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**AJANKOHTAISTA  
MAATALOUSEKONOMIAA**

**CURRENT TOPICS  
IN AGRICULTURAL  
ECONOMICS**

MAATALOUDEN TALOUDELLINEN TUTKIMUSLAITOS  
AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, FINLAND

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**ENVIRONMENTAL PROBLEMS OF AGRICULTURAL PRACTICES AND CONSEQUENCES OF ENVIRONMENTAL POLICIES FOR FARMS IN FINLAND<sup>1)</sup>****John Sumelius**

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HELSINKI

*Abstract: This paper describes a) the environmental impacts of agricultural practices b) policy measures which decrease the environmental pressure of agricultural degradation c) impacts from external sources of pollution on agriculture d) consequences for farm management.*

*Although environmental repercussions have been less severe than in some more densely populated countries, agricultural practices exert a pressure on water-courses, air, soil, species and landscape. The most important issue has been the eutrophication of waterways. Agricultural policy has not had any environmental objective. Anyhow, a series of measures in order to prohibit environmental degradation has been taken. Agriculture is also affected by pollution from external sources, ozone pollution providing one example. Negative economic effects of pollution have, however, not yet clearly been demonstrated in agriculture.*

*The new environmental demands will pose new questions for agriculture in order to achieve rationalization gains. The importance of vocational education, entrepreneurship and management skills will increase. The emerging environmental issues will have implications for cost level, daily management and for farm structure.*

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*Index words: Environmental policies, environmental effects, pollution, rationalization, farm management*

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<sup>1)</sup> This paper was presented in a slightly modified version at the FAO/ECE Working party on Agrarian Structure and Farm Rationalization (Tenth session, Wageningen, Netherlands, 12-17 February 1990).

## 1. Natural conditions for agriculture in Finland

Finland is one of the most northern countries in the world where agriculture is widely practiced. Its geographical location between the 60th and 70th latitudes has obvious implications for crop yields, and the conditions for agriculture vary considerably between the north and south of the country. The northern boundaries for cultivating winter and spring wheat, winter rye, barley, oats, peas, oil plants and sugar beet are all run across Finland (TORVELA 1981). The effective temperature sum, i.e. the sum of the part of the average daily temperature that exceeds +5°C, is approximately 1350°C in the southernmost part but only 400°C in the northernmost part of the country (KÖPPÄ, 1980). The availability of land, however, is not a critical factor limiting agricultural production. Only 8% of land is used for agricultural purposes while 70 % is forest, 10 % is wetland and open land, 10% is water and only 2% is built-up land. Out of the total area, including all the above land use types, 2.8 % is protected as nature parks and national parks (STATISTICAL YEARBOOK OF FINLAND, 1987).

Therefore the intensity of agriculture has traditionally been somewhat lower than in central or southern Europe. Because of the cold, the need to control pests and insects is not as great as in warmer climates. Nevertheless, the intensity of agriculture combined with specialization has led to pressure on the environment, in some regions more than in others. The most important issue has been the eutrophication of waterways. The consequences of acid rain and the greenhouse effect have also received much attention, although they are of more concern to the forest sector, as forestry is more adversely affected by pollution and environmental changes than agriculture (cf. KAUPPI 1989).

The average size of Finnish farms is small (12 ha of arable land and 37 ha of forest). Agriculture accounts for about 4 % of the gross domestic product and 8 % of the labour force.

## 2. Development of the intensity of agriculture

A basic goal of Finnish agricultural policy has been self-sufficiency in essential foods. This goal was not achieved until after the Second World War, primarily as a result of increased use of external inputs in agriculture. Apart from a slight decrease in farmland during the Second World War, the cultivated area has been more or less stable during the last 50 years. This is illustrated in Table 1.

Table 1. Farmland in Finland, 1938–1988<sup>1)</sup>

Year	area, 1000 ha	Year	area, 1000 ha
1938	2,608.2	1982	2,516.6
1945	2,375.0	1983	2,466.6
1950	2,430.9	1984	2,438.8
1960	2,654.1	1985	2,410.4
1970	2,667.1	1986	2,391.9
1975	2,641.3	1987	2,411.3
1980	2,562.7	1988	2,441.3
1981	2,539.9		

1) The figures include a non-cultivated area consisting of fallowland, pasture, an unharvested area and land belonging to a soil bank system. In 1984–1988 this non-cultivated area varied between 374,000 ha and 518,000 ha.

Source: Statistical Yearbook of Finland.  
Kettunen (1989).

Food production suffered severely during the Second World War and in the post-war period; production volumes fell and approximately 12 % of the arable land was ceded to the USSR in the peace treaty even though the size of the population remained the same. The slight increase in the area of farmland in 1945–1960 was due to several factors: the need to compensate for the ceded agricultural land, the growing population, the shift in consumption towards dairy and meat products and the efforts to achieve self-sufficiency in food.

As in most other West European countries, hectare yields rose during the same period owing to new cultivation practices and the increasing volume of inputs. Figure 1 illustrates the rising trends in yields of spring wheat, rye, barley and silage.

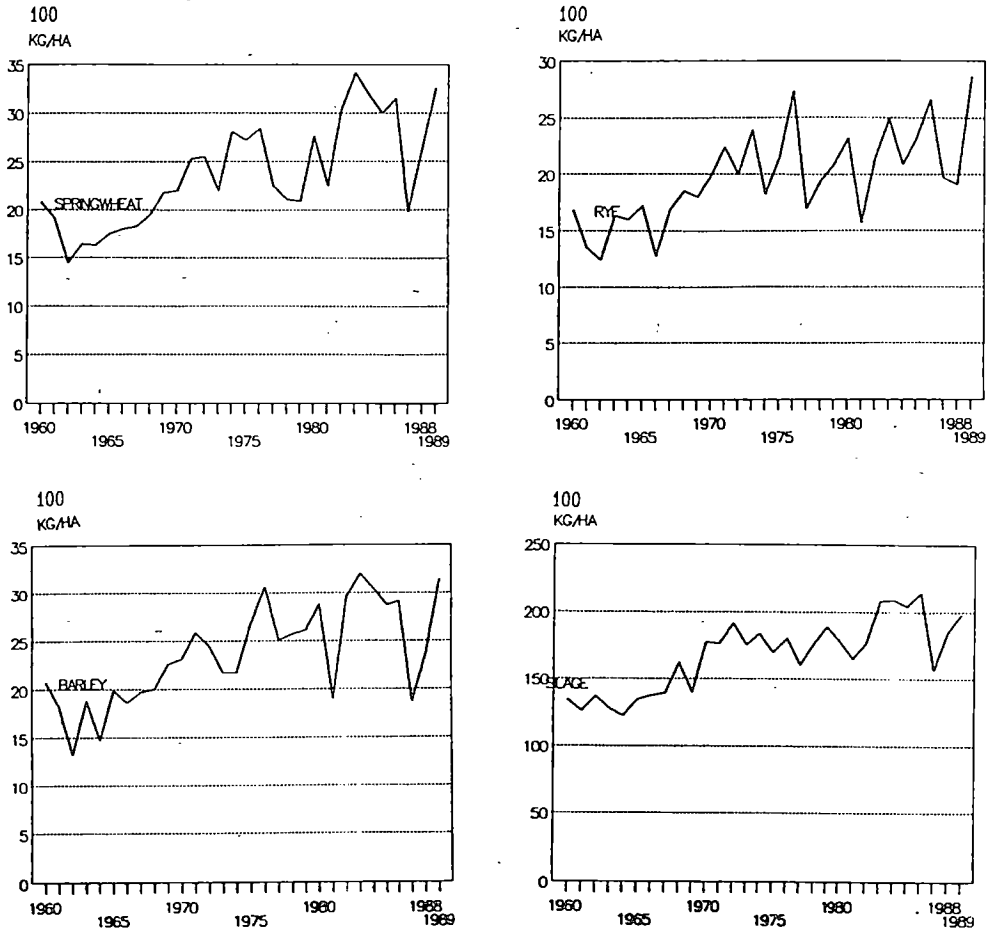


Figure 1. Yields of spring wheat, rye, barley and silage 1960–1989, 100 kg/ha

The increase in yields can be explained a) by higher levels of purchased variable inputs such as fertilizers, seeds and plant protectants (see Figure 2), b) by the increase in capital investment through mechanization, construction of better buildings and drainage, and c) by the growth of human resources due to improved education, and to an increase in extension as well as research activities.

Figure 2 shows the trends in application of fertilizers between 1960 and 1988. In less than thirty years the average amount of nitrogen applied to one hectare has quadrupled, the amount of phosphorus has doubled and the amount of potassium has more than doubled.

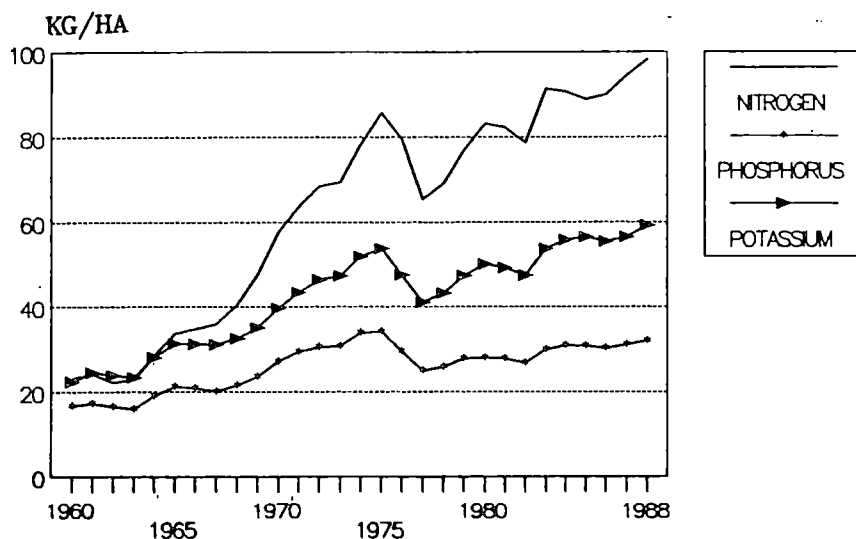


Figure 2. Nutrient amounts of fertilizers in Finland, kg/ha, 1960–88.

