

IENICA

**Interactive European Network for Industrial Crops and their
Applications**

Forming Part of the IENICA-INFORM Project

REPORT FROM THE STATE OF ESTONIA



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METHODOLOGY

This report has been compiled for IENICA (An Interactive European Network for Industrial Crops and their Applications) on the development of the Estonian non-food sector.

Mr. Einar Kikkas prepared this report from the Ministry of Agriculture and Mr. Anti Viikna from the Tallinn Technical University. More information about the Estonian country report is available from authors referred to at the beginning of each chapter and from the authors of this report. Contacting various organisations and companies and collecting information from them mainly compiled the report. We acknowledge numerous people for their kindness in providing information and making the writing of this report possible.

All remarks and supplementary information requests are welcome.

Tallinn, Estonia, January 2004

EXECUTIVE SUMMARY

In the last years the development of non-food activities has decreased. The intentions to establish new bioplastics and biodiesel undertakings were not successful. The only potato starch undertaking has finished its operation. Flax is no longer grown since 2003; the last harvest was in 2002 (about 35 ha). The main reason for the end of the flax growing was the lack of a straw primary processing industry. But the primary processed fibre exported from Latvia, Lithuania and Belgium is still used as an industrial raw material for the production of textiles and insulation materials. The research in the related fields is finished.

This situation may be change in the future, if the rapeseed oil mill Werol Tehased make the investment to the biodiesel production, but this is only intention at this stage.

Oil Crops

The only oil crop currently grown for non-food purposes in Estonia is linseed. The area cultivated with linseed in 2003 was 85 ha with a total yield of 42 tonnes. 99% of this was used for the production of animal feed. About 500 kilos of linseed were pressed for selling into the chemistry industry as a personal care product. The surface coatings from linseed oil are imported.

Biodiesel: The Estonian Research Institute of Agriculture has researched the cost, cost-effectiveness and appropriate production technologies of biodiesel in 2001. The results of the study show that if the buying-in price of rapeseed is 0.2237-0.2429 EUR/kg then it isn't possible to produce biodiesel with the cost price below 0.5432-0.6391 EUR/litre. However, if the price of rapeseed would be 0.1278-0.1598 EUR/kg then it would be profitable to produce biodiesel in Estonia if it is not taxed with excise duty. If the price of biodiesel would rise in Estonia to the level of Germany then it would be profitable to produce biodiesel even at the current prices of the rapeseed.

During the study (described in this report) the original technology for the production of quality biodiesel from rapeseed was devised. In the former chemistry industry in Kiviõli, which now belongs to the company Alexela several tonnes of biodiesel, which meets the western standards, and B20 fuel, were produced from hot pressed rape oil according to the suggestions of the Prof. Leevi Mölder. These fuels were tested during the fall ploughing of AS RAUBRI (tractor Massey Ferguson). The tractor functioned well; no complications appeared with the engine and as compared to the fossil diesel fuel

the fuel consumption did not increase while using biodiesel and B20 fuel during the fall ploughing. The tests will be continued in 2002. However, the production of the biodiesel did not begin. The main reasons were missing of the related laws (taxes and quality standards).

Fibre Crops

The only fibre plant grown in Estonia was the flax. Since 2003, flax is no longer grown. The calculation of the cost-effectiveness of flax growing and processing shows that the first processing undertakings need, for profitable production, the raw material in a big quantity from the proximate area. However, Estonian farmers are not able to make the required investments, which the flax growing technology in the outset phase needs. Flax was last grown in 2002 on about 35 hectares. To establish the new flax primary processing undertaking the minimum growing area must be about 1500 hectares within 50 km from the undertaking place.

Carbohydrate Crops

The main project of interest in the non-food field in Estonia was the biodegradable polymers. The researchers of the University of Tartu have synthesised biodegrading polymer optically clean isomers of lactic acid (PLA) with determined characteristics. The work conducted so far allows executing the entire PLA (poly lactate acid) production scheme as a continuous process, which is the precondition for the low cost price of PLA.

The usage of cereal for the production of plastics was developing in three directions:

1. Adding starch and its modifiers to the petrochemically-produced plastics to increase their degradability in nature;
2. Producing plastics and films from grain protein;
3. Fermenting the sugar from starch into lactic acid and producing polylactate from it.

Thanks to the broad run possibilities (packages, tare¹, textile products, medicines etc) PLA is one of the most potential bioplastics. The synthesis of clean optical isomers necessary for the production of PLA is at present in the industrial sense possible only by microbic synthesis.

In 2001 OÜ Estbiotech started to construct a bioplastic production factory, which costs ca 115 million EUR, the execution of which was planned for 2004 and the production of which would increase Estonia's economic independency. The technology for PLA has been patented in 86

¹ Non-returnable empties

countries all over the world. The patent is active for 15 years. OÜ Estbiotech, however, was voluntarily bankrupted in 2003 and the project ended. The realisation of this project would have meant the production of this environmentally friendly product and a big raw-material market for cereal growing farmers.

The only potato starch factory has finished the operation since 2003. It isn't useful to produce in small quantities. As the specialists find – the cost-effective production begins at 10,000 tonnes per year. The last production of the plant was 89 tonnes in 2002. Other types of starch (maize, barley, etc.) are not produced in Estonia.

Speciality Crops

Fennel, Hypericum, Melissa, Peppermint, Petroselinum, Rosa, Taraxacum, Thymus and Valerian are grown in small areas for herbal health products. Most of herbs marketed as the health products are collected from wild nature.

INTRODUCTION

Agriculture has been an important sphere of activities and income for the Estonian population. During the last century the importance of agriculture in the world economy has decreased, but it still has the essential role in supplying the population with basic food products, in rural business and in designing cultural landscapes.

There have been significant changes in Estonian agriculture during the past ten years, which are mainly due to:

- land reform
- ownership reform (agricultural reform)
- economic structure from Soviet times, which did not meet the requirements of the new market and ownership structure;
- changes in the economic environment, including development of external trade policy during the 1990s:
- accession to the European Union.

The Republic of Estonia has set a goal to become a full member of the European Union. This process sets a new challenge for the agricultural sector and additional requirements because agriculture is the most regulated sector of the economy in the EU.

Estonia is finalizing the preparations to integrate into the Common Agricultural Policy of the European Union, while keeping in mind the last trends of the EU. In this situation the key question is: how can the agricultural sector adjust to the changes and stay in the competition in the longer perspective. While transferring to the Common Agricultural Policy of the EU we have to keep in mind the common priorities. Estonia has to bring its production into accordance with EU requirements, the presumption of which is the implementation of a market management system which is in accordance with the EU requirements, regulation of the import and export of food products and support to the rural economy, through which a stable agricultural production and optimal prices for the producer and the consumer would be guaranteed.

Estonia has to implement a veterinary and phytosanitary control system, which meets EU requirements; improve organic farming, processing and marketing of production and restructure, develop and modernise the food processing enterprises.

Development of alternative possibilities for using agricultural products

Through the development measures (research and investment support) the state supports the development of the industry, which uses agricultural raw materials for the production of different niche products (such as insulation materials, energy etc.).

The Rural Development Plan (RDP) has been drafted in accordance with the programming requirements of Article 4 of Council Regulation (EC) No 1268/1999. By implementation of this framework the production of alternative agricultural products and agricultural non-food products for which a normal market outlet exists, as well as opportunities for added value, will be substantially expanded.

No separate national strategy for the development of the non-food sector has been carried out and considering our limited resources it may not be very expedient at this moment.

OPPORTUNITIES

1 Science and technology

1.1 Oil crops

The only oil crops grown in Estonia are oilseed rape and linseed. In 2003 linseed was grown on about 85ha with a total yield of 42 tonnes of seed. About 1% of the pressed oil was marketed as a personal health product in the chemistry industry. The rest of the pressed oil was used to produce animal feed. Whilst there has been interest and developments into biofuel production from rapeseed, no commercial production exists at present; the pilot projects mentioned in this report were not successful. 100% of the rapeseed currently grown is used for the production of food oil and animal feed.

Study of cost-effectiveness and appropriate production technologies of biodiesel in the Estonian Institute of Mechanisation of Agriculture in 2001²

The price of diesel fuel produced from oil increased in Estonia almost 3 times during 2001, which significantly raised the cost prices of agricultural products. In many EU countries, in the USA and elsewhere, biodiesel, which is used both for tractor and car engines, has been produced from the seeds of oleaginous plants for many years. In Estonia also, there are several enthusiasts (J. Rõõmusaar, T. Pangsepp etc) who have for several years experimented with rapeseed to produce biodiesel (rape methyl ester - RME). However, results of the analysis of the quality of the biodiesel produced by the means of a very simple technology (authors R. Muoni and H. Olak) show that several indicators (alkaline metal and water content) do not meet the quality standards of the EU member states. Therefore the biodiesel production technology used by the enthusiasts needs to be improved.

The aim of research-development work has been to find out:

- production potential of rapeseed in Estonia;
- production costs and cost-effectiveness in Estonia;
- to give an evaluation to the biodiesel production technologies used in Estonia;
- biodiesel production technologies and equipment most suitable for Estonian conditions;

² Arvi Kallas, Director of Estonian Institute of Agricultural Engineering

- the production technologies and equipment of the companies producing biodiesel production equipment, which would suit both co-operatives and big productions;
- costs and cost prices of production of biodiesel from rapeseed in enterprises of different sizes and using different production technologies;
- production costs and cost price of furnace fuel (i.e. crude oil of rape) and its influence on the cost prices and cost-effectiveness of cereals and other seeds
- influence of biodiesel (of rapeseed) on the cost prices and cost-effectiveness of cereals and other seeds;
- energy balance of biodiesel (of rapeseed).

The time allocated for the research was too short to give satisfactory answers to all the questions stated in the goals. This especially concerns the evaluation of and drawing up of improvement proposals for implementation and controlling of biodiesel production technologies and equipment used in Estonia. These would demand continuous research and development work, which would last for several years.

An evaluation of the biodiesel production technologies used in Estonia and the production trials of biodiesel from rapeseed are shown in Section 2.1.

The areas cultivated with rapeseed, its yield and the production potential of the biodiesel are shown in Section 3.1.

In 2001 the Estonian Institute of Mechanisation of Agriculture has carried out the payback studies of oil flax. This study was a part of the common payback calculation of the different arable crops. Now the linseed growers may download from the institute homepage a calculation algorithm and use this for evaluating the growing costs.

