fig. 4. Total income, total inputs (EEK ha^{-1}) and cost benefit (%) depending on farm size (ha) according to actual FADN data (A) and according to conditional data (B). A – inputs and cost benefit are presented according to the FADN methodology; B – costs of yet unpaid labour are included in the calculation of costs and cost benefit.

Gorton et al. (2003) noted that in Central and Eastern European countries the profitability of commercial farms is sensitive to estimation of labour input. As the ratio of unpaid to paid labour is various for different farm sizes, it distorts the indicator of the real profit from grain production. To obtain the real profit, we included the wages for the yet unpaid labour to costs. In calculating additional costs, we proceeded from the costs of paid labour. Such an approach affected mainly the cost benefit of small farms (Fig. 4) for which unpaid labour dominates in calculation of costs. Profit decreases with the increase in one AWU by 508 EEK ha^{-1} and production becomes unprofitable in case a grain farm employs more than 2.6 workers per 100 ha. In calculating total labour costs, small farms appear unprofitable, while in farms with a size of over 100 ha profitability varies between 20–47%. The size range for the highest profitability remained the same after taking into account total labour costs. The wages for paid labour were on average 3,053 EEK ha^{-1} per month. As the present low level of wages in the agricultural sector increases in the near future, optimum use of labour will affect even more the competitive ability of grain producers.

The lowest limit of the profitable size of FADN farms coincides with the theoretical calculations of the breakeven size of grain farms. Möller et al. (1998) have found that maximum cost benefit is guaranteed for a grain farm with sowing acreage from 78 to 95 ha. Lower cost benefit in FADN farms larger than 600 ha is mainly related to higher labour costs.

Yield of grains was positively correlated with profit (r = 0.33 – 0.37; P < 0.01), while correlation was weaker with cost benefit (r = 0.16–0.22; P < 0.01). Consequently, increasing costs increase yield less than would be required for attaining economic efficiency. Cost benefit is reduced by increase in total costs (r = -0.24; P < 0.01) and costs of wages (r = -0.34; P < 0.01). There is no correlation between the level of specific costs and cost benefit, which gives evidence of the incorrect ratio of inputs to selling price of production, or of the low efficiency of inputs.

CONCLUSIONS

Decreased production and low agronomical efficiency have induced a situation where Estonia is unable to ensure self-sufficiency for cereals. The low realisation of yield potential at national level is partly caused by insufficient fertilisation. In FADN farms agronomical efficiency is somewhat higher compared with the national average but grain yield differs to a great extent between farms. The European Union Common Agricultural Policy was implemented in Estonia as late as 2004, and for that reason the share of subsidies in income of grain farms in 2000–2003 was low. Further it is crucial to analyse how EU support schemes have affected the economic situation of grain producers. The estimation of economic sustainability should be improved with a Stochastic Frontier Analysis and Data Envelopment Analysis. Those methods have been widely used for determination of farm efficiencies in transitional economies (Fandel, 2003; Latruffe et al., 2004) but not in Estonia so far. Although FADN grain farms were profitable in all size groups, the profitability was highest in the size range from ~150 to 400 ha. Use of labour and its estimation markedly affects the cost benefit of production. Consideration of total labour costs indicates that small grain farms are unprofitable.

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