Whereas the average input of nitrogen per hectare was only 5.5 kg in 1950 it rose to 23 kg in 1960 and to 86 kg in 1975. Owing to the oil crisis and increases in fertilizer prices, fertilizer consumption fell after 1975. In 1985, fertilizer prices started to fall and by 1988 had declined by a fifth. The consumption of phosphorus and potassium followed a similar trend, though the fluctuations were smaller during the same period. From 1988 to 1989 phosphorus consumption has fallen by approximately a tenth despite the continuous low price of fertilizers. This is attributed mainly to the growth of extension activities and to changes in fertilizer composition made by the fertilizer industry.

The relative prices of fertilizers (the ratio between fertilizer and producer prices) is illustrated in Figure 3.

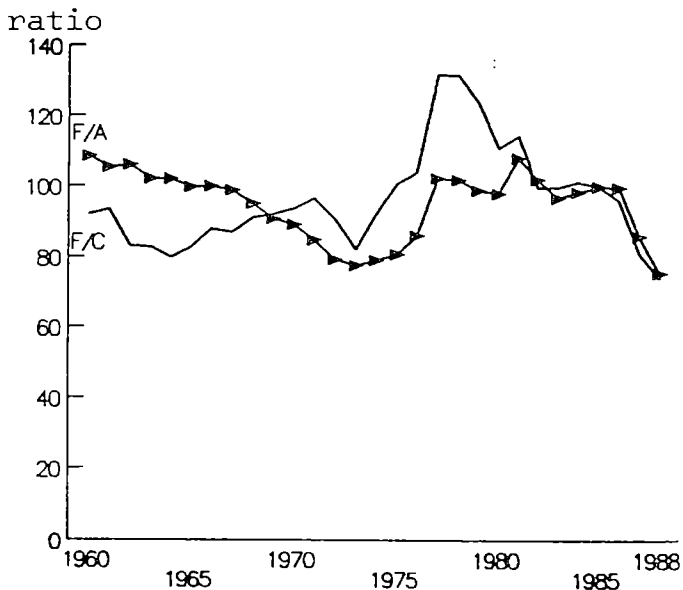


Figure 3. The relation between fertilizer prices and producer prices 1960–1988. F/C = The quota between fertilizer price and producer prices for crop production. F/A = The quota between fertilizer price and producer prices for animal production.

From the figure it is evident that at the end of the 1970s fertilizers became expensive with respect to crop production, whereafter prices started to decline. The relation between fertilizer prices and producer prices of crops was at its maximum in 1977–78. In 1985 it had fallen by a quarter, to only 74% of the level in 1978. By 1988 the ratio between fertilizer price and crop producer prices had further decreased to only 56% of the level in 1978.

The ratio between fertilizer prices and animal product prices changed in the same direction, although the change in their ratio was smaller. In 1988 the ratio was 73% of the level in 1977 (the year the fertilizer price/animal product price ratio reached its maximum).

With respect to increases in productivity the development in animal husbandry is similar to crop husbandry. The average milk yield per cow rose from just over 3000 kg in 1960 to approximately 5000 kg in 1988. Average carcass weights of bulls (over 130 kg) rose by a quarter between 1975 and 1987, from 179 kg to 222 kg. Annual egg production per hen rose from 13.0 kg to 14.9 kg in the same period. Food utilization of fattening pigs is continuously increasing.

Agriculture has gone through a period of rapid mechanization. Between 1970 and 1988 the number of hectares per tractor decreased from 16 to 10 and, correspondingly, per combine harvester from 46 to 28.

The increasing intensity of agriculture led to self-sufficiency and productivity gains and, ultimately to overproduction. Although environmental repercussions have been less severe than in some more densely populated parts of Europe, agricultural practices have still had an effect on watercourses, air, soil and landscape. Agricultural policy has not had any environmental objective as the effects of agriculture were considered rather minor. The situation has, however, changed, and environmental considerations are gaining more weight in policy formulation, especially in extension activities and within the producers' organizations.

### 3. Impact of agriculture on the environment

Many studies have been conducted in Finland on the impact of agriculture on the environment, and also on the consequences of environmental degradation for agricultural production. The issue which has received most attention is probably the loading of waterways. The following examines the various types of impact.

#### Water

The Finnish waterways are naturally oligotrophic, poor in nutrients, phosphorus in particular. Despite the large area covered by lakes, the water volume is small, the average depth of the lakes being less than 7 m. As a consequence, the waterways are easily polluted (WAHLSTRÖM 1989, ANON 1986). Besides the increase in the acidity of waterways due to acid rain, eutrophication has become a local problem in some places in southern and central Finland. In some cases the nutrient content of small lakes and rivers has risen sharply, leading to growth of algae and water plants. The three major sources of phosphorus are agriculture, industry and population centres. Emissions from industry and population centres, but not the diffuse loading from sources such

as agriculture, forestry, peat production and summer cottages, can be cleaned through sewage treatment plants.

The agricultural inputs which load the waterways most heavily are chemical fertilizers, plant protectants, slurry, solid and liquid manure, microbes and press effluents from silage (UUSI-KÄMPPÄ 1989). In 1988 the average phosphorus and nitrogen amounts in chemical fertilizers applied to one hectare were 32.0 kg and 98.2 kg respectively. The average amount of nutrients in manure and slurry is more difficult to estimate, and also less meaningful owing to farm specialization. Inappropriate storage of manure, slurry and press effluent, inadequate animal sheds and bad practices for the spreading of manure are some reasons why nutrients are washed out of manure.

Eutrophication is more problematic in the south and southwest of the country, which are the grain producing areas. Cattle husbandry (and pig meat production) is practiced widely in central Finland, where problems with pollution of lakes have occurred to a certain extent. In some farms the structure of the soil is a problem, causing not only lower yields but also increased leaching of nutrients.

Sometimes the groundwater has been affected, but since the density of animals is not very high and since farm sizes are controlled through the Act on the regulation of the establishment of large production units, groundwater is not as important an issue as in some more densely populated countries.

In the west of Finland, however, an environmental problem is posed by the fur farms, which are often situated next to one of the many rivers discharging into the Gulf of Botnia. Fur animal breeding is very intensive and, though research results are sparse, there are signs of groundwater contamination near some of the farms (OECD 1988).

The Agricultural Research Centre and the National Board of Waters and Environment are currently conducting an extensive joint research project concerning the leaching of fertilizers into waterways and groundwater.

### Soil

Degradation of soil is not a major problem in Finland. In general, the abundances of heavy metal in soil are low. The amounts of heavy metal found next to roads are small (with the possible exception of city centres). Pig manure, however, shows rather high concentration of copper, which may present a problem.

Sludge from sewage treatment plants is used on some farms. The potential area for spreading the sludge is extensive, and the abundances of heavy metals have remained within the recommended limits. Because of the large area of the country, heavy metals in the sludge do not present much of a problem (OECD 1988). The allowed cadmium content to be spread per year per hectare has been 20 g. Still stricter limits are likely to be adopted soon, because of reluctance of farmers to use sewage sludge. The average Cd-content of sewage sludge in Finland has been estimated to 5.3 mg/kg dry matter (LUOMA 1990).

On some farms, crop husbandry farms in particular, the soil suffers from compaction by machines. The problem is aggravated by the difficulties to include sown grassland in the crop rotation. This risk is greater when bad weather conditions prevail.

### Air

The main Finnish sources of nitrogen emissions in the atmosphere are traffic followed by energy production (power plant use of fuel oil) and industry (WAHLSTRÖM 1989). Animal husbandry, however, is emitting ammonia into the atmosphere. Ammonia, nitrous oxide  $N_2O$  (and also methane  $CH_4$ ) is released into the air from manure and to a certain extent from chemical fertilizer.

It has been estimated that one fifth of the total nitrogen in animal manure, 62,800 tonnes, is lost through volatilization during storage and another fifth when the manure is spread on the fields. From chemical fertilizers 7,500 tonnes are vaporized. In the grazing season a further 5,600 tonnes of nitrogen evaporates from livestock. Total annual nitrogen losses from manure and commercial fertilizers through vaporization are estimated to be approximately 38,000 tonnes of ammonia nitrogen  $NH_4NO_3$  or 16 kg/ha (the total emissions of nitrogen dioxide  $NO_2$  from traffic, industry and energy production has been estimated to 260,000 tonnes in 1987). If the ammonia evaporating from fertilizing agents should fall evenly within the borders of Finland, the annual nitrogen would amount to 1.12 kg/ha. If all ammonia nitrogen would nitrify into nitrates, the acidifying effect would correspond to a sulphur fall-out of 1.3 kg/ha (KERÄNEN and NISKANEN 1987). The annual nitrogen vaporized from fur farms is estimated to be 5000 tonnes.

Only a minor part of this, however, returns to the Finnish soil in the form of acid rain. One part falls down in other countries and another part is denitrified into a "greenhouse" gas, nitrous oxide  $N_2O$ , or to nitric oxides. According to NORDLUND (1989) only 15 % of the nitrogen deposited in Finland is from Finnish sources.

### Nature and landscape

Agriculture as practiced in Finland is considered to enhance the landscape. As forests abound and the population is sparse, people highly appreciate the variation provided by fields and houses. The cultural landscape is considered to complement the natural forest and lake landscape.