The Jõgeva Plant Breeding Institute has tested different linseed varieties during 1998-2002. The goal of the study was to select the best varieties for Estonian conditions. After the five year testing the variety `Taurus` has got the best average results. During the tests four different oil flax varieties: `Flanders`, `Helmi`, `Lirina`, `Taurus` were sown on the area of 0.5 ha. According to the set good practice 7 indicators were tested in 28 average samples during the field trials:

1. Length of stems
2. Technical length
3. Fibre yield
4. Seed yield

5. Mass of 1000 grains
6. Number of capsules on the plants
7. Number of seeds in a capsule.

The best seed yields among the oil flax varieties were received from `Taurus` and `Lirina`, which gave 55-70% higher seed yields than the standard variety `Helmi`. The varieties, which gave the seed yields (`Taurus` and `Lirina`) has put on the Variety List of 2003 and they can continually be recommended.

During the comparative trials of oil flax harvesting technologies it appeared that the higher seed yield was guaranteed by harvesting with a cereal combine at a cutting height of 30-40 cm from the ground. 1.98 t of seeds per hectare was received.

Table 1. Yield of oil flax `Taurus` depending on the harvesting technology

Variant	Way of harvesting *	Height from the ground (cm)	Pre-harvesting handling **	Yield of stems t/ha	Yield of fibre t/ha	Yield of seeds /ha
1	1	With roots	+	3.84	0.69	1.19
2	2	Up to 10	+	2.88	0.60	1.37
3	2	20-30	+	2.23	0.58	1.58
4	2	30-40	+	2.00	0.48	1.98
5	2	40-50	+	0.92	0.17	1.86
6	2	30-40	-	2.34	0.40	1.78
7	2	40-50	-	1.08	0.15	1.82

* Way of harvesting: 1 – flax combine, 2 – cereal combine

** Pre-harvest handling: + handled with Roundup 3 l/ha

Table 2. Linseed varieties' testing results in Mooste experimental station 2001³

Variety	Stem yield t/ha	%	Fibre yield kg/ha	%	Fibre contents in stems %	Seed yield kg/ha	%	Mass of 1000 grain s g	Height of the flax plants
Helmi	3.57	100.0	828	100.0	23.2	1260	100.0	5.32	56.4
Flanders	3.05	85.4	790	95.4	25.9	1440	144.3	5.24	69.9
Lirina	4.62	129.4	998	120.5	21.6	1955	155.2	5.52	69.8
Taurus	4.40	123.3	1179	142.4	26.8	2160	171.4	5.56	74.8

³ The results and the updated data will be available at the April 2004 in the homepage of the Jõgeva Plant Breeding Institute (www.jpbi.ee)

In 2004, at the Jõgeva Plant Breeding Institute, the new research project to test *Camelina sativa* as an oil crop was started. The main aims of the research is explain the best growing conditions, average yields, and application possibilities by improving the rape oil quality. The tests will be extending in three years. Beginning with this year 15,338 EUR was allocated for the product development research.

1.2 Fibre crops

The only fibre plant grown in Estonia was the flax. Since 2003, flax is no longer grown. The calculation of the cost-effectiveness of flax growing and processing shows that the first processing undertakings need, for profitable production, the raw material in a big quantity from the proximate area. However, Estonian farmers are not able to make the required investments, which the flax growing technology in the outset phase needs. Flax was last grown in 2002 on about 35 hectares. To establish the new flax primary processing undertaking the minimum growing area must be about 1500 hectares within 50 km from the undertaking place.

The only flax-using factory - AS Vestra - in Southern Estonia processes insulation material from the imported short fibre: approximately 140 tonnes in year of short fibre is imported and used each year, for insulation for log houses. The total production is 95,000 m² of linen felt and the production is primarily exported to Finland and Norway. They didn't undertake Estonian linseed straw because the available quantities are too small. Straw primary processing for AS Vestra is cost-effectiveness at the minimum quantity 300 tonnes of the straw.

We have the legal basis for growing hemp but the investments for the growing of this plant (especially the supervision required during the entire vegetation period of the herbage) nullify the economic profit gained from hemp.

The studies on flax growing are conducted by the Mooste experimental station of Jõgeva SAI, where until now mostly the applied research of the introduction of foreign varieties and agro-technology are being conducted.

Adapting the agro-technology of imported fibre and to the Estonian weather conditions ⁴

During the tests in 1998-2002 five different fibre flax varieties: `Ariane`, `Elise`, `Hermes`, `Ilona`, `Viola` were sown on the area of 0.5 ha. According to the set good practice 7 indicators were tested in 35 average samples during the field trials:

1. Length of stems
2. Technical length
3. Fibre yield
4. Seed yield
5. Mass of 1000 grains
6. Number of capsules on the plants
7. Number of seeds in a capsule.

The best yields among the fibre flaxes were received from `Viola` and `Ilona`, which gave 12-18% higher fibre yields than other fibre flax varieties. The varieties, which gave the best fibre yields (`Viola`, and `Ilona`) has put on the Variety List of 2003 and they can continually be recommended.

The possibilities of harvesting the stems of oil flax were tried with the variety `Taurus`. Until this, the stems were burned. The fibre in the stems of oil flax is an insufficient quality for spinning linen thread, but the quality is sufficient for insulation material (this is produced by AS Vestra; see earlier).

Table 3. Flax varieties' testing results in Mooste experimental station 2001⁵

Variety	Stem yield t/ha	%	Fibre yield kg/ha	%	Fibre contents in stems %	Seed yield kg/ha	%	Mass of 1000 grain s g	Height of the flax plants
Viola	7.50	100.0	2708	100.0	36.1	806	100.0	4.85	89.6
Ilona	6.97	92.9	2656	98.1	38.1	825	102.4	5.17	79.1
Elise	6.46	86.1	2293	84.7	35.5	755	93.7	5.33	76.3
Hermes	6.14	81.7	2333	86.2	38.0	615	76.3	4.81	75.5
Ariane	6.10	81.3	2239	82.7	36.7	800	99.3	5.44	76.4
Helmi	3.57	100.0	828	100.0	23.2	1260	100.0	5.32	56.4
Flanders	3.05	85.4	790	95.4	25.9	1440	144.3	5.24	69.9
Lirina	4.62	129.4	998	120.5	21.6	1955	155.2	5.52	69.8
Taurus	4.40	123.3	1179	142.4	26.8	2160	171.4	5.56	74.8

⁴ Kalju Paalman, Director of Department, Jõgeva Plant Breeding Institute

⁵ The results and the updated data will be available at the April 2004 in the homepage of the Jõgeva Plant Breeding Institute (www.jpbi.ee)

Manufacturing Technical Textiles⁶

The aim of the project was to find a use for short flax fibre which is produced in large quantities during the first processing of flax stems, for tows and wastes, especially in the production of technical textiles used in agriculture and also to explore the possibilities for use of the stems of oil flax for the same purposes.

In this project the possibilities of using the fibres from short flax fibre and the tows and stems of oil flax for manufacturing agricultural-technical textiles (row covers, batts, mulches, mats, growing environments etc.) through dry processing (needlepunching, rolling a carded batt from the mixture of fuse fibre and flax fibre) and wet processing (formatting a fibre batt material by soaking it with water-dissolvent adhesives) were studied. During the project in 2001 trials in agricultural production were carried out with developed materials and their biological durability and influence on the growth of plants were investigated.

Conclusions from the study of short fibre flax materials:

1. According to the trial results we can say that materials needlepunched and made of short flax fibre joined by fuse fibre had good consistency, but the short flax fibre materials soaked with adhesives dilapidated easily when wet. Considering the peculiarities of the materials conclusions were made on the potential application possibilities of these materials.
2. For use as a growing material both the needlepunched as well as the fibre materials joined with adhesive are suitable. The material with fuse fibres is heated during the production process at a very high temperature, so the seeds are destroyed. During the course of this study the use of needle punched material as a growing material was studied. Further research could be done on the use of material joined with adhesive as a growing area. In such case the adhesive could be paste, which at the same time works as a seed adhesive. Due to the fact that the material joined with the adhesive dilapidates easily in a wet environment then it would be suitable to manufacture mats, which have to biologically decompose after the plants have grown.
3. The materials joined by fuse fibres are very well suited for use as row covers (for early harvest). Using fuse fibres allows to manufacturing thin materials, using needlepunching and soaking with adhesive allows manufacturing materials with higher surface density. Fuse fibre materials

⁶ Anti Viikna, Professor, Tallinn Technical University *Survey on manufacturing technical textiles from short flax fibre and the stems of oil flax*

made of orientated fibres have significantly better fibre-wise tensile strength. It would be possible to put this factor into use. For example if the row cover is rolled on the headland then the longways-tensile strength is especially important. This way the sufficient longways tensile strength could be achieved at a lower surface density. Then less flax fibre, which later has to biologically decompose, will be in contact with the ground.

4. Needle punched materials would suit especially well for applications where the durability of the material is necessary during a certain period, for example for weed control at the roots of plants. The materials joined with adhesives dilapidate too fast and they are therefore not effective enough. Using different soaking substances can regulate the speed of biological decomposing of the needlepunched materials.

Using unwoven materials of short flax fibre in agriculture - testing linen mulches in horticulture

On the experimental fields of Polli Horticultural Institute of Estonian Agricultural University the mulches made of needlepunched material ($\sim 420 \text{ g/m}^2$) manufactured in OÜ Vestra EX equipment's were used to protect the plants of sea buckthorn from weeds and drying. For that purpose 40x40 cm mats were cut out of linen material. In the centre of the mats a cross-shaped incision was made, in three directions 1-2 cm and in the fourth up to the edge. The mats were placed around the plants of sea buckthorn and were tightly pressed against the wet ground. As a result the mats were strongly fixed to the ground when it dried. The mats were observed during the summer of 2001 and the following observations were made:

1. The size of the linen mats (mulch) sufficient to cover the necessary area around the plant.
2. On the covered area the weeds perished. Not a single weed plant could penetrate through the mulch. Neither did the plants grow under the mulch or elevated it from the ground.
3. Some weed plants grew out of the incisions, which had been left ajar
4. The sea buckthorn plants could get sufficient moisture and developed well
5. No spreading of plant diseases or pests was noted
6. Some biological decomposing of unsoaked mats was noted. The durability qualities of the mats had decreased but the weed control qualities had not.

Developments of seed mats on the basis of OÜ Vestra EX

The technical basis of OÜ Vestra EX consists of mixer, shaker, carding machine with automatic weighing device, batt former (mainly the cross generator is used, but the lengthwise generator is also available), and needlepuncher with cutting and coiling device. Considering the previous laboratory tests on grass mats a model for grass mat production was developed in co-operation with the specialists from OÜ Vestra EX.