However, modern agricultural practices have led to a decline in the number of plant and animal species. Of the total of 40,000 species in Finland approximately 87 have lived in old cultural environments and are lost or threatened with extinction by modern agricultural practices and a further 113 need special consideration. Of the species which already have died out more than twenty have been connected with old cultural environments (meadows, cultivated land and parks) (ANON 1986). Meadows and groves ecosystems that support a particularly rich diversity of flora and fauna have disappeared. Of the species threatened by agriculture, 158 live in these environment created by a traditional agriculture. The populations of a number of bird species, e.g. starling, lapwing, house-martin, swallow and yellow wagtail, have declined by 50–80% as the agricultural landscape has been made more uniform (ULFVENS 1989).

The overall picture may be considerably brighter than in some countries, but there is still concern about the disappearance of species. The areas covered by wetlands have also declined, but more because of modern forestry practices than of agriculture.

The concern about the loss of species has, however, been criticized for representing a static view of nature. The living conditions of many of the species now threatened with extinction were gradually created by traditional agriculture during the last two millenia; before that they did not exist. According to the dynamic view of nature, new species are bound to be born and old ones to die. What man is doing is simply speeding up the latter process.

#### 4. Policies to prohibit environmental degradation

##### Water:

Administrative measures have been taken to improve the condition of the waterways. The spreading of slurry or manure on frozen earth is prohibited. Due to the risk of leaching no recommendations have been given for spreading it in the autumn.

The regulations applying to storage facilities for manure were made more stringent in the beginning of 1989. In the south of Finland, the capacity of storage facilities has to correspond to the volume of manure produced in six months; in the north of Finland the corresponding figure is eight months. In some particularly sensitive areas this capacity has to correspond to the need for twelve months. The intention is for the storage capacities of all old animal buildings to be expanded to meet these demands.

Regulation of establishment of large production units, a system originally planned for supply management, has turned out to be an effective tool for controlling environmental degradation. According to this system, establishing a production unit for more than 200 pig places, 1,000 hens, 30,000 chickens or 60 beef cattle is subject to a licence issued by the National Board of Agriculture. The establishment of production units for more than 25 pig places, 100 hens or chickens or 30 beef cattle requires a licence from local authorities (KETTUNEN, 1989). A certain amount of self-sufficiency in feed is also required of farms. Milk production is regulated by a quota system.

In June 1990, a fertilizer tax of one Finnish mark (approximately USD 0.24) per kg of phosphorus fertilizer will be introduced (a fertilizer tax of half a Finnish mark per kg of phosphorus is paid by the fertilizer industry during the first half of the year). The leading fertilizer manufacturer has also reduced the content of phosphorus in the most common commercial fertilizer. A small nitrogen tax of FIM 0.05 per kg has been collected with a view to restrict production. The phosphorus tax has anyhow been criticized for superficial analysis. Some economists argue that the real issue to be discussed is whether such a tax improves the conditions of waterways or not (NEVALA 1989). The tax has, however, turned more attention to environmental issues and the real impact is difficult to assess.

Farms which switch to organic or biological farming are entitled to a certain support. The amount corresponds to FIM 2,800 per ha of cultivated land (USD 670), reduced by 20% if drainage or other arrangements are incorrect. The

support is paid for three years until the whole hectareage is under organic cultivation.

The condition for obtaining loans at a low interest rate is that the manure and the press effluent from silage has been properly stored.

Possibly the most effective measure has been the enforcement of extension in environmental issues carried out by the agricultural extension agencies. These agencies have recently turned their attention to the eutrophication of waterways. Information on the handling of manure, the right time of spreading and the necessity of ploughing down the manure is distributed widely. A campaign has been launched urging all Finnish farms to have soil and nutrient content analyses made within the next five years. In this way, excessive use of chemical fertilizer can be avoided. It has been estimated that the phosphorus condition of fields is good because of extensive fertilization during the past twenty years. The average phosphorus dose could therefore be reduced by 20 % without decline in yield level (ELONEN, 1988). As a result, the recommendations for phosphorus fertilization have now been lowered. Phosphorus doses in 1989 were clearly lower than in 1988. The importance of proper drainage and good structure of soil in order to minimize nutrient losses has been emphasized.

To curb excessive production, a premium is offered for allowing land to remain fallow. Research results have shown, however, that the eluviation of nitrogen and the erosion of phosphorus are severe where the fallow has been left open, whereas only small amounts of nutrients are washed away from green fallow. Since December 1989 a distinction in premium for fallowing has been made, the green fallowing premium being FIM 300/ha (USD 70/ha) higher.

#### Soil:

The compaction of soil by machines has mainly been counteracted through extension efforts, by recommending farmers to use a double set of wheels and to minimize the number of times a tractor is driven on the field and by recommending proper crop rotation.

#### Air:

The effects of agriculture on the air have not received much attention in Finland. The measures prescribed for preventing eutrophication of waters, however, basically serve to reduce the vaporization losses from manure and fertilizers as well.

### Nature and landscape:

In 1987, a law was passed requiring a fee of FIM 30,000 (USD 7150) to be paid for the clearance of one hectare of land. Though intended mainly to restrict production, it has had the side effect that no more wetlands are being cleared.

Protected forest and wetland areas such as nature parks and national parks are found all over the country. For protecting the species threatened by modern agriculture a committee has proposed more surveys and preservation plans to be made (ANON 1986).

### **5. Economic effects of external pollution on agriculture**

The economic effects of external sources of pollution on agriculture mainly concerns air pollution. This includes the increase in ozone levels, the acid rain and the greenhouse effect.

The increase in the ozone level in the troposphere and the associated negative effects on plant and tree growth has not been investigated in Finland. The Finnish meteorological institute has measured the ozone content of the air at three stations. In summer the average monthly concentration has been 80–95  $\mu\text{g}/\text{m}^3$  and in winter 40–50  $\mu\text{g}/\text{m}^3$ . The limit, according to the WHO, of 200  $\mu\text{g}/\text{m}^3$  an hour has not been exceeded, but the upper recommended limit of 65  $\mu\text{g}/\text{m}^3$  per 24 ha has continuously been exceeded at the most southern station, Utö (NORDLUND 1989).

In 1989, some experiments focusing on the effects of an increase in the ozone level on agricultural production were launched at the Agricultural Research Centre. It is difficult to assess the economic impact of the increase in ozone concentrations on agricultural production before the results from these experiments are available. However, it looks as if the impact is less than in central Europe since the Finnish environment, in general, is cleaner and there is less pollution. The problem is that the joint effect of an increase in the ozone level and other air pollution can be greater or smaller than the separate effect of ozone alone. These joint effects may be different further north. In any case, the increase in ozone concentrations is not likely to have affected crop plant growth much.

Acidification can easily be prevented through increased liming. Acidification of arable land is due to the use of nitrogen fertilizers rather than to acid precipitation. Therefore acid rain probably has no economic consequences of importance

for agriculture. Anyhow, according to well documented studies, acid rains, poses concern for the forest (KAUPPI 1989). In one estimate, 40% of sulphur fall-out derives from the USSR, one third from domestic sources, one quarter from Eastern Europe and the rest from Scandinavian countries and Western Europe. Of nitrogen fall-out (which mainly are due to traffic), however, 30% are estimated to derive from Western Europe and Scandinavia, 20% from the USSR, 16% from Eastern Europe and only 15% from domestic sources. The remaining percentage derives from unidentified sources (NORDLUND 1989).

Many different estimates have been made on the consequences of an increase in the levels of carbon dioxide, CFC:s, methane and nitrous oxide ( $N_2O$ ) for the climate. According to one, the temperature in Finland would increase by 1.5–4–5°C by the year 2030, with winters in particular becoming warmer (WAHLSTRÖM 1989). Precipitation would also increase, possibly meaning that yields of grain would increase and the cultivation boundaries for wheat, rye, barley and oats would move northwards. If this is true, the greenhouse effect will raise crop yields and increase farm incomes if prices and costs do not change. At the level of the whole national economy this assumption is, however, questionable, Finland is already producing more agricultural products than the market can absorb (KETTUNEN et al.1988). Many effects may be unknown yet. With the change in climate new pests and diseases, for instance, may occur.

In short: Pollution in Finland does not appear to have affected agriculture to the extent that it causes clear economic disadvantages.

## **6. Consequences of environmental policies for farm holdings**

The heavier environmental demands will pose new questions for agriculture. How can increasing rationalization gains be achieved in the future when environmental policies are setting new limits for farmers? It has been suggested that gains in productivity need not be considered as important as in the past in terms of the whole national economy. In terms of individual farms, however, this does not make sense. The expansion of farms has already been severely prohibited through different supply management measures.

Some consequences of agriculture are described and some suggestions as to how agriculture should adjust to new circumstances are made below:

### General consequences:

Stricter regulations for agricultural practices present a risk for farmers, affecting the returns on their investment. In the context of Finnish agriculture, the importance of vocational education and extension seems to be increasing. Farmers who are able to adjust to environmental demands and who are also able to plan their production with a minimum of repercussions for the environment are probably those who can best counteract the risks associated with new regulations.

### Consequences with regard to production costs:

The new regulations are forcing the production costs up. For instance, the prohibition of spreading slurry in winter and the heavier demands on slurry and manure storage capacity per hectare will create financing problems for farmers with insufficient storage. Storage facilities, which at the time they were constructed received the approval of authorities, are now considered inadequate; this surprises many farmers. However, only farms where the treatment and storing of manure can clearly be shown to create problems for waterways can be forced to enlarge their facilities.

Because of the high cost of enlarging slurry and manure facilities, all farms with inadequate storage are to receive a public support of 20% of building expenses for renovation or expansion of manure storages. Calls for this support to be raised to 50% have also been made. It has also been suggested that the rate of depreciation for the manure storage facilities should be higher than for other buildings (currently 10%) in taxation.