Problems, which need technological solutions:

1. Setting the seeds in the mat. At first it seemed to be the best solution to set the seeds into the mat during the formation of the batt, before needlepunching;
2. Making the holes into the material. Initially the most probable possibility is to place a one- or two-row punch between the needlepuncher and coiler.

As other realistic possibilities using the spiked arbor after needlepunching and forming holes into the batt with compression air could be mentioned. All technological problems need to be tried and tested in practice.

Using linen mats as growing areas

Time of the experiment: 24.04-24.10.2001

15 test bodies, 7 cm in diameter, were covered with paste (of potato starch 35 g/l). On each test body 100 grass seeds were placed. The test bodies were dried and placed into an airtight plastic bag. After a month the 3 test bodies were placed in plastic boxes, were irrigated and covered with film and were left to germinate at around 21-22 °C. The same was repeated after 3 and 6 months. It is planned to repeat the test after 1 year.

Results of germination:

1 month	3 months	6 months
A 98 %	A 92 %	A 94 %
B 91 %	B 96 %	B 91 %
C 96 %	C 98 %	C 99 %
On the 5 th day the germination on the 2 cm long was ~95 %	On the 6 th day the germination on the 2 cm long was ~95 %	On the 8 th day the germination on the 2 cm long was ~95 %

Conclusion: after 6 months the germination of the grass seeds had remained the same and it allows manufacturing paste glued grass seed mats with long duration.

In determining the pH of the linen mats 3 test bodies were taken with the corresponding charges of 0.5 g, 1.0 g and 2.0 g and were placed in 350 ml glass bulbs. 200 ml of distilled water was added to each of the bulbs, and then it was sealed air tightly and left for three days (shaked at times). On the fourth day the pH merit was determined with the pH-meter. The pH merits were correspondingly 6.7; 6.6; 6.7; the average pH 6.7.

Results of cress germination, length of the buds in cm

	3p*	5p	7p*	9p	11p	13p
Paste matt + 1 mm of sand	0,5 cm	3,5 cm	5 cm	Plants drooped		
Paste matt	0,5 cm	4 cm	5,5 cm	7 cm	8,5 cm	10 cm
Moist matt	0,5 cm	3 cm	4,5 cm	6 cm	8 cm	9 cm
Moist matt + 2 mm of sand	-	-	-	-	-	-

* on the 3rd day the film was removed from the aquarium and placed on the windowsill at 21°C.

Conclusions: On the sand-covered mat, mould was formed due to excess moisture; where there was 1mm of sand the seeds were partly destroyed; where there were 2 mm the seeds were destroyed completely. On the matt covered with paste the cress plants grew faster. After 13 days the plants stopped growing and started to mature, which is natural for cress. Therefore, the cress plants are ready to use after 9 days if there is enough moisture, heat and light. This work needs to be continued. Unfortunately the Ministry of Agriculture does not have fund for it in the budgets of 2002 and 2003.

1.3 Carbohydrate crops

There are no carbohydrate crops grown in Estonia for technical applications anymore. The last industry processing potato starch was closed in 2003.

Applied research on production of biodegradable plastic⁷

For the synthesis of PLA (poly lactate acid) with determined characteristics as a biodegrading polymer optically clean isomers of lactic acid are needed. Until now the only considerable method of industrial production of optically clean lactic acid (or lactate) has been its microbial synthesis. Production of PLA, which is compatible in price, presumes minimising expenses in all technological links.

The research done in the field by the Institute of Molecular and Cellular Biology of the University of Tartu are:

1. Using grain as a complex raw material, which after PLA synthesis would allow issuing chaffs rich in cereal protein and fibre as a product;
2. Isolation and selection of thermophile producers of L-lactate;
3. Possibilities of saving energy and material on the production of growth mediums and fermentation;
4. Optimising the medium considering the growth demand and posterior extraction and cleaning methods of L-lactate;
5. Synthesis of lactate necessary for PLA synthesis as a continuous process:

To produce lactic acid from grain the conditions for liquidising and saccharification of cereal starch have been developed in the Institute of Molecular and Cellular Biology of the University of Tartu. These conditions allow the extraction of the protein, which is unnecessary for fermentation from the medium in its native form – to allow using it in feedingstuffs, food as well as in the chemical industry. At the same time the posterior extraction of lactic acid from the growing environment will become simpler.

The thermophilious producers of L-lactate, which allow fermentation at 57-60°C, have been isolated. Using them decreases the danger of microbic pollution and simplifies the technological scheme:

- a) The energy-costly sterilisation of the medium and fermenters with high-pressure steam can be avoided by replacing it with short-term, approximately 100-degree continuous process;
- b) Allows combining the preceding crystallisation of starch with fermentation in the conditions of pH and temperature optimal for the both processes, i.e. to discard of the long-stay and voluminous after-crystallisation reservoirs and at the same time the waste of amylases.

The work conducted so far allows executing the entire PLA production scheme as a continuous process, which is the precondition for the low cost price of PLA.

Rye, barley, wheat and triticale were used in small quantities by the laboratory trials for testing of the production of the plastics in three directions:

1. Adding starch and its modifiers to petrochemically produced plastics to increase their bio-degradability;

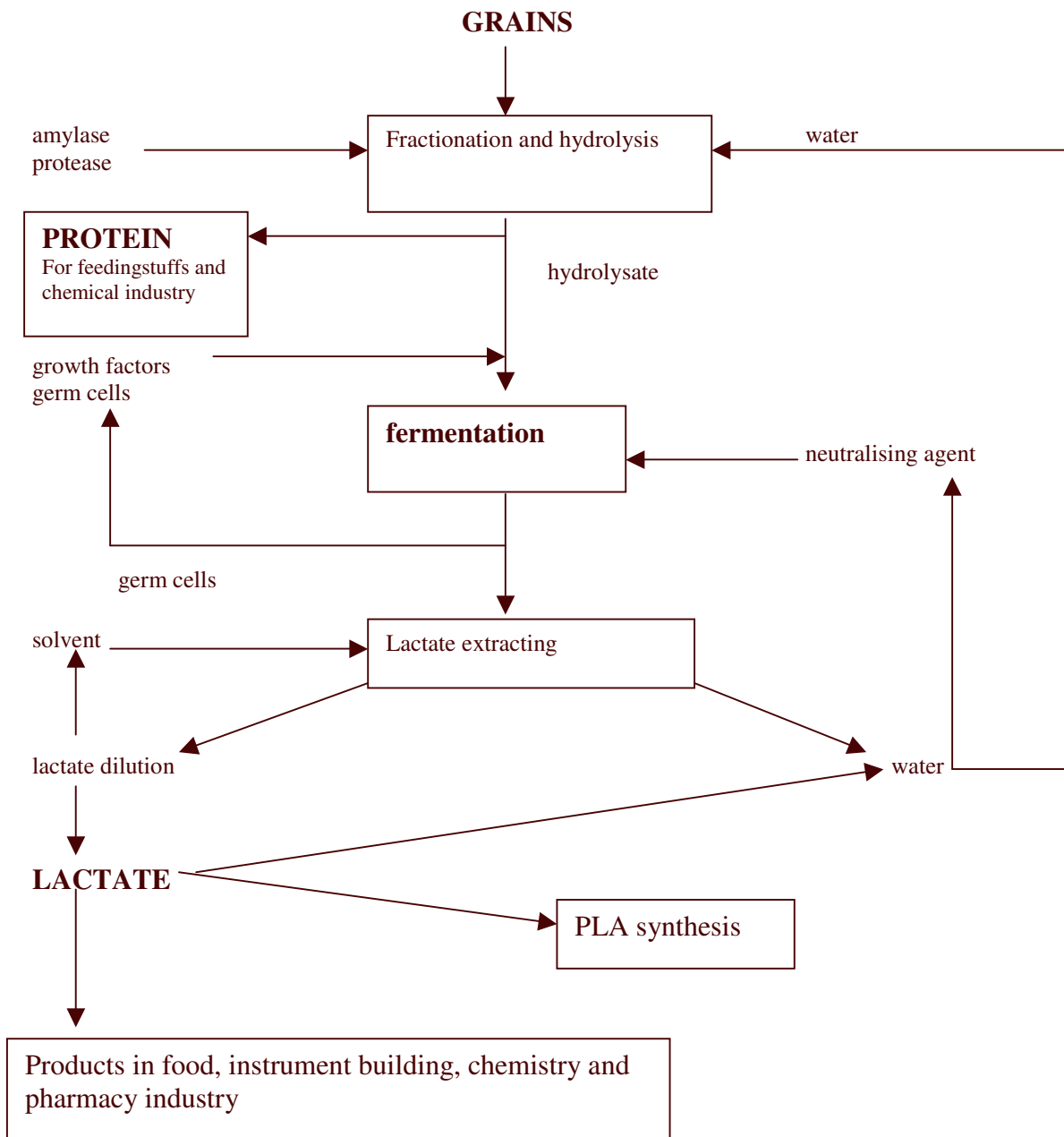
⁷ Jaan Simisker, Professor, University of Tartu, Institute of Molecular and Cell Biology

2. Producing plastics and films from grain protein;
3. Fermenting the sugar from starch into lactic acid and producing polylactate from it.

Thanks to the large number of possibilities (packages, tare, textile products, medicine etc) PLA is one of the most potential bioplastics. The synthesis of clean optical isomers necessary for the production of PLA is at present, in the industrial sense, possible only by microbial synthesis.

In addition to the above the lactic acid and the compounds received from it have found broad use in many areas as a result of which the demand for lactic acid on the market has increased 10-15% per year during the last ten years.

The food industry uses lactic acid and its Ca, Na, and K salts as preservatives, casein as (milk protein) depositor, as flavourings, also as a regulator of the structure, density and pH of the products and as a stabiliser. The esters of lactic acids with fatty acids are as surfactants used as emulsifiers, foam stabilisers and stabilisers of the characteristics of dried products (including potato). The pharmacy industry uses optically clean lactic acid esters for the synthesis of optically active components of medicinal products. In perfumery products the lactic acid esters with certain fatty acids are used in the contents of most skin products. In the chemistry industry the use of lactic acids is increasing first and foremost in producing non-toxic solvents (lactic acid ethyl and butyl esters) as a replacement for glucose esters. On cleaning metal and semiconductor surfaces in the electronics industry the chlorine-organic compounds, which are toxic and resolve with difficulty in nature can be replaced by lactic acid ethyl and isopr-esters.



Taking into consideration the above the experimental production of lactic acid in Estonia is possible before the production of PLA. In Estonia the dairy industry is interested in the extension of lactic acid, for depositing milk protein, to significantly improve the quality of curd cheese and extend the range of products (according to the research carried out in the Estonian Agricultural University).