Since 1989, a higher price has been paid for high protein wheat. This has made the use of nitrogen fertilization more profitable. The example illustrates how the increasing demands on better efficiency at farm level, and the environmental demands on farmers are often opposite and hard for farmers to deal with.

### Consequences for daily management of farms:

Good management of plant nutrients is one of the most important single improvements which can be made. Appropriate pipe drainage and attention to the structure of soil are other activities which diminish the eluviation of nutrients and volatilization of nitrogen. It is particularly important to plough manure down into the soil, and to spread it at the correct time. The common practice of placement fertilization (used in grain production) could be used for spreading of slurry as well. Placement of slurry with fertilizer drills can increase the

nutrient use of liquid manure. Leakages from manure storages or silage storages should be prevented.

Farmers should make more use of soil and manure nutrient analyses for estimating the need for fertilizers. Methods for analysing the nitrogen balance could be developed by research institutions for extension purposes.

#### Consequences for farm structure:

To a certain extent the structure of farms has been inhibited from developing due to the regulation of establishment of large production units. This system was, however, introduced as a part of supply management, not as an environmental instrument. Supply management may, however, be subject to change. Since the supply side is moving towards balanced markets the whole system may be abolished, although it could be retained as a part of environmental policy. In either case, it freezes the structure of farms, prohibits expansion of the number of animals and causes inefficiency in production. HEIKKILÄ (1984, 1988) has clearly demonstrated that the profitability of milk, pig and egg production depends on the size of the farm. The current quota system for milk production and the regulation of farm size in pig, beef and egg production prohibits expansion. Saving in production costs is the only way to raise productivity. The demands on feed self-sufficiency further reduce the possibility of saving on feed cost. The land clearing fee that came into force in 1987 has also restricted the opportunities to expand fields through clearance.

### 7. Concluding remarks

The overall picture of the environmental effects of agriculture in Finland seems to be brighter than in the more densely populated and more intensively cultivated regions of Europe. By making use of this opportunity and by avoiding the danger of aggravating potentially serious environmental issues, while there is sufficient time, the agricultural sector will be able to escape future mandatory measures (fertilizer quotas, obligatory green fallowing, stricter regulations of plant protectants, etc), which might hit farmers very hard. This, however, requires a continuous effort of agriculture to decrease the pressure on the environment.

For farmers, entrepreneurship and management skills will become still more vital. New environmental regulations and a concern for the environment will turn the attention of farmers not to making maximum yields but to becoming good managers, of both the environment and the farm's profitability.

## 8. Sammanfattning

På grund av sitt nordliga läge har lantbruket i Finland inte utövat ett lika starkt tryck på miljön som i en del tätare befolkade länder i Europa. Den kalla vintern och den låga befolkningstätheten har bidragit till ett mindre behov av att bekämpa skadedjur och en lägre intensitet. Den stigande intensiteten i lantbruket efter 1945 har dock gradvis lett till självförsörjning, småningom till överproduktion och slutligen till ett tryck på vatten, luft, mark och artrikedom. Relationen mellan priset på konstgödsel och producentpriser för växtodlingsprodukter steg åren 1973–77 till följd av oljekrisen. Efter 1978 har relationen utvecklats i en riktning mot billigare konstgödsel och var år 1988 endast 56 % av motsvarande relation tio år tidigare. Då negativa effekter på miljön har börjat uppmärksammas allt oftare, har även lantbrukets egna rådgivnings- och producentorganisationer börjat lägga en allt större vikt vid miljöproblemen. Även kulturlandskapets betydelse som en positiv miljöeffekt uppmärksammas allt mer.

Den allmänt mest omdiskuterade effekten av lantbruket är urlakningen av kväve och fosfor och påföljande eutrofiering av sjöar och åar. Vattendragens förorening och igenväxning har blivit ett lokalt problem på många ställen i södra och centrala Finland. Förutom lantbruket är även industrin och bosättningscentra huvudkällor till fosfor- och kväveutsläppen. Även pressaft från ensilage samt urlakade växtskyddsmedel kan skada vattendragen. Uppmärksamhet bör riktas speciellt på odlingstekniska åtgärder för att minska urlakningen från stall- och konstgödsel. Detta kan vara det effektivaste sättet att skona vattendragen. Grundvattenförorening har förekommit, men problemet är av avsevärt mindre omfattning än i Mellaneuropa.

Föroreningen av jordmånen är inte omfattande i Finland. Man har dock varit orolig för kadmiummängderna i det rötslam som erhålls från avloppsreningsverken. Därför kommer de stadgade gränserna för denna kadmiummängd troligen att sänkas.

Huvudkällorna till kväveutsläppen i luften består av trafiken, energiproduktionen och industrin. Ammoniak, kväveoxidul och metan avdunstar dock från dynga och stallgödsel, och i viss mån även från konstgödsel. Totalt har man estimerat att kväveavdunstningen är ca 16 kg/ha/år. Om man inför ett hypotetiskt antagande att all denna kväve skulle falla jämt inom landets gränser och om all nitrat skulle nitrifieras till nitrat skulle den försurande verkan av nedfallet motsvara 1.3 kg svavel/ha/år.

Sammanlagt 87 växt- och djurarter knutna till kulturmiljöer (olika typer av ängar, odlingsmark, parker och bebyggd miljö) är akut hotade och sårbara medan 113 är hänsynskrävande. Av dessa sammanlagt 200 arter hör 158 till miljöer som skapats av ett traditionellt jordbruk som försvunnit. Till följd av nya jordbruksmetoder har många åkerfåglar minskat starkt.

Det är inte bara jordbruket som belastar miljön. Omvänt belastas jordbruksmiljön även av det övriga samhället. Ozonföroreningen vid markytan som framkallats av trafik och energiproduktion minskar växtproduktionen. I avsaknad av forskningsresultat är det dock svårt att göra sig en uppfattning om storleken på denna förlust.

En räkka olika åtgärder med syfte att minska vattendragens belastning har vidtagits. Till dessa hör vissa administrativa åtgärder som förbud att sprida stallgödsel eller flytande gödsel på frusen jord. Minimikrav på storleken av gödselstäderna har införts. En omdebatterad fosforskatt om en mark överförs till konstgödselpriserna fr.o.m. andra hälften av år 1990. Gårdar som helt övergår till naturenlig odling erhåller ett stöd om 2800 mk/ha under tre års tid. Trädespremierna har även i slutet av år 1989 graderats så att man betalar 300 mk/ha mer för grönträda än för öppen träda. Etableringssystemet, ursprungligen stadgat för att styra och begränsa produktionen har även haft en positiv effekt med tanke på belastningen av miljön.

Den kanske mest effektiva enskilda punkten har varit en förstärkning av rådgivningen i miljöfrågor. Lantbrukets rådgivningsorganisationer har allmänt börjat uppmärksamma miljöaspekterna och man har i rådgivningen börjat påpeka vikten av att bestämma tidpunkten för spridning av gödsel rätt. Bördighetsundersökningarna har intensifierats. Även fosforhalten i de vanligaste konstgödselmedlen har sänkts.

De nya kraven på skona miljön för med sig nya frågor för lantbruket. Hur kan man öka rationaliseringsvinsterna då allt stramare krav på miljövänlighet begränsar jordbrukarens möjligheter? Man kan räkna med följande konsekvenser. För det första kommer betydelsen av utbildning och rådgivning att öka. För det andra ökar tempot i kostnadsjakten ytterligare, man måste försöka komma till rätta med kostnaderna för att förbättra lönsamheten. För det tredje kommer miljöhänsynen troligen att beaktas mer än tidigare i dagliga rutiner på gårdarna. För det fjärde kan även kraven på miljövänlighet leda till att strukturomvandlingen i jordbruket saktar in.

Slutligen kan man konstatera att lantbrukets negativa miljöeffekter inte har hunnit bli lika omfattande som i de tätt befolkade delarna av Europa. Genom att ta till vara denna möjlighet och undvika att förvärta potentiellt känsliga miljöproblem kan lantbruket även undvika eventuella framtida obligatoriska åtgärder som konstgödselkvoter, obligatorisk grönträda, starkare reglering av växt skyddsmedelanvändningen osv.

## REFERENCES:

- ANON 1986. Uhanalaisten eläinten ja kasvien suojelutoimikunnan mietintö. (Report given by the Commission on preservation of threatened animal and plant species). Committee report 1985:43. General part. 123 p. Helsinki.
- ELONEN, P. 1988. Jordbruk, miljö och ekonomi. Det moderna jordbrukets inverkan på åkermarkens produktionsförmåga. (Agriculture, environment and economics. The effects of modern agriculture on the production capacity of soil). LOA 12 1989. 69:528-529.
- HEIKKILÄ, A-M. 1984. Perheviljelmän koko ja viljelijäperheen toimeentulon lähteet. (English summary: The size of farm holdings and the sources of family farm income). Agric. Econ. Res. Inst. Publ.48. 95 p. Helsinki.
- HEIKKILÄ, A-M. 1988. Maidon tuotantokustannus yrityskoon vaihdellessa. (English abstract: Milk production costs according to farm size). In "Tuotantokustannuksista maatilamatkailuun". Agric. Econ. Res. Inst. Publ. 55. p. 89-100. Helsinki.
- KAUPPI, P. 1989. Ilmakehän muutokset ja metsät. (The changes in atmosphere and the forests). Pellervo Economic Research Institute. Katsaus 4/1989. p.2-7.
- KERÄNEN, S. and NISKANEN, R. 1987. Typpilannoituksen vaikutus happamoitumiseen Suomessa. (English summary: The effects of nitrogen fertilization on acidification in Finland - a review). Environmental Ministry, Series D 30/87. 64 p. Helsinki.
- KETTUNEN, L. 1989. Finnish agriculture in 1988. Agric. Econ. Res. Inst. Publ. 52a p. Helsinki.
- KETTUNEN, L., MUKULA, J., POHJONEN, V., RANTANEN, O. and VARJO, U. 1988. The Effects of Climatic Variations on Agriculture in Finland. pp 511-597 in "The Impact of Climatic Variations on Agriculture", Vol.1. Ed. Parry, M.L., Carter, T.R., Konijn, N.T. Publication by IASA and UNEP. Published by Kluwer Academic Publishers. 876 p. Netherlands.
- KÖPPÄ, P. 1980. Kasvinviljelyoppi 1. (Crop husbandry 1). 230 p. Rauma.
- LUOMA, T. 1990. Jätevesilietteen maataloudellinen hyväksikäyttö. (English summary: Agricultural Use of Sewage Sludge). Institute of Agricultural Technology, Helsinki University. Res. rep. 61. 142 p. Vaasa.