The experimental production of L-lactic acid, before the production of PLA, would solve the issues of optimising fermentation in industrial conditions and would give experience for the production and use of products of L-lactic acid and grain protein. The range of products made from grain protein (including biodegradable plastics) is expanding quickly and this direction is worth attention.

The small-capacity technology necessary for experimental production is similar to large capacity production.

Experimental production allows specification of the components, which determine the cost price of lactic acid, considering the complexity of grain use.

Estonia has the following advantages for beginning the production from lactic acid grain:

1. The Institute of Molecular and Cellular Biology of the University of Tartu has the isolated thermophilous producers of L-lactate, which are suitable for production of lactic acid, dependant on the starch contents of the grain;
2. The researchers of the Institute of Molecular and Cellular Biology of the University of Tartu have long-term experience in using hydrolysates of grain starch in different conditions of fermentation.
3. The need for specialists is soluble on the basis of the students of Tartu University, Tallinn Technical University and Estonian Agricultural University;
4. The readiness of the grain growers to grow technologically suitable, starch rich cultures.

Ongoing research into the production of L-lactate:

1. Choice of suitable variety: to meet not only the requirements of production scheme, not only by the yield but also by the technological characteristics of the grain;
2. Choice of grain fractionation scheme, which in addition to the optimal usage possibilities of starch would allow transforming the second component of the grains – protein - into products;
3. Forming the fermentation medium on the basis of starch and protein hydrolysates;
4. Choice and production of growth factors preferably of domestic raw material (yeast extract, whey hydrolysate etc.);
5. Optimising fermentation in relation to growth factors, temperature, acidity, neutraliser etc, minimising the production of residues and by-products;
6. Choice of separation and cleaning technology of lactate;
7. Minimising the need for water by reusing it;
8. Neutralising the residues of production;
9. Specifying the range of products produced on the basis of L-lactate.

The results of the research will give basic data for determining the parameters of the apparatus and conditions of fermentation necessary for production of L-lactic acid. The apparatus and facilities needed to complete the work are partly usable in experimental production.

1.4 Specialist crops

Fennel, Hypericum, Melissa, Peppermint, Petroselin, Rosa, Taraxacum, Thymus and Valerian are grown in small areas (approximately 6 ha in total) for herbal health products. Most of the herbs marketed as the health products are collected from wild nature. No industrial applications exist at the moment.

The researchers of the Pharmaceutical Institute of the University of Tartu have carried out research on herbs. The Horticultural Institute of the Estonian Agricultural University has to a certain extent conducted research on aromatic herbs. Due to the large number and narrow specifics of the works it is not expedient to present their summaries here. A review of the titles of the named works and their authors will be provided by the list of authors at the end of this paper.

2 Industry

2.1 Oil crops

There are no industrial applications of the oil crops for non-food purposes at the moment. The only oil crop currently grown for non-food purposes is linseed. The area cultivated with linseed in 2003 was 85 ha with a total yield of 42 tonnes. 99% of this was used for the production of animal feed. About 500 kilos of linseed were pressed for selling into the chemistry industry as a personal care product. The surface coatings from linseed oil are imported.

Production trials of the biodiesel from rapeseed⁸

Raismiku farm

In co-operation with the former professor of the Estonian Agricultural University, Rein Muoni, the farmer Jüri Rõõmusaar has tried to produce and use biodiesel from rapeseed. He was given an oil presser, which was brought from Germany (a cold presser with the production capacity of 800 kg a day, N=3.2 kW, price 20,452 EUR). The rapeseed will be pressed at the pressure of 40 at, at which the temperature of oil and oil cake will rise up to 40°C. The oil will be poured into the reactor with a

⁸ Arvi Kallas, Director of Estonian Institute of Agricultural Engineering, 2001

capacity of 600 litres where, according to the volume 10% of high quality methanol and 0.2 grams of NaOH will be added. It will be mixed for 7 hours. The products will be biodiesel and glycerol.

Since 2000, the farmer has used this simple technology biodiesel (tractor MTZ) for all field works. The tractor works well. Periodically the fuel filter needs to be cleaned of the deposited residues. The biodiesel of Raismiku farm was analysed by the laboratories of SGS Eesti AS as well as Tallinn Technical University. It appeared that the fuel does not meet the Western standard requirements and Professor emeritus Leevi Mölder tried to improve its quality in the laboratory. However the expected results were not achieved. Estonian Institute of Mechanisation has proposed the farmer specific suggestions for the modernisation of the technology, however these have not yet been implemented due to the lack of funds.

The results of the analysis of the Raismiku farm biodiesel carried out in the laboratory of the Chemical Institute of Tallinn Technical University in 2001.

The aim of the analysis was to determine:

- To what extent the esterification has taken place (indicated by viscosity and Conradson number)
- Does the product contain catalyst residues (qualitatively indicated by the existence of water-soluble alkalis and quantitatively by Na and ash content)
- To what extent does the product contain unreacted methanol (qualitatively indicated by flash point, quantitatively by direct determination) and water (indicated by direct determination).

The results were as follows:

- | | |
|---|---|
| • Density at 15 °C | 903,5 kg/m ³ |
| • Cinematic viscosity at 40 °C | 11,26 mm ² /s |
| • Flash point | 63 °C |
| • Ash content | 0,09 %wt |
| • Conradson (10% by vol. residue on distillation at reduced pressure) | undeterminably
(cannot be distilled) |
| • CFPP (summer) | -13 °C |
| • CFPP (winter) | -17 °C |
| • Water-soluble alkalis | are included |
| • Na content | 420 mg/kg |
| • Methanol content | 0,48 %wt |
| • Water content (Karl Fisher) | 1200 mg/kg |

The following conclusions can be made:

- The metaesterisation reaction has not completed (viscosity over 12 mm²/s), the product is undistillable; the viscosity of rape oil methyl esters (RME) should be 4-6 mm²/s and they should distil in the temperature range of 320–360 °C.
- The catalyst has not separated with glycerol but has remained in the product (large content of ash and sodium, water-soluble alkalis).
- There is a large probability that the reaction will continue on its own after the separation of the glycerol from the reactor. During this process an additional amount of glycerol and soap is produced.
- The product contains unreacted methanol, but its amount is not large. Probably part of the methanol used for the reaction has volatilised from the reactor (or less methanol was taken than theoretically needed).
- The separation of soap was not complete. (However, a certain amount of soap could have been produced during the out-distillation of methanol and water).

Therefore the process as a whole needs significant restructuring and technical improvement.

Oru Taimeõlitöös

In 1996 research on using hot pressed rapeseed oil as a fuel for diesel engines was started in Oru, in co-operation with the Institute of Agricultural Technology of Estonian Agricultural University. Experiments on using the mixture of rape oil and diesel fuel (in a ratio of up to 1:1) as a diesel fuel have been carried out. The results were satisfactory. In 1997 the production of biodiesel from rape oil (methyl ester) was started. It could be used in tractor engines if the outside temperature was above -5°C. To reduce viscosity and to facilitate engine starting the viscosity-reducing substances isopropyl and isoamyl spirit and polyisobuten were added to the biodiesel. During the two years 2200 litres of biodiesel have been produced in Oru. The main results of the bench tests conducted on the tractor engine of D-240 in the EAU were the following:

- If there are no substances stabilising viscosity of the biodiesel, then it is practical to increase the work pressure of the injectors from the prescribed 17 Mpa to 19 Mpa;
- As compared to the diesel fuel made of oil the potency of the engine decreases on working at full capacity up to 5% and in case of rape oil ethyl ester up to 11%;
- The indicators of the engine's work are the same on the use of biodiesel produced from hot and cold pressed rape oil.

The Oru Taimeõlitööstus has also been presented specific proposals to improve technology because the biodiesel produced there doesn't meet Western standards.

The results of the analysis of the Oru Taimeõlitööstus biodiesel carried out in the laboratory of the Chemical Institute of Tallinn Technical University in 2001.

The aim of the analysis was to determine:

- To what extent the esterification has taken place (indicated by viscosity and Conradson number)
- Does the product contain catalyst residues (qualitatively indicated by the existence of water-soluble alkalis and quantitatively by Na and ash content)
- To what extent does the product contain unreacted methanol (qualitatively indicated by flash point, quantitatively by direct determination) and water (indicated by direct determination).

The results were the following:

Density at 15 °C	904,0 kg/m ³
Cinematic viscosity at 40 °C	11,21 mm ² /s
Flash point	30 °C
Ash content	0,11 %wt
Conradson (10% by vol. residue on distillation at reduced pressure)	undeterminably (cannot be distilled)
CFPP (summer)	-8 °C
CFPP (winter)	-11 °C
Water-soluble alkalis	are included
Na content	510 mg/kg
Methanol content	1,35 %wt
Water content (Karl Fisher)	1140 mg/kg

The following conclusions can be made:

- The metaesterification reaction has not completed (viscosity over 12 mm²/s, the product is undistillable, density over 900 kg/m³; the viscosity of rape oil methyl esters should be 4-6 mm²/s, density approximately 885 kg/m³ and they should distil in the temperature range of 320–360 °C). According to the approximate estimation only 44-46% of the glycerol esters in rape oil have metaesterified.

- The catalyst has not separated with glycerol but has remained in the product (large content of ash and sodium, water-soluble alkalis).
- There is a large probability that the reaction will continue on its own after the separation of the glycerol from the reactor.
- The product contains unreacted methanol (very low flashpoint).

The fuel company Alexela

In the former chemistry industry in Kiviõli, which now belongs to the company Alexela several tonnes of biodiesel, which meet Western standards, and B20 fuel were produced from hot pressed rape oil, according to the suggestions of the co-author of this report Mr. Leevi Mölder. These fuels were tested in Harjumaa, during the autumn ploughing of AS RAUBRI (tractor - Massey Ferguson). The tractor functioned well; no complications appeared with the engine and as compared to the fossil diesel fuel the fuel consumption did not increase while using biodiesel and B20 fuel during the autumn ploughing. The tests will be continued in 2002⁹.

2.2 Fibre crops

Whilst flax growing is now finished, it is being processed in Võru, Narva and Pärnu. The fabric's process uses only imported raw material.

Pärnu Linavabrik (Pärnu Linen Factory)

Pärnu Linavabrik is one of the biggest consumers of flax fibre in Europe. Over 6 million metres of different fabrics are woven each year – linen, tapestry, shirt fabric, dress fabric, and 2500 tonnes of yarn and thread, for which, among other things, 2600 tonnes of flax sliver and 1000 tonnes of tow yarn are spent.