- NEVALA, M. 1989. Perusteeton haittavero haittaa. (A groundless Fertilizer tax damages). Pellervo Economic Research Institute. Katsaus 4/1989. p. 17-19.
- NORDLUND, G. 1989. Suomen ilmansaasteet läheltä ja kaukaa. (The air pollution in Finland). Maataloustuottaja 11, 1989:20-21.
- OECD. 1988. Suomen Ympäristöpolitiikka. Environmental Policies in Finland. A Review by the OECD and its Environment Committee Undertaken in 1986/1987 at the Request of the Government of Finland. 276 p. Paris.
- STATISTICAL YEARBOOK OF FINLAND 1977-1987. Central statistical office of Finland.
- TORVELA, M. 1981. Regional problems of agricultural production in Finland. EAAE-congress paper in Belgrade 1981. Part B: Problems and policies. B3. Less-favoured areas in Northern climates. 15 p.
- ULFVENS, J. 1989. Jordbrukaren kan göra mycket för mångfalden i odlingslandskapet. (The farmer can do much for variety in the landscape). LOA 1989 6-7. 70:250-251.
- UUSI-KÄMPPÄ, J. 1989. Vesistöjen suojaaminen rantapeltöjen valumilta (Protection of waterways from the run-off from riverside fields). Agricultural Research Centre Reports 10/89. 66 p. Jokioinen.
- WAHLSTRÖM, E. 1989. Miljöhandboken. (Handbook of the environment). 215 p. Helsinki.

## ECONOMIC ASPECTS ON THE PRODUCTION TIME OF DAIRY COWS

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*Abstract: The purpose of this article is to answer the question: How many years, from the economic point of view, are the minimal, optimal and maximum production times of dairy cows. The research is based on data on Lowland Black and White cattle. The data covers the whole information of cow testing in the years 1983-1987. The minimal, optimal and maximum production times of cows were calculated by means of an analysis of the net income with taking into consideration the replacement costs of cows. On the average, the actual time of production of dairy cows in Poland, particularly on state farms, is much shorter than the optimal time. This causes considerable losses and reduces the profitability of milk production.*

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*Index words: economics, dairy cattle, milk production, production factors, production functions, productivity*

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## 1. Introduction

Since dairy cows have an basic role among domestic animals, economically they can be regarded as fixed production assets. As a consequence of this, the following question can be formed: How to determine the optimal moment to replace a cow? From the economic point of view it would be recommendable that the production time of cows would be as long as possible, since the replacement costs of cows would be lower per year and thus the encumbrance to the milk production would be smaller. However, characteristic changes occur in the milk yield, slaughter value, use of feed, fertility and functional conformation during the production time of cows. These factors lead to extentions and shortenings of the production time of dairy cows. Therefore, the determination of the length of use is a vital decision each milk producer has to make.

In 1987, milk production made up 13.5 per cent of the value of global agricultural production and 17.4 per cent of the value of marketed production. In the Polish agriculture milk production is one of the basic production lines. Nevertheless, on the average, the annual yield per cow is evaluated to be very low in Poland. In 1987, the average milk production in the country amounted to as little as 3,062 litres per cow, but only 2,964 litres per cow were produced on private farms, where 87 per cent of the country's cows are kept. Such results were achieved 30 - 40 years ago in the economically developed countries. According to the experts, reasons for such a low yield of the Polish cows are as follows: too extensive and insufficient organization of cattle rearing, which especially appears in cattles of few cows (the average number of cows on private farms is 1.9), low level of specialization (only three per cent of private milk producers have more than ten cows), poor organization of feed production, and poor mechanization of milk production (half of all cows are milked by hand) (Table 1).

Table 1. Milk production in Poland  
*Taulukko 1. Maidontuotanto Puolassa*

	1980	1985	1987	1988
Cattle, in thousands <i>Nautoja, 1000 kpl</i>	12 649	11 055	10 523	10 322
Dairy cows, in thousands <i>Lypsylehmiä, 1000 kpl</i>	5 956	5 528	4 937	4 806
- On private farms <i>- Yksityisillä tiloilla</i>	5 098	4 834	4 295	4 183
Milk production, mill. litres <i>Maitotuotos, milj. l.</i>	16 000	15 955	15 079	15 177
Milk production, litres per 1 ha <i>Maitotuotos, l/pelto-ha</i>	839	812	810	802
Milk yield, litres per cow <i>Maitotuotos, l/lehmä</i>	2 730	2 897	3 062	3 165
- On private farms <i>- Yksityisillä tiloilla</i>	2 695	2 808	2 964	3 061

Considering the growing demand for dairy products and the stagnation of, or even drop in, the supply of milk caused by a decrease in the number of cows, the average annual yield will become a major problem in the Polish agriculture. The attempts to solve the problem by administrative measures failed. The only effective way to increase the farmers' interest in milk production is to raise its profitability. Without raising the prices of dairy products, one way to aim at this is to extend the length of the production time of dairy cow.

The purpose of this article is to try to answer the question: How many years, from the economic point of view, are the minimal, optimal and maximum production times of dairy cows? The production time of a cow is concerned to be from the first calving to the rejection of the cow.

The minimal production time occurs, from the point of view of profitability of milk production, when the difference between the value of the production gained and the total costs arisen is equal to zero. The optimal period occurs when maximum profit is made on the production time of a cow under certain conditions. And the maximum period occurs when the value of the production is equal to the costs arisen.

## 2. Source material and research methods

The research is based on data on Lowland Black and White breed of cattle. The data, which has been carried by the Central Station of Animal Breeding during the years 1983 - 1987, covers the whole information of cow testing. In order to determine the actual length of life of dairy cows, the length of their production time and the reasons for rejecting defective cows, the whole data on all cows was used. But for calculating the minimal, optimal and maximum production times, information on those cows that had had over ten lactations and on those that had been slaughtered during the years 1983 - 1987 was collected. This data were useful for calculating the parameters of the functions of the cows' milk yield and live weight during the successive years of the production time. Other parameters necessary for the calculations were brought into use on the basis of the studies on the practice of agriculture and agricultural science, results of which were regarded as the standard in the conditions of the Polish agriculture.

The minimal production time of a cow, from the economic point of view, was calculated by means of an analysis of the net income when assuming different production times. The replacement costs were taken into consideration in the calculations. The optimal and maximum production times were calculated by the calculation technique elaborated by STEFFEN and KELLNER. It has been derived from the neo-classical models of balance, assuming that maximization of profit is the goal of farming. In this study the profit gained from the cows in production is compared with the profit that could be made by obtaining new cows.

In this study the methods of the value of capital and yearly payment were used. The first method is based on the calculation of the volume of capital during different periods, and the second method on the comparison between the final profit and the average profit of separate years.

The following mathematical formulas have been used for the calculations:

$$WK_0^N = -CZ + Wrz_N * q^{-N} + \sum_{i=1}^N (ZBr) * q^{-i}$$

$WK_0^N$  value of the capital gained on account of a production time of a cow

$CZ$  purchase price or breeding costs of a heifer in calf

$Wrz_N$  slaughter value of a cow

$N$  number of the successive years of a production time of a cow

$ZBr$  gross profit during the successive years of a production time

$q$  percentage factor ( $q = 1 + 0.0p$ )

$$WK_0^\infty = WK_0^N \frac{q^N}{q^N - 1}$$

$WK_0^\infty$  amount of the total capital, ensures profit in the form of accumulated percentage, equal to the worth of the capital  $WK_0^N$  obtained from the production time of a cow

$$ZS = WK_0^N \frac{q^N (q - 1)}{q^N - 1}$$

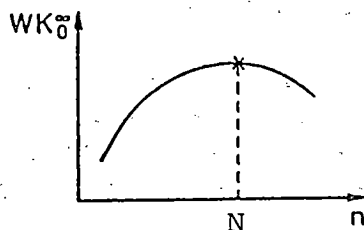
$ZS$  average profit made during the production time

$$ZK = ZBr + Wrz_N - Wrz_{N-1} * q$$

$ZK$  final profit

In accordance with the method of the value of capital, the optimal production time of a cow, assuming that it will be replaced by a heifer of the same level of lactation, will occur at the point 'N', in which the value of the total capital (WK) will reach the maximum. On the contrary, in accordance with the method of yearly payment, the optimal period will occur at the point in which the final profit (ZK) is equal to the average profit (ZS), and, at the same time, the average profit achieves the maximum value (Figure 1). The formulas above refer to a situation in which an infinite number of investments are being implemented. This signifies continuity of the processes of milk production by means of replacing old cows by young ones. If a cow to be rejected will be replaced by a heifer of a higher level of lactation, the optimal production time will occur at the point in which the average profit obtained (ZS) from a new cow at the first time will be higher than, or equal to, the final profit (ZK) obtained from the cow to be rejected.

$$WK_0^\infty = WK_0^N \frac{q^N}{q^N - 1} = \max$$



$$ZS = WK_0^N \frac{q^N/q - 1}{q^N - 1} = \max$$

$$ZK = ZBr + W_{rzN} = W_{rzN-1} \cdot q$$

$$ZK = ZS$$

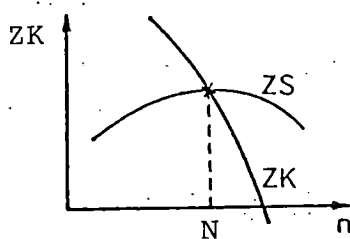
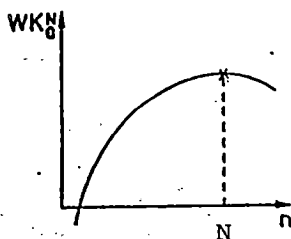


Figure 1. The optimal production time of a cow in continuous production.