The entire production is exported because the Estonian clothing industry is too small that it does not take an interest in marketing here. The factory is as a supplier of the Levi Strauss Company. The competition was won in front of several hundred offers. The policy of the factory is to sell a product with a consistent quality and low price. This ensures the market. There is no need for a marketing department (which they do not have) – the merchants come looking for them if the product is good.

There are 650 people working in the flax factory. The raw material is 100% imported from Western Europe. The production buildings are continuously modernised. A new spinning workshop was

⁹ The tests results was positive but the production of the biodiesel wasn't still continued cause the excise tax duties for the bio fuels aren't still adopted

recently completed. Due to the fact that linen mills have moved from Western Europe to Eastern Europe, and the same is expected with Pärnu Linavabrik when the labour will become more expensive, the latter has to make continuous technical improvements and concentration of labour to preserve its production. It is planned to buy a combing line to produce flax sliver.

AS Vestra EX

AS Vestra uses currently 140 tonnes of short flax fibre imported from Latvia and Lithuania, which is used for producing insulation material for log houses. Potentially Estonian flax could be used, but the flax straw primary processing industry requires a minimum quantity of 300 tonnes which is currently not grown in Estonia.

OÜ Eesti Lina

The OU Eesti Lina has tried to grow the flax in 1999-2001. The company started in 1999 as an association of specialists of different fields – choosing, growing and processing flax fibre and marketing, management and finances. The main aim of the company was to revive the Estonian flax sector and to give farmers the possibility for flax growing. They were involved in buying-in and the primary processing of flax straws. Whilst the farmers didn't start the flax growing due to the high investing capacities and risk, the company finished the operation on 2001. Since 2003 in Estonia flax is not grown anymore.

2.3 Carbohydrate crops

OÜ Estbiotech

In 2001 OÜ Estbiotech started to construct a bioplastic production factory, which costs ca 115 million EUR in Southern Estonia, the completion of which was planned for 2004 and the production of which would increase Estonia's economic independency. A European company - Lurgi Lifescience - was involved in the project as a partner. The plant was planned to manufacture lactic acid from grain and, in turn, the bioplastic. The technology for grain lactic acid has been patented in 86 countries all over the world. The patent is active for 15 years. The market size for lactic acid (worldwide) is considered to be approximately 2.8 million tonnes per year. The planned turnover of the plant for 2005 was 190 million Euro and the profit 500,000 Euro. The estimated payoff period was 3-4 years. The products (different biodegradable plastics mostly for the packaging industry) would be sold to Europe, China, Japan, USA and the Arab Countries.

OÜ Estbiotech was voluntarily bankrupted in 2003 and the project ended. The main reasons were economical and different interests amongst scientists and bankrollers.

2.4 Crops with specialist uses

Kubja Herb Farm is one of the biggest and oldest producers and packagers of herbs in Estonia. The farm was restored according to the ESSR Farm Act in the fall of 1991 but the herbs were grown and picked before this. The first tea mixtures, then under the brand “Herba” entered the market in 1988. The farm is a family enterprise owned by Mrs. Merike Sander.

The farm itself produces approximately twenty different species of plants: Calendula, Chamomile, Digitalis, Fennel, Gentiana, Hypericum, Hyssop, Lavender, Leonurus cardiaca, Marjoram, Melissa, Nettle, Nepeta, Oregano, Peppermint, Petroselinia, Rosa, Salvia, Taraxacum, Thymus and Valerian. These plants are grown on approximately 3.5ha in total. These herbs are marketed as the health product mixed in the different tea mixtures.

Other activities also involve experiments on natural herb species and the collection of many sorts of herb species and varieties in their gardens. Last summer there were more than 300 kinds in the garden. Generally the herbs are grown naturally. Grass flakes are also used as fertiliser compost and composted manure. The herbs are faded at first by natural airing in the pre-dryer and then in the drying cabinets with electrical heating. This ensures fast drying and preserves the active ingredients and natural colour of the plants. The moisture content of the dried plants is low, 7-8%, which allows storing them in an airtight package and preserves their aroma. The finished product will be packed into plastic bags allowed to use for foodstuffs and that usually containerise 20 grams.

OÜ Elujõud operates in the field of growing, packaging and sales of herbs. The main production is carried out in a 5.8 hectare area in Central Estonia. The products have been made of naturally grown herbs, which are picked from a clean environment. The herb teas and tea mixtures have been made according to the knowledge of Estonian national medicine and combining it with modern science. Over 20 herbs and the same number of tea mixtures are produced. The herbs are grown on several hectares without mineral fertilisers and chemical control products. The natural plant species are picked only from selected and clean areas. Thymus, Salvia, Rosa, Artemisia, Alchemilla, Solidago, Hypericum, Marjoram, Melissa, Nettle, Plantago, Parsley, Echinaceae and Yarrow are grown on approximately 2ha in total. These herbs are marketed as the health product mixed in the different tea mixtures.

AS Paulig Baltic

In 1992 Paulig established a subsidiary in Estonia, which became the first Estonian coffee and seasonings producer. This enterprise was one of the first large foreign investments into Estonia.

By now the company's turnover has risen to over 17 million Euro and it employs 92 people. The company produces seasonings for the common consumer as well as big kitchens and food industries. Production satisfies the needs of Finnish, Swedish, Russian, Ukrainian, Belorussian, and Kazakh, Lithuanian, Latvian and Estonian markets. The Eastern European marketing, sales and logistics centre for Paulig is also situated here.

Unfortunately all the raw materials necessary for the production of seasonings are imported. Due to the volume of output no mutually beneficial contracts have been signed with Estonian herb growers. The problem lies in the small quantities offered by the producers.

Tallinn Pharmaceutical Plant is the oldest and most experienced manufacturer of medicinal products in Estonia, commencing work in 1914. The factory is situated in Tallinn and it is the only producer of medicines and drugs in Estonia operating with a full production cycle. At present the Tallinn Pharmaceutical Plant manufactures more than 50 different product items. Most of the production consists of medicines, but the range of products also includes semi-medicinal products, natural products, and food additives. The products are produced from a range of different medicinal plants (the exact data is not available) but this raw material is imported.

3 Markets

3.1 Oil crops

The only oil crop currently grown for non-food purposes in Estonia is linseed. The growing area in 2003 was 85 ha with a total yield of 42 tonnes. 99% of this was used for the production of animal feed. About 500 kilos of linseed was crushed and sold in the chemistry industry as a personal care product.

Oilseed rape has been investigated for biofuel, but at present there is no commercial production. There are no other industrial applications for rapeseed.

The growing areas and yield of rapeseed in 1992-2000

Due to the relatively favourable sales price and marketing possibilities of rapeseed the price of rapeseed in Estonia has grown during the last years. At the same time the average yield of rapeseed has unfortunately not grown in Estonia, therefore there is a rapeseed deficit in Estonia after the establishing of the cooking oil factory AS WEROL TEHASED as this factory alone needs 60,000 tonnes of rapeseed a year. When it appears that it is cost-effective to produce biodiesel from rapeseed in Estonia, we may face a situation where Estonian farmers are not able to supply the producers of domestic cooking oil and the biodiesel with rapeseed.

Table 4. Production of rapeseed (summer and winter rape/turnip rape in total) 1992-2003

Year	Growing area (ha)	Yield (kg/ha)	Total harvest (tonnes)
1992	2 920	799	2 334
1993	1 304	1 324	1 727
1994	2 646	819	2 167
1995	6 030	1 165	7 025
1996	8 552	1 170	10 007
1997	7 905	1 216	9 614
1998	19 492	1 024	17 918
1999	24 147	1 232	29 759
2000	28 988	1 270	36 815
2001	28 800	1 351	38 900
2002	32 900	1 944	63 900
2003*	44 238	1 492	66 000

© Statistical Office of Estonia * Estimated

This table shows the total rapeseed grown in Estonia. 100% of this is used for the production of food oil.

The price and cost-effectiveness of biodiesel made from rapeseed depends greatly on the cost and sales price of rapeseed. The cost price of rapeseed in turn depends on agro-technology – choice of the field, soil preparation technologies, seed and sowing technologies, control methods of weed, diseases and pests, fertilising, harvesting and post-harvest processing. We think that the low yields of rapeseed are due to the fact that all the requirements of agro-technology are not met. The chain of agro-technology is strong only if all the links in the chain are equally strong. For example, if control measures of diseases or pests are late or not used at all the yield will probably be about 1 t/ha, despite proper soil preparation, fertilising etc.

The production potential of rapeseed in Estonia

On the assumption of the growing area of cereals and rape (the average in 1998-2003 being ca 360,000 ha) and the requirement that the time gap from the last sowing of crucifers must be 6-8 years, the possible total area for rapeseed of the current used land in Estonia (360,000 hectares) could be 45-60 thousand ha in year. The main Estonian rape growth specialists Karl Kaarli and Jaak Läänemets have calculated that the optimal growth area of rapeseed is 50,000 ha because we have to consider the fact that not all the lands used for growing cereals are suitable for growing rape. In their opinion the rape area cannot be extended by cultivating the unused lands (in 2000 there were in total of 269,737 ha of unused lands in Estonia!) because these are probably fields with one of the lowest yield potentials and are generally not suitable for growing rape.

One of the main problems of rape growing in Estonia is the low yield – in the years 1992-2003 it was between 799-1944 kg/ha (the average 1234 kg/ha). Dr. Karl Kaarli suggests that the low level of yield is due the lack of knowledge of the growers, which is expressed in the mistakes in the principles of agro-technology. In the best farms of Estonia the yield of rapeseed is 2-3 t/ha, which shows that the yield can be significantly increased.

Table 5. Total harvest of rapeseed from 50,000 ha depending on the average yield

Growing area (ha)	50,000							
Yield (kg/ha)	1500	1600	1700	1800	1900	2000	2200	2500
Total harvest ('000 tonnes)	75	80	85	90	95	100	110	125

Therefore the production potential of rapeseed in Estonia is, depending on the yield, 75,000-125,000 tonnes.

The production costs and cost price of rapeseed

The Estonian Institute of Mechanisation of Agriculture has calculated the production costs and cost prices of rapeseed. For the cost-effectiveness calculations it is necessary to know the yield of rapeseed on the fields with different fertility and their dependency on the fertilisers used, plant protection products, costs of machines (straw peeling, ploughing, gliding, spraying/weed control, cultivation, sowing/fertilising, on-fertilising, spraying for disease and pest control, harvesting, drying, cleaning, storage) and sales prices. For the calculations of costs made regarding the plant protection products the experiences and suggestions of Dr Karl Kaarli and farmers Jaak Läänemets and Madis Ajaots etc. have been used. The costs of fertilisers have been calculated with the help of

a calculation program for fertiliser need and costs of AS Hydro Eesti, based on the average soil fertility indicators.

The production costs and cost prices depend on the recommended yields (the fertilisers and plant protection products used), the buying-in price of the seed and the costs on the machines. These have been calculated on the basis of algorithms developed in the Estonian Institute of Mechanisation of Agriculture. As a conclusion of the calculations the following is stated:

- the production of rapeseed is not cost-effective if the yield is below 1.25 t/ha, if the costs on machines are calculated on the basis of the prices for repairs and if the buying-in price of the rapeseed is over 224 EUR/t;
- in the case of the rapeseed price 236 EUR/t, which was valid until 2003 the yield of the rapeseed should be over 1.50 t/ha;
- if we could increase the yield of rapeseed to 3 t/ha, the rapeseed could be produced at the cost price of below 128 EUR/t;
- if the yield of the rapeseed is over 2 t/ha and the buying in price over 223 EUR/t, the profit from rapeseed growing is rather high – up to 109 EUR/ha;
- if for example the yield of rapeseed is 2 t/ha and the buying in price 240 EUR/t, the profit per ha is 73 EUR. To receive the same profit in the case of cereal yield of 3.5-4 t/ha the buying-in price of the cereal should be 141 EUR/t;
- it is cost-effective to grow rapeseed in Estonia if it is done in accordance with the agrotechnology requirements, in which case it should not be a problem to achieve the yield of 1.75 t/ha. This yield should be the minimal goal of all the rapeseed growers.

Production costs and cost price of biodiesel

Until spring 2003 the average buying-in price of rapeseed was 236 EUR/t. The price of rapeseed as the main raw material of biodiesel naturally influences greatly the price of biodiesel. As shown above, rapeseed can be produced in Estonian conditions at the cost price of below 128 EUR/t.

For the above-mentioned reasons the price for rapeseed cake has risen. Whilst a year ago it cost 0.14 EUR/kg it now costs, according to the data from WEROL TEHASED, 0.17 EUR/kg (+ VAT 18%). In the calculations the price of 0.17 EUR/kg for rapeseed cake has been used, but in comparison the calculations where the spring price of 0.14 EUR/kg has been used, have been presented.

A lot of raw glycerol arises during the production of biodiesel. At the moment there is no enterprise for processing of raw glycerol because the amount of raw glycerol is so low that it would not be expedient to establish such kind of plant. However, in Tallinn, in the former Orto factory where AS LEIOS now is, there is the necessary equipment and the company has agreed to process all of the raw glycerol from Estonian biodiesel enterprises in the future. For the above reasons the current price for raw glycerol is not known. In the calculations the price for raw glycerol has been set at 0.25; 0.48 and 0.64 EUR/kg.

Investment demand

The most difficult task is to find investment demands for the construction of biodiesel plants of different throughput. For the calculations of production costs and cost prices of biodiesel we still found them from several sources. Naturally, these are to be considered as referential.

Production costs and cost price

In Table 6 the example calculation algorithm for the production costs and cost prices of biodiesel produced in 5 different biodiesel plants with different throughputs and investment costs have been presented. As it appears from the table the cost price of biodiesel firstly depends on the prices of by-products of rapeseed and biodiesel production – rapeseed cake and glycerol, not on the fixed costs, where the main amount consists of interests costs of amortisation (they depend on the investment costs of the plant).

Table 6. Calculation of cost price biodiesel

Nr.	Name	Unit	1	2	3	4	5
INITIAL DATA							
1.	Cost of the building	EUR	6391,16	6391,16	6391,16	6391,16	6391,16
2.	Cost of the oil presser	EUR	4473,82	4473,82	28760,24	28760,24	28760,24
3.	Cost of the reactor	EUR	6391,16	6391,16	6391,16	6391,16	12782,33
4.	Service life of the building	year	25,00	25,00	25,00	25,00	25,00
5.	Service life of the oil presser	year	8,00	8,00	8,00	8,00	8,00
6.	Service life of the reactor	year	10,00	10,00	10,00	10,00	10,00
7.	Throughput of the oil presser	ltr/h	100,00	100,00	100,00	100,00	100,00
8.	Working time of oil presser in year	hours	500,00	300,00	500,00	800,00	1500,00
9.	Throughput in a year (bio diesel)	ltr	50000,00	30000,00	50000,00	80000,00	150000,00
10	Intrest rate	%	12,00	12,00	12,00	12,00	12,00
11	Maintenece costs of the equipment	%	3,00	3,00	3,00	3,00	3,00
12	Maintenance cost rate of the building	%	0,30	0,30	0,30	0,30	0,30
13	Insurance rate of equipment+ building	%	0,30	0,30	0,30	0,30	0,30
14	Usage capacity of electric engines	kW	40,00	40,00	40,00	40,00	40,00
15	Price of electricity	EUR/kWh	0,05	0,05	0,05	0,05	0,05
16	Specific costs of electricity	kWh/ltr	2,50	2,50	2,50	2,50	2,50
17	Number of employees	tk.	2,00	2,00	2,00	2,00	2,00
18	Man work cost	h/ltr	0,02	0,02	0,02	0,02	0,02
19	Remuneration rate	EUR/h	1,92	1,92	1,92	1,92	1,92
20	Social+sickness insurance tax	%	33,00	33,00	33,00	33,00	33,00
21	Methanol costs	%	10,00	10,00	10,00	10,00	10,00
22	Methanol price	EUR/kg	0,19	0,19	0,19	0,19	0,19
23	Oil yield from rapeseed	%	30,00	30,00	30,00	30,00	30,00
23	Rapeseed spending	kg/ltr	3,33	3,33	3,33	3,33	3,33
24	Rapeseed price	EUR/kg	0,19	0,19	0,19	0,19	0,19
25	Rapeoil price	EUR/ltr	0,64	0,64	0,64	0,64	0,64
26	Bio diesel+glycerol yield	ltr/kg	0,40	0,40	0,40	0,40	0,40
27	Glycerol yield	kg/kg	0,04	0,04	0,04	0,04	0,04
28	Bio diesel yield	ltr/kg	0,36	0,36	0,36	0,36	0,36
29	Glycerol price	EUR/kg	0,64	0,64	0,64	0,64	0,64
30	CALCULATION RESULTS						
31	Amortisation	EUR/ltr	0,03	0,05	0,09	0,06	0,03
32	Interest	EUR/ltr	0,02	0,03	0,05	0,03	0,02
33	Insurance	EUR/ltr	0,00	0,00	0,00	0,00	0,00
34	Maintenance cost	EUR/ltr	0,05	0,05	0,17	0,17	0,10
35	Other	EUR/ltr					
36	Total fixed costs	EUR/ltr	0,10	0,14	0,31	0,25	0,15
37	Rapeseed	EUR/ltr	0,64	0,64	0,64	0,64	0,64
38	Methanol	EUR/ltr	0,06	0,06	0,06	0,06	0,06
39	Electricity	EUR/ltr	0,12	0,12	0,12	0,12	0,12
40	Remuneration	EUR/ltr	0,04	0,04	0,04	0,04	0,04
41	Social+sickness insurance tax	EUR/ltr	0,01	0,01	0,01	0,01	0,01
42	Other	EUR/ltr					
43	Other	EUR/ltr					
44	Total variable costs	EUR/ltr	0,87	0,87	0,87	0,87	0,87
45	Total direct costs	EUR/ltr	0,98	1,01	1,18	1,13	1,02
46	General costs	EUR/ltr	0,10	0,10	0,12	0,11	0,10
47	TOTAL COSTS	EUR/ltr	1,07	1,11	1,30	1,24	1,12
48	BY-PRODUCT INCOME						
49	Glycerol	EUR/ltr	0,03	0,03	0,03	0,03	0,03
50	Rapeseed cake yield	EUR/ltr	2,33	2,33	0,23	2,33	2,33
51	Rapeseed cake price	EUR/ltr	0,14	0,14	0,14	0,14	0,14
51	Rapeseed cake cost	EUR/ltr	0,32	0,32	0,03	0,32	0,32
51	Total by-products	EUR/ltr	0,48	0,48	0,20	0,48	0,48
52	PROFIT (ON THE BASIS OF BIO DIESEL COST PRICE)						
53	On the basis of direct costs	EUR/ltr	0,49	0,53	0,99	0,64	0,54
54	On the basis of total costs	EUR/ltr	0,59	0,63	1,10	0,76	0,64
55	Planned profit (10%)						
56	Sales price on the basis of total costs	EUR/ltr	0,65	0,69	1,21	0,83	0,70

Table 7. Sample of the cost prices of biodiesel depending on the price of rapeseed, when the methanol price is 0.32 EUR/ltr, the price of rapeseed cake is 0.17 EUR/kg and glycerol price is 0.25; 0.48 and 0.64 EUR/ltr

Rapeseed price (EUR/kg)	0,13	0,16	0,19	0,20	0,22	0,23	0,24
Glycerol price (EUR /kg)	0,25						
Biodiesel cost price (EUR /ltr)	0,29	0,39	0,48	0,52	0,56	0,60	0,64
Glycerol price (EUR /kg)	0,48						
Biodiesel cost price (EUR /ltr)	0,26	0,36	0,46	0,49	0,53	0,57	0,61
Glycerol price (EUR /kg)	0,64						
Biodiesel cost price (EUR /ltr)	0,25	0,34	0,44	0,48	0,51	0,55	0,59

The oil presser is one of the most complicated and expensive pieces of equipment in the biodiesel plant. There is production of these machines on the basis of the prototypes of Western companies. Due to the fact that up until now there haven't been possibilities to test them in production conditions it is not possible to give a technical-economic evaluation to them. The oil presser made in Estonia may be 2-4 times less expensive than the corresponding machine of a western company, however as there are no evaluations of their work quality and durability (maintenance costs, work resources in hours), we cannot give recommendations to the biodiesel producers and make calculations of biodiesel cost prices.