Kuvio 1. Optimaalinen lehmän tuotantoaika jatkuvassa tuotannossa.

The problem of the optimal production time of a cow with one-time investment is somewhat different, for example, when the producer considers an interruption of milk production. In that case, the optimal time is equal to the maximum time and will occur at the point in which the value of the total capital (WK) reaches its maximum value, and the final profit (ZK) is equal to zero (Figure 2).

$$WK_0^N = -CZ + W_{rzN} \cdot q^{-N} + \sum_{i=1}^N ZBr / q^{-i} = \max$$



$$ZK = ZBr + W_{rzN} - W_{rzN-1} : q = 0$$

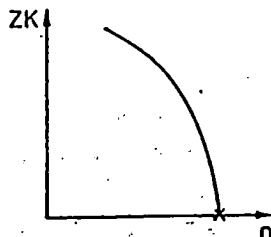


Figure 2. The optimal production time of a cow considering interruption of milk production.

Kuvio 2. Optimaalinen lehmän tuotantoaika maidontuotannon keskeytyessä.

### 3. Results of the study

The appraisal of the values of milk during the years 1983 – 1987 covered 95.5 per cent of the cows of state farms but only 2.4 per cent of the cows of the most profitable private farms. The average annual yield was 4,350 kilograms and fat content 3.97 per cent in 1987.

During the years 1983 – 1987, the average length of life of cows was 7.17 years and the average production time 4.93 years on private farms. On state farms the corresponding figures were 5.87 and 3.33 years respectively. The main reason for such a short production time is the considerable number of rejections of cows. The essential reasons for that are sterility, accidents and, to a smaller extent, the selective rejection due to low yield (Table 2).

The profitability of cattle rearing depends on many factors, most important of which are the following groups:

1. Breeding factors: biological advance, selection and choice of animals
2. Biological and organizational factors: race, age at which the first calving takes place, milk yield during successive lactations and after the whole production time, systems of producing and feeding, size of the herd
3. Economic factors: costs of the farm's own production of feed and of purchased feed, rearing costs or purchase price of a heifer in calf, costs of labour, selling price of milk, quality of the calves, risk of dying.

Considering the study being a model, only a few factors, mainly the economic ones, were taken into account. Those factors are the level of milk yield, price of milk, purchase price or rearing costs of heifers in calf and interest on capital. In the calculations capital changes in the value of money have been taken account.

In order to be able to make calculations, it is necessary to know the slaughter value and the milk yield of a cow during successive years of production time. Parameters of functions determining changes in the live weight of cows on five different production levels were calculated (Figure 3). Slaughter value is determined, as well as the live weight, by the selling price of a cattle on the hoof. Despite the increase in the live weight, the selling price goes down with the age and causes slaughter value to decrease simultaneously.

Table 2. The average length of life and production time of dairy cows and the reasons for rejection of cows.  
Taulukko 2. Lypsylehmien keskimääräinen elinikä ja tuotantoaika sekä syyt lehmien poistoon.

Year	Length of life on average	Production time on average	Reasons for rejection of cows, %						
			low yield	mastitis	sterility	infections	high age	other	
Vuosi	Keskimääräinen lehmän elinikä	Keskimääräinen räinen tuotantoaika	alhainen tuotos-taso	utaretulehdus	hedelmättömyys	taudit	korkea ikä	muut tapaturmat	
State farms	5.59	3.09	24.6	7.0	35.4	3.1	1.9	28.0	
	5.77	3.14	25.8	6.5	36.5	3.4	2.0	25.8	
Valtion-tilat	5.91	3.27	26.1	7.4	36.5	3.0	2.0	25.0	
	6.12	3.54	24.7	6.5	35.3	2.8	2.0	27.7	
1987	6.12	3.62	23.9	6.2	37.6	3.6	1.7	27.0	
average keskim.	5.87	3.33	25.2	6.8	36.3	3.7	1.9	26.1	
Private farms	7.23	4.99	12.9	7.0	27.9	2.4	3.8	46.0	
	7.32	5.06	12.2	6.7	27.0	1.3	4.0	48.8	
Yksityiset tilat	7.03	4.77	10.7	7.2	30.5	1.4	3.7	46.5	
	6.89	4.65	10.3	7.6	32.1	1.9	4.5	43.6	
1987	6.90	4.69	10.5	6.5	35.6	2.2	4.3	40.9	
average keskim.	7.17	4.93	11.9	6.9	30.4	1.9	4.1	44.8	

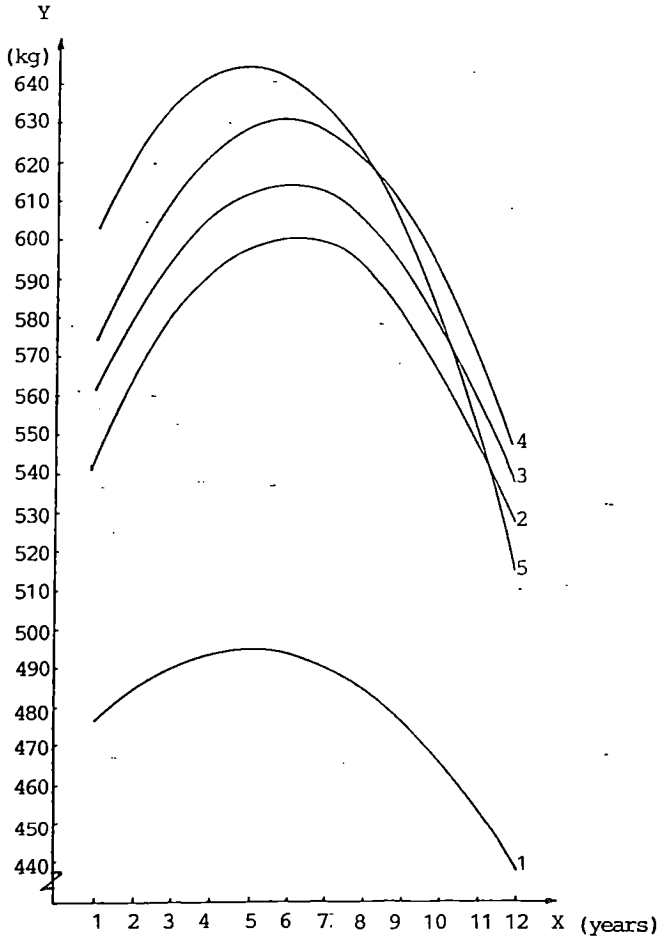


Figure 3. The parameters of functions determining changes in the live weight of cows according to the milk yields and the years of the production time.

Kuvio 3. Lehmän elopainon kehitystä kuvaavat funktiot eri tuotostasoilla tuotosvuosien mukaan.

$Y_1, Y_2, Y_3, Y_4, Y_5$	live weight of a cow time lehmän elopaino, kg
X	years of the production time tuotosvuodet
$N_1, N_2, N_3, N_4, N_5$	coefficients of correlation korrelaatiokertoimet

$Y_1 = 466,97727 + 11,441809x - 1,1525974x^2$	$N_1$ 0,98857
$Y_2 = 579,27273 + 27,250749x - 2,2597403x^2$	$N_2$ 0,93006
$Y_3 = 538,38636 + 25,62013x - 2,1630869x^2$	$N_3$ 0,92537
$Y_4 = 548,61364 + 28,245004x - 2,4053446x^2$	$N_4$ 0,98863
$Y_5 = 579,84091 + 26,244005x - 2,6371128x^2$	$N_5$ 0,96623

Milk yield varies with the age of the cow, too. This could be seen from the calculated parameters of thirteen functions concerning different production levels of cows. The fat content was 3.5 per cent during successive 305-day-long lactations. As it appears from the figures 4 - 7, the maximum production per year is achieved in four to six lactations, after which the production decreases. The drop is the biggest in the case of the cows with the highest production level and the cows with the lowest production level.

The level of other factors taken into account in the calculations was accepted in accordance with the prices in 1987 (Table 3). The calculation was done on the RIAD-35 computer at the Agricultural University. Taking notice of all the factors listed, the minimal production time was calculated in 208 variants and the optimal and maximum times in 1,040 variants.

Table 3. Factors considering the calculation of the production time of dairy cows.

*Taulukko 3. Lehmien tuotantoaika koskevissa laskelmissa käytetyt muuttujat.*

Number of function	Milk yield per cow, kg/year	Price of milk zl/kg	Cost per feed unit, zl		Price of heifer, zl	Percentage factor
Funktion numero	Maitotuotos/lehmä kg/vuosi	Maidon hinta zl/kg	Rehuyksikkökustannus, zl		Hiehon hinta, zl	Korkotekijä
			a)	b)		
1	2351	I. 24.70	3.9	6.6	84 930	1.01
2	2755	"	"	"	"	"
3	3263	"	"	"	"	"
4	3752	"	"	"	111 750	1.05
5	4116	"	"	"	"	"
6	4630	"	"	"	"	"
7	5159	"	"	"	"	1.07
8	5676	"	"	"	163 900	"
9	6356	II. 21.20	6.6	9.7	"	1.14
10	7038	"	"	"	"	"
11	7502	"	"	"	"	"
12	7738	"	"	"	200 000	1.18
13	8443	"	"	"	"	"

The **minimal production time** of a cow, in accordance with the various calculations, was one to eight years. In four cases production was unprofitable, reasons for which were high prices of heifers, high costs of feed and low prices of milk. The factors influencing the length of the period in question are the following: milk yield, purchase prices of heifers in calf, production costs of feed and selling prices of milk. When the purchase prices of heifers were high and feed was expensive, the minimal production time of a cow of the lowest milk yield (less than 3,263 kilograms) was long, from four to eight years (Table 4). That long minimal production time indicates that the profitability of milk production will be very low. That can also be noticed by comparing the above-mentioned period with the actual production time of a cow on state farms. On them the minimal production time of the best cows, milk yield of which amounted to between 7,000 and 8,500 kilograms, was one to three years. In most cases, however, it was one year, which resulted from the high level of production.

From the economic point of view, the **optimal production time** of a cow, on the assumption that the rejected cows were replaced by heifercows of similar milk yield, amounted to five to twelve years (Table 5). In thirty-three cases production was unprofitable. When considering the influence of individual factors on the length of the optimal production time, it can be stated that the increase in milk yield brings about first an extension and then on the highest level of yield a shortening of that time. That can be seen from the run of the curves of milk yield of successive lactations. Price of milk and production costs of feed do not essentially influence the length of the production time of a cow. A rise in the purchase price of heifers extends the production time by one to two years. Similarly, a rise in the interest rate from one per cent to eighteen per cent extends, in many cases, the production time by one to two years.

The carried-out calculations concerned situations in which the rejected cows were replaced by heifercows of similar milk yield. In practice, however, farmers more frequently replace old cows with cows of a higher milk yield. Then the optimal production time becomes shorter. The replacement of cows producing 3,752 kilograms milk by heifercow producing between 4,116 and 7,038 kilograms milk leads to the fact that the optimal production time varies between one and twelve years. The length of the period depends mainly on the level of milk yield of new heifercows and on the purchase price of heifers in calf (Table 6).

The **maximum production time** was nine to twelve years, except in the cases the milk production was unprofitable. It can be useful to know the length of that period when the discontinuance of milk production is being considered. From the economic point of view, longer production time, even beyond the maximum time, of those cows whose milk yield and thus also value of breeding are high can be justified because of the high value of their calves.

You can notice that the actual length of production time of a cow is very short when comparing it with the calculated optimal and minimal production times. On state farms the actual period was 3.33 years with average milk yield of 4,017 kilograms and fat content 3.5 per cent. When comparing this with the calculations, the result can be seen to be similar to that of the minimal period, which was one to five years. The actual production time would be similar to the optimal period if the rejected cows were replaced by heifercows the milk yield of which were between 5,500 and 6,000 kilograms and if purchase price of heifers were about 200.000 zlotys.

The situation was better on private farms. The actual length of production time was longer than the minimal period, and it could be even similar to the optimal period if the rejected cows were replaced by heifercows the milk yield of which were between 5,000 and 5,500 kilograms. Since some of the cows are rejected as early as during the selection (see the table 2), the average length of production time cannot be equal to the length of the optimal period, which should be remembered when making such comparisons. According to the information given by the Central Station of Animal Breeding, eighteen per cent of the cows do not reach the level of average milk yield, and they should be rejected earlier. It is economically efficient to reject them either two months after the first calving or after a 100-day-long lactation. Then the farmer will get a higher price for slaughter cattle, and he can make better use of reserve stances for cows.

#### 4. Summary and conclusions

This study deals with optimal production time of dairy cows, but it does not cover every situation of the process of milk production. The reality is more differentiated. Therefore, in order to be able to make decisions, economic calculations should be made on every farm specializing in milk production. In spite of many oversimplifications, the following conclusions can be drawn from the variant results obtained:

1. On state farms the production time of cows, on the average, was a little over three lactations and on private farms over four lactations during the years 1983 - 1987. Compared with the years 1960 -1965, the production time became shorter by two to three years, whereas no essential changes occurred in relation to the years 1965 - 1980.

2. One of the reasons for the shortness of the production time of a cow is the high age at the first calving. Forty-seven per cent of the heifercows are calving at the age of 2.5 years or later, which is half a year later than the optimal term. That is why it seems advisable to improve the conditions of rearing calves and heifers on many farms.
3. A factor affecting the shortness of the production time of a cow is the considerable number of rejections caused mainly by sterility, accidents and low milk production. In order to extend the production time, these problems should be solved by ensuring favourable environmental conditions, such as proper feeding, careful nursing and attendance as well as adequate cowsheds, to the animals.
4. A consequence of the rejections is that only a small number of cows achieve the maximum yield of lactation which, for instance, the cows of the Lowland Black and White breed reach during four to six lactations. The earlier rejection of cows accounts for the fact that milk production does not increase. In effect, it decreases the profitability of the production.
5. On the average, the actual production time of a cow in Poland, particularly on state farms, is much shorter than the optimal time. This causes considerable losses and reduces the profitability of milk production or even makes it unprofitable.

## REFERENCES

- OLKO-BAGIENSKA, T. 1987. The production time of dairy cows of the Lowland Black and White breed and the profitability of milk production. Doctor's thesis published by the Institute of Economics and Farm Organization. Warsaw.
- REISCH, E. & ZEDDLIES, J. 1977. Einführung in die Landwirtschaftliche Betriebslehre. Band. 2. Verlag Eugen Ulmer, Stuttgart.
- STEFFEN, G. & KELLNER, L. Determining of the optimal deadline for the exchange of fixed assets and investment goods in the course of making decisions. Annals of Agricultural Sciences. Series G volume 81. Warsaw.

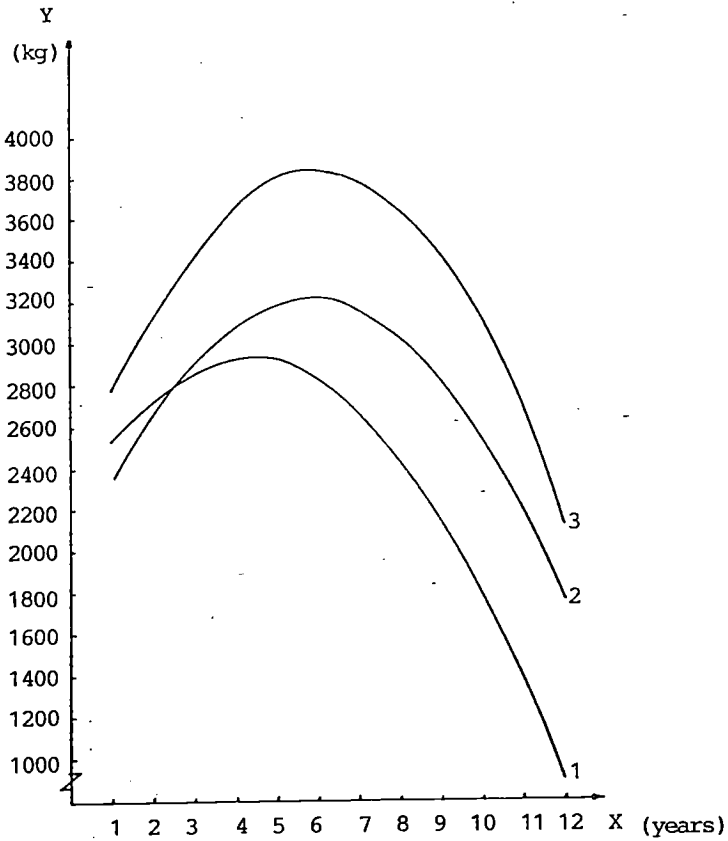


Figure 4. The parameters of the milk yield (fat content 3,5 %) according to the milk yields and the years of the production time.

Kuvio 4. Maitotuotosta (rasva-% 3,5) kuvaavat funktiot eri tuotostasoilla tuotosvuosien mukaan.

$Y_1, Y_2, Y_3$  milk yield, kg/year  
maitotuotos, kg/vuosi

$X$  years of the production time  
tuotosvuodet

$N_1, N_2, N_3$  coefficients of correlation  
korrelaatiokertoimet

$$\begin{aligned}
 Y_1 &= 2280,4350 + 298,08348x - 34,462135x^2 & N_1 &= -0,89760 \\
 Y_2 &= 1985,0297 + 426,71314x - 26,986534x^2 & N_2 &= 0,96710 \\
 Y_3 &= 2348,2079 + 506,21168x - 43,858761x^2 & N_3 &= -0,96770
 \end{aligned}$$

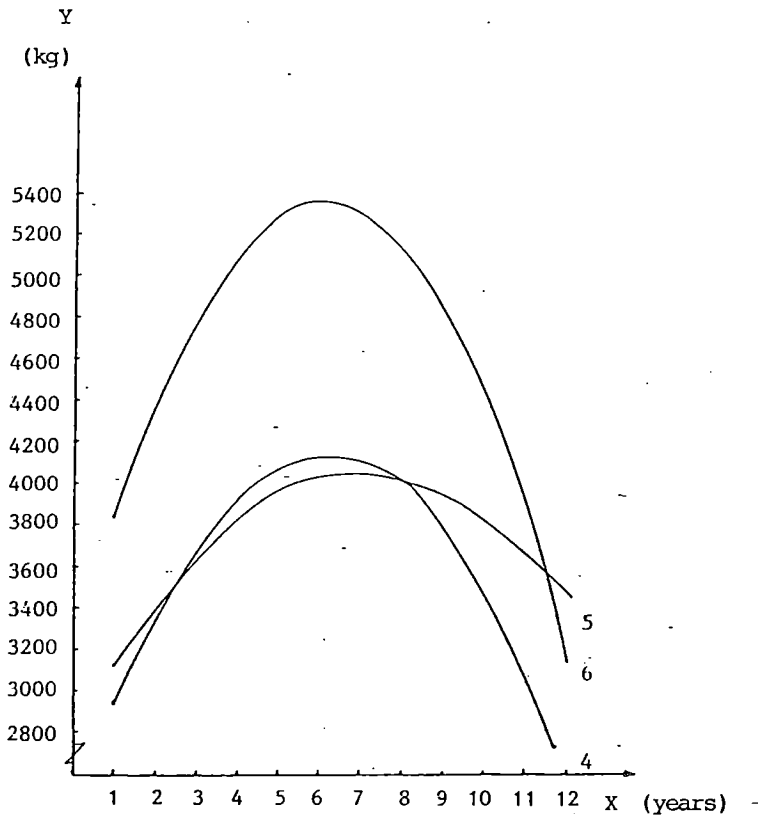


Figure 5. The parameters of the milk yield (fat content 3,5 %) according to the milk yields and the years of the production time.