Examples of investments of oil plants and chambers built on the basis of cold pressers:

- with throughput of 80 kg/h of seeds on the basis of oil presser 32 000 EUR
- with throughput of 300 kg/h of seeds on the basis of oil presser 100 000 EUR
- with throughput of 500 kg/h of seeds on the basis of oil presser 130 000 EUR
- with throughput of 1200 kg/h of seeds on the basis of oil presser 325 000 EUR

Price of biodiesel

The calculations show that at present, where the buying-in price of rapeseed in the world market, including in Estonia, is relatively high (ca 243 EUR/t) the rapeseed biodiesel, which meets the quality requirements cannot be produced cheaper than the agricultural diesel fuel costs at the moment. At the current buying-in prices of rapeseed the cost price of the biodiesel will be at least

0.57 EUR/l (the investments have been taken on the basis of comparable investments in Austria, Sweden and England).

Table 8. Variants for cost price of biodiesel

	Variant			
	1	2	3	4
Yearly throughput of the plant ('000 tonnes)	300	360	720	2,160
Investments (EUR)	41,543	76,694	146,997	680,659
Fixed costs (EUR/l)	0.0262	0.0428	0.0409	0.0524
Variable costs (EUR/l)	0.8679	0.9184	0.8807	0.9037
Total direct costs (EUR/l)	0.8941	0.9612	0.9216	0.9561
Income from by-products (EUR/l)	0.4026	0.4026	0.4026	0.4026
Cost price (10% general costs) (EUR/l)	0.5809	0.6557	0.6110	0.6500

Conclusions and suggestions

1. Rapeseed is and will be a main arable crop in Estonia from which quality biodiesel can be produced. Taking into consideration the growing area of cereals and rape in Estonia (1998-2000 - average 360,000 ha) and the requirement that the time gap between the last sowing of crucifers must be 6-8 years, the growing area of rapeseed in Estonia, in the case of the current land use, is 45,000-60,000 ha. If we could increase the rapeseed yield in Estonia to 2-2.5 t/ha (in 1992-2003 the average yield was only 1234 kg/ha) then there would be sufficient rapeseed to produce cooking oil in AS WEROL TEHASED (requires 60,000-65,000 tonnes of rapeseed in a year) as well as for the production of 20,000-35,000 litres of biodiesel in a year.
2. If the average specific expenditure of diesel fuel for the production of cereal and rapeseed is 150 litres/ha, then with the above-mentioned amount of diesel fuel the cereal and rapeseed could be grown on 133,000-233,000 ha in Estonia.
3. To produce biodiesel from rapeseed is energetically very beneficial:
 - If we consider liquid fuel used only for machines we could produce depending on the yield of rapeseed, 3.6-6.0 times more energy than is spent on the field for machines;

- If we add up the energy expenditure on the field and energy expenditure for producing biodiesel from rapeseed (pressing and esterification) is possible to produce 2-3 times more energy from the rapeseed;
 - If we add to the energy expenditure of fieldwork and esterification the energy used on the production of fertilisers and plant protection products, we can still produce 1.3-1.6 times more energy than is used for the production of biodiesel.
4. If the buying-in price of rapeseed is 0.2237-0.2429 EUR/kg then we cannot produce biodiesel with the cost price below 0.5432-0.6391 EUR/litre. However, if the price of rapeseed would be 0.1278-0.1598 EUR/kg then it would be profitable to produce biodiesel if it is not taxed with excise duty. If the price of biodiesel would rise in Estonia to the level of Germany then it would be profitable to produce biodiesel even at the current prices and taxes of the rapeseed.
5. The known supplies of oil and natural gas may end in 50 years; therefore we must to start using more green energy, including biodiesel. Estonian farmers do not have the finances to buy complex plants from the west, therefore it would be wise to develop biodiesel production on the basis of co-operative enterprises taking advantage of the unused equipment (reactors-mixers, several reservoirs etc.) of the chemical factories of Soviet times (e.g. Orto, Kiviõli Keemiatehas etc.).

After adopting the European Parliament and Council directive No 2003/30 on the promoting of the biofuels in the transport sector, each member state shall ensure, that at 2006 2.75% liquid fuels marketed on transport sector are some kinds of biofuel. Accordingly this aim the Werol Tehased AS is preparing the plan to invest into the biodiesel production. The finally decision must be made at end of the year 2004.

Buying-in prices of rape in Estonia (arithmetic mean of purchasers, who buy EUR/t without VAT)

	22.12.2002	27.11.2003	22.12.2003	Change +/- %	
				22.12.03-27.11.03	22.12.03-27.12.02
Average	249,25	235,83	235,32	-0,2	-5,6

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3.2 Fibre crops

If, by 2008, the growing area of fibre flax increases to 1900 hectares (although this is currently not possible whilst the company has finished operations and there is no one else to do this at present), and the yield to 3700 kg/ha, and the growing area of oil flax to 1500 hectares, the raw material requirement of the flax industry will be guaranteed by domestic raw material. If the growing area increases to 2000 hectares it would be possible to increase the buying-in price. The textile industries are ready to buy flax fibre grown in Estonia if it is of the same quality and price level as that bought from Belgium and France. If there is even a slight decrease in quality it is not profitable to use it as raw material. OÜ Eesti Lina was offered a buying-in price of flax straw 134.21 EUR/t (depending on the quality of the flax straw) and 1,086.50 EUR/t for linseed in 2001.

However, the flax fibre imports meet demand at present and wouldn't increase significantly because the production capacities of industries are fulfilled. It isn't credible that the flax growing in Estonia would be restored on the short time period.

Table 9 Flax and hemp, import and export 1995-2002 (tonnes)

Year	1995	1996	1997	1998	1999	2000	2001	2002
Flax import, raw or processed but not spun, CN Code 5301, (t)	689	126	154	105	1 486	2 842	2 779	3 198
Flax export, raw or processed but not spun, CN Code 5301, (t)	96	91	44	9	27	48	6	7
True hemp import, raw or processed but not spun, CN Code 5302, (t)	5	2	2	1	1	-	5	-

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Present industrial applications of the (imported) fibre are divided into two products – insulation material made from short flax fibre and textiles made from quality long flax fibre. Currently 140 tonnes/year of short fibre imported is used for making insulation for log houses. The total production is 95,000 m² of linen felt. The production is primarily exported to Finland and Norway.

Long flax fibre is used in textile industries in Pärnu and Narva. Pärnu Linavabrik is one of the biggest consumers of flax fibre in Europe. Over 6 million metres of different fabrics are woven each

year – linen, tapestry, shirt fabric, dress fabric, and 2500 tonnes of yarn and thread, for which, among other things, 2600 tonnes of flax sliver and 1000 tonnes of tow yarn are spent.

The entire production is exported because the Estonian clothing industry is too small that it does not take an interest in marketing here. The factory is a supplier of the Levi Strauss Company. The competition was won in front of several hundred offers. The policy of the factory is to sell a product with a consistent quality and low price; this ensures the market. There is no need for a marketing department (which they do not have) – the merchants come looking for them if the product is good.

3.3 Carbohydrate crops

The only potato starch industry finished operations in 2003. It isn't useful to produce in small quantities. As the specialists find – the cost-effective production begins at 10,000 tonnes per year. The last production of the plant was 89 tonnes in 2002. Other types of starch (maize, barley, etc.) are not produced in Estonia.

The starch imported is mainly used in the paper industries as well as in food industries.

Table 10 Export of grains and grain products without customs warehouses and their import for free circulation in 1999–2002 (tonnes)

Code	Chapter	EXPORT				IMPORT			
		1999	2000	2001	2002	1999	2000	2001	2002
1008	Buckwheat	27.1	3.7	3.9	9.8	317.9	222.0	43.2	15.6
1101	Wheat flour	133.2	1173.7	197.0	125.1	43223.4	39477.1	35067.0	19605.0
1107	Malt	8786.0	5737.7	4797.3	2192.6	12566.7	15077.3	15690.4	17318.4
1108	Starch	20.0	0.4	1.4	1.0	1844.5	2532.5	2919.8	3982.3

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Table 11 Buying-in prices of grains, (the considered average of processing enterprises, EUR/tonne)

	Average price 2002 (€)	Average price 2003 (€)
Rye	103,34	102,26
Wheat	96,63	91,39
Barley	94,2	93,95
Oats	82,5	79,89

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3.4 Crops with specialist uses

The major enterprises growing and wholesaling the drugs are OÜ Elujõud and Kubja Herb Farm, who offer 35-40 items of single drugs and different mixtures of teas. The total area under production was 25 hectares in 2003. The annual total production of herbs varies between 2-2.5 tonnes. There are no industrial applications of specialist crops.

BARRIERS

One of the main problems of rape growing in Estonia is the low yield – in the years 1992-2003 it was between 799-1944 kg/ha (the average 1234 kg/ha). Prof. Karl Kaarli thinks that the low level of yield is due the lack of knowledge of the growers, which is expressed in the mistakes in the principles of agro-technology. In the best farms of Estonia the yield of rapeseed is 2-3 t/ha, which shows that the yield can significantly be increased.

After the establishing of the cooking oil factory AS WEROL TEHASED there is a rapeseed deficit in Estonia because this factory alone needs 60,000 tonnes of rapeseed in a year. When it appears that it is cost-effective to produce biodiesel from rapeseed in Estonia, we may face a situation where Estonian farmers are not able to supply the producers of domestic cooking oil or the biodiesel with the rapeseed. So, the biodiesel producer must use the technologies that permit to use different crude.

We cannot produce biodiesel from the rapeseed, if the price level is so high as in autumn 2003: 4-3,7 kr / kg (0, 2364EUR / kg). However, if the price of rapeseed would be 0,1278-0,1598 EUR/kg then it would be profitable to produce biodiesel in Estonia if it is not taxed with excise duty.

We have the legal basis for growing hemp but the investments for the growing of this plant (especially the supervision required for the entire vegetation period of the herbage) nullify the economic profit gained from the hemp.

The Estonian textile industry needs a big quantity of the raw material but the problem is investing in the growing. The farmers are not capable to make so big invest to the production as a flax growing need.

ANNEXES

General statistics from the Statistical Office of Estonia

EXPLANATION OF SYMBOLS

...	<i>data not available</i>
..	<i>category not applicable</i>
-	<i>magnitude nil</i>
0	} <i>magnitude less than half of the unit employed</i>
0.0	
0.00	

Annex 1

GENERAL DATA

Utilised agricultural land decreased 30% in the years under observation (2001-2002). In 2002 the area of utilised agricultural land totalled 698,289 hectares, the area being 22% smaller than a year earlier. The sown area of field crops was 588,122 hectares, i.e. 9% smaller than in 2001. The sown area of cereals in 2002 was 259,248 hectares and the cereal production amounted to 524,652 tonnes (6% less than in 2001) or 2,024 kilograms per hectare (2,037 kilograms in 2001). Per inhabitant, 386 kilograms of cereals were produced in 2002 (409 kilograms in 2001). In 2002 the area under potatoes was 16,023 hectares, which gave 210,861 tonnes of potatoes (39% less than in 2001) or 13,160 kilograms per hectare (15,503 kilograms in 2001). The production of potatoes per inhabitant was 155 kilograms (252 kilograms in 2001). Due to good marketing opportunities, the sown area of rape grew from 6,000 hectares in 1995 to 32,855 hectares in 2002; the production increased from 7,000 tonnes to 63,865 tonnes.

SOWN AREA OF FIELD CROPS

thousand hectares

Field crop / Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Field crops total	935,0	850,7	859,1	864,2	861,1	818,7	809,8	644,2	588,1
Cereals	319,5	304,3	288,8	326,6	354,1	321,0	329,3	274,1	259,2
..winter crops	37,1	45,4	48,8	52,1	58,2	37,3	50,6	50,6	51,0
....rye	21,7	32,0	31,6	34,3	38,8	24,2	28,9	20,9	17,9
....winter wheat	15,4	13,4	17,2	17,8	19,4	13,1	21,7	25,5	27,8
....triticale	..	..	..	..	..	..	..	4,2	5,3
..spring crops	282,4	258,9	240,0	274,5	295,9	283,7	278,7	223,5	208,2
....spring wheat	18,8	25,2	28,7	33,1	47,4	53,0	47,2	34,1	36,7
....barley	217,9	186,5	148,0	165,7	166,8	153,9	165,1	134,3	129,9
....oats	36,1	38,5	49,0	54,4	61,0	61,0	53,3	48,1	35,2
....mixed grain	9,6	8,7	14,2	21,3	20,6	15,7	12,6	6,3	6,3
....buckwh eat	0,0	0,0	0,1	0,0	0,1	0,1	0,5	0,7	0,1
Legumes	0,7	3,7	5,8	8,7	6,4	2,9	3,9	3,7	2,4
Industrial crops	3,6	7,3	9,5	9,0	17,8	24,6	29,1	28,3	33,2
..fibre flax	0,3	0,2	0,1	0,3	0,1	0,1	0,1	0,1	0,0
..oil flax	..	..	..	..	..	..	0,1	0,1	0,1
..sugar beet	0,5	0,4	0,1	0,0	-	-	-	-	-
..rape	2,5	6,0	8,6	7,9	17,5	24,2	28,8	27,5	32,9
Vegetable s and greens	4,4	4,6	4,2	3,9	4,2	3,9	3,8	3,3	3,0
Potatoes	39,9	36,9	35,3	35,2	32,6	31,1	30,9	22,1	16,0
Forage crops	566,9	493,9	515,5	480,8	446,0	435,2	412,8	312,7	274,3
..fodder roots	12,0	10,8	8,8	6,9	4,7	3,5	2,5	1,4	0,4
..annual and perennial hay	554,9	483,1	506,7	473,9	441,3	431,7	410,3	311,3	273,9

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PRODUCTION AND AVERAGE YIELDS OF FIELD CROPS

Indicator	Field crop / Year	1995	1996	1997	1998	1999	2000	2001	2002
Production of field crops, thousand tons	Cereals	513,5	629,2	650,5	576,2	401,6	696,6	558,4	524,7
	..winter crops	83,6	97,2	109,3	88,0	57,3	112,3	109,2	128,4
	....rye	58,2	62,1	71,9	54,6	38,8	60,8	42,9	41,5
	....winter wheat	25,4	35,1	37,4	33,4	18,5	51,5	57,3	74,0
	....triticale	..	..	..	..	..	..	9,0	12,9
	..spring crops	429,9	532,0	541,2	488,2	344,3	584,3	449,2	396,3
	....spring wheat	51,7	66,2	73,8	84,6	69,9	95,3	75,6	74,4
	....barley	279,4	317,1	311,7	272,8	186,4	347,5	270,0	249,4
	....oats	80,0	114,8	114,7	99,3	70,7	117,1	91,4	61,7
	....mixed grain	18,8	33,9	41,0	31,3	17,2	23,9	11,6	10,7
	....buckwheat	0,0	0,0	0,0	0,2	0,1	0,5	0,6	0,1
	Legumes	6,3	13,8	17,0	8,3	3,1	6,6	6,5	5,0
	Flax stalks	0,2	0,2	0,1	-	0,1	0,1	0,1	0,1
	Oil flacks seed	..	..	..	..	..	0,1	0,1	0,1
	Sugar beet	12,7	2,4	0,5	-	-	-	-	-
	Rape seed	7,0	10,0	9,6	17,9	29,8	38,6	41,3	63,9
	Vegetables and greens	56,8	54,7	52,3	50,2	44,7	53,3	54,0	39,3
	..open-field vegetables	48,8	48,1	44,2	43,1	37,5	45,5	40,0	27,3
	Potatoes	537,4	500,2	437,5	316,7	403,7	471,7	343,1	210,9
	Forage roots	240,8	180,8	146,8	96,7	58,4	49,5	36,1	7,3
	Annual and perennial hay	618,0	475,8	484,1	354,6	354,3	375,1	315,7	155,5

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AGRICULTURAL PRODUCTION PER INHABITANT

Year / Kind of production	Cereals, kilograms	Potatoes, kilograms	Vegetables, kilograms	Meat, kilograms	Milk, kilograms	Eggs, pieces
1980	644	775	84	110	791	366
1985	473	542	82	117	820	344
1990	610	394	67	116	770	349
1991	602	379	77	97	700	358
1992	390	436	51	70	600	297
1993	543	360	47	56	540	231
1994	349	385	53	47	528	246
1995	357	374	40	47	492	227
1996	444	353	39	41	477	213
1997	465	313	37	38	512	211
1998	416	228	36	43	526	220
1999	292	293	33	44	455	200
2000	509	344	39	39	460	186
2001	409	252	40	42	501	204
2002	386	155	29	50	450	186

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CROP FARMING, 2002

In 2002 the sown area of field crops was 588,122 hectares (9% smaller than in 2001), the sown area of cereals was 259,248 hectares (5% smaller than in 2001). The area under legumes was 2,371 hectares (35% smaller than in 2001). The area under rape was 32,855 hectares (19 larger than in 2001).

The area under potatoes was 16,023 hectares (28% smaller than in 2001), and the area under open field vegetables – 3,018 hectares (9% smaller than in 2001).

The grain production amounted to 524,652 tonnes (6% less than in 2001), the production of rapeseed was 63,865 tonnes (55% more than in 2001), the production of potatoes – 210,861 tonnes (39% less than in 2001) and the production of vegetables – 39,290 tonnes (27% less than in 2001).

The yield of grain was 2,024 kilograms per hectare (in 2001 – 2,037 kilograms). The yield of potatoes was 13,160 kilograms per hectare (in 2001 – 15,503 kilograms).

The area and production of garden and field crops grown in kitchen gardens of agricultural holdings is included in the sown area and production of the corresponding crop.

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AS Werol Tehased (producer of high-quality edible oil):

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Estonian Legal Language Centre (official translation of legalisation's):

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Annex 3

REFERENCES

Agricultural and Rural Development Programme (SAPARD 2000-2006), Ministry of Agriculture, Estonian Agricultural Registers and Information Board, Tallinn, 2000

Agriculture 2002, 2003, Annual Report, Statistical Office of Estonia, Tallinn, 2001

Anti Viikna, Research on the use of short flax fibre and tow for producing of fleeces, mulch matting and geotextiles. Tallinn Technical University, Tallinn, 2002

A. Viikna, M. Soiela, E. Kikkas, The development and future for the flax industry in Estonia. Bast Fibrous Plants on the Turn of Second and Third Millennium: Natural Fibres, Shenyang, China, 2001, Proceed. Int. Conf., II/6 1-8

Arak, E. Activity on medicinal and aromatic plants in Estonia. News Newsletter of the International Council for Medical and Aromatic Plants (ICMAP), Paris, France, C/O IUBS, 1998, 5, 12.

Arvi Kallas, Leevi Mölder, Economical aspects of the processing and using of Biodiesel. Estonian Institute of Agricultural Engineering, Saku, 2001

Arvi Kallas, Annual Report 2001, Estonian Institute of Agricultural Engineering, Saku, 2001

Daisy Volmer, Modification and practical using of SCREEN-technique of phytochemical analysis of Estonian origin herbs. Supervisors PhD Uno Mäeorg and PhD Ain Raal. Tartu, 1994.

Elo Atla, Testing the antioxidant efficiency of thyme (*Thymus vulgaris* L.). Supervisors Ph.D. Ain Raal, Ph.D. Kersti Zilmer, Ph.D. Tiiu Kullisaar, Dr. Med. Mihkel Zilmer. Tartu, 2000.

Heidi Annuk, *In vitro* actions of aqueous extracts of some herbs on *Escherichia coli* and *Helicobacter pylori*. Supervisors PhD. Elmar Arak and PhD Endel Türi. Tartu, 1998

Jaan Simisker, Allan Nurk, L-lactate production and biodegradable polymers. Innovation Centre of Tartu University, Tartu 2000

Kaidar Erik, Flax growing and recycling in Estonia. Estonian Agricultural University, Faculty of Economics and Social Sciences, Tartu, 2001

Kalju Paalman, Annual Report 2001, Jõgeva Plant Breeding Institute, Jõgeva, 2001

Karin Karelson, Some first data about the accordance of the quality of Estonian and Western Europe essential oil-based drugs on the European Pharmacopoeia. Supervisors Ph.D. Ain Raal and Ph.D. Elmar Arak. Tartu, 2000.

Katrin Pudersell, The study of the content of the main tropane alkaloids and some plant nutritional elements of *Hyoscyamus niger* L. Supervisors PhD Elmar Arak and PhD Ain Raal. Tartu, 1998.

Katrin Salusaar, Testing the antioxidant efficiency of oregano (*Origanum vulgare* L.). Supervisors Ph.D. Ain Raal, Ph.D. Kersti Zilmer, Ph.D. Tiiu Kullisaar, Dr. Med. Mihkel Zilmer. Tartu, 2000.

Kristi Paumets, Evaluation of lead intensity in flores *Calendulae* depending on distance from highway. Supervisors Ph.D. Andres Meos and Ph.D. Ain Raal. Tartu, 2000.

Laur Soovere, Evaluation of lead intensity in flores *Calendulae* depending on distance from highway. Supervisors Ph.D. Andres Meos and Ph.D. Ain Raal. Tartu, 2000.

Pihlik, U. Cultivation of wild berry plants and using them for medicinal purposes. Forestry studies XXX: International conference, Wild berry culture: an exchange of western and eastern experiences, Tartu, 10-13. Aug. 1998, 127-133.

Quarterly Review of the Estonian Economy, Estonian Institute of Economic Research, Tallinn
2002

Tiina Koppel, Antimicrobial studies of some forms of drugs prepared on the basis of medicinal herbs. Supervisors PhD Elmar Arak and PhD Endel Türi. Tartu, 1994.