Kuvio 5. Maitotuotosta (rasva-% 3,5) kuvaavat funktiot eri tuotostasolla tuotosvuosien mukaan.

$Y_4, Y_5, Y_6$	milk yield, kg/year maitotuotos, kg/vuosi
$X$	years of the production time tuotosvuodet
$N_4, N_5, N_6$	coefficients of correlation korrelaatiokertoimet

$$\begin{aligned}
 y_4 &= 2469,6933 + 541,86094x - 43,980245x^2 & N_4 & -0,98188 \\
 y_5 &= 2826,5300 + 348,91000x - 24,777100x^2 & N_5 & -0,9217 \\
 y_6 &= 3215,8479 + 717,75725x - 60,029729x^2 & N_6 & -0,97717
 \end{aligned}$$

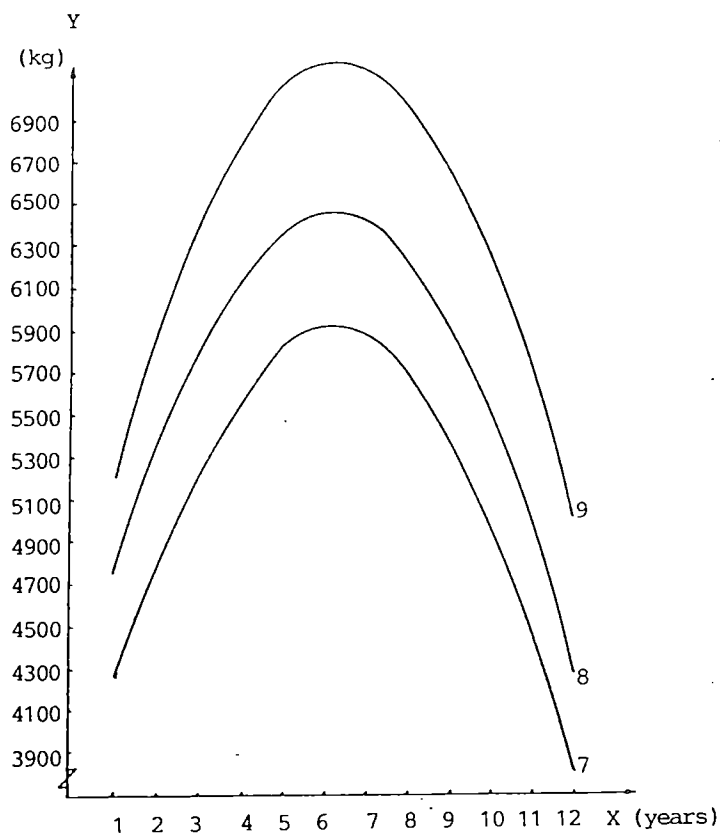


Figure 6. The parameters of the milk yield (fat content 3,5 %) according to the milk yields and the years of the production time.

Kuvio 6. Maitotuotosta (rasva-% 3,5) kuvaavat funktiot eri tuotostasolla tuotosvuosien mukaan.

$Y_7, Y_8, Y_9$	milk yield, kg/year maitotuotos, kg/vuosi
$X$	years of the production time tuotosvuodet
$N_7, N_8, N_9$	coefficients of correlation korrelaatiokertoimet

$$\begin{array}{ll}
 Y_7 = 3530,6231 + 772,54556x - 62,692024x^2 & N_7 -0,98255 \\
 Y_8 = 4033,979 + 786,93095x - 64,1063x^2 & N_8 -0,96072 \\
 Y_9 = 4413,9319 + 866,87263x - 68,15798x^2 & N_9 -0,96898
 \end{array}$$

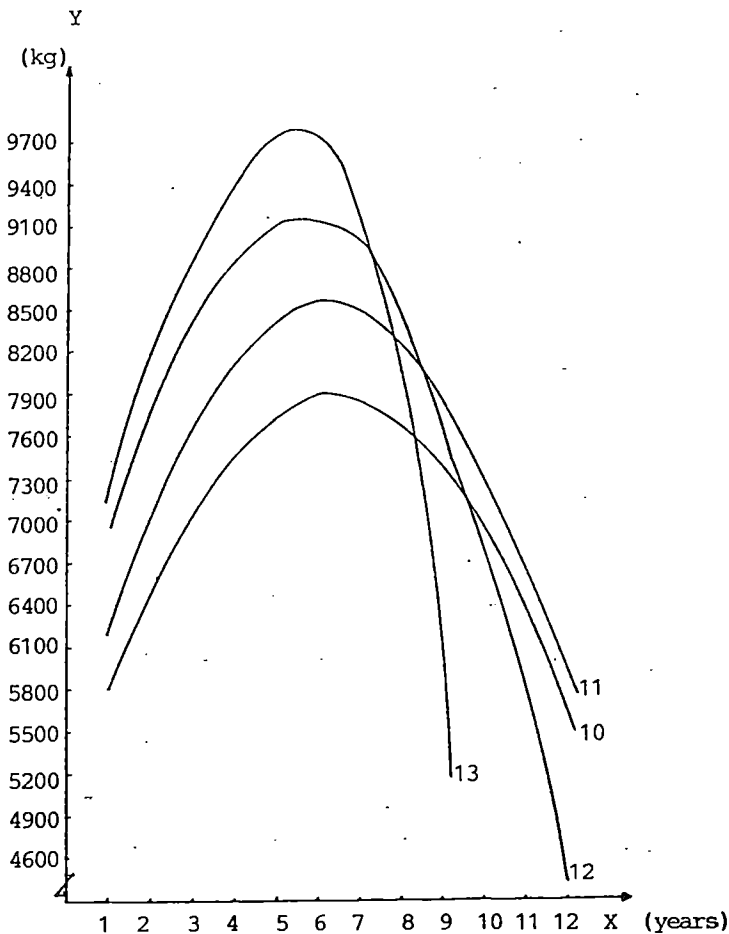


Figure 7. The parameters of the milk yield (fat content 3,5 %) according to the milk yields and the years of the production time.

Kuvio 7. Maitotuotosta (rasva-% 3,5) kuvaavat funktiot eri tuotostasoilla tuotosvuosien mukaan.

$Y_{10}, Y_{11}, Y_{12}, Y_{13}$	milk yield, kg/year maitotuotos, kg/vuosi
$X$	years of the production time tuotosvuodet
$N_{10}, N_{11}, N_{12}, N_{13}$	coefficients of correlation korrelaatiokertoimet

$y_{10} = 4970,0998 + 931,67283x - 73,609554x^2$	$N_{10} -0,96076$
$y_{11} = 5317,246 + 1055,1844x - 86,271061x^2$	$N_{11} -0,05194$
$y_{12} = 5804,046 + 1247,4341x - 113,99055x^2$	$N_{12} -0,97599$
$y_{13} = 4289 + 2539,8452x - 228,5119x^2$	$N_{13} -0,98049$

Table 4. The minimal production time of a cow according to different milk yields.

Taulukko 4. Lehmien vähimmäistuotantoaika eri tuotostasolla.

Nr function	Milk yield, kg	Price of milk	Cost per feed unit	Price of heifers Hiehojen hinta			
Funktion numero	Maitotuotos, kg	Maidon hinta	Rehuyksikkökustannus				
1	2351	I	a	1	2	4	5
			b	2	3	6	x
			a	1	3	5	7
		II	b	3	5	x	x
			a	1	3	4	5
			b	2	3	6	6
2	2755	I	a	1	3	4	5
			b	2	3	6	6
			a	1	3	5	6
		II	b	3	5	8	x
			a	1	1	3	4
			b	1	2	4	5
3	3263	I	a	1	1	3	4
			b	1	-2	4	5
			a	1	2	4	5
		II	b	1	3	5	7
			a	1	2	3	4
			b	1	2	3	4
4	3752	I	a	1	1	3	4
			b	1	2	3	4
			a	1	2	3	5
		II	b	1	3	5	6
			a	1	1	2	3
			b	1	1	3	4
5	4116	I	a	1	1	3	4
			b	1	1	3	4
			a	1	1	3	4
		II	b	1	2	4	5
			a	1	1	2	3
			b	1	1	3	4
6	4630	I	a	1	1	3	4
			b	1	1	3	4
			a	1	2	3	4
		II	b	1	3	4	5
			a	1	1	2	3
			b	1	1	2	3
7	5159	I	a	1	1	2	2
			b	1	1	2	3
			a	1	1	2	3
		II	b	1	1	3	3
			a	1	1	2	2
			b	1	1	2	3
8	5676	I	a	1	1	2	2
			b	1	1	2	3
			a	1	1	2	3
		II	b	1	1	3	3
			a	1	1	1	2
			b	1	1	2	2
9	6356	I	a	1	1	1	2
			b	1	1	2	2
			a	1	1	2	2
		II	b	1	1	2	3
			a	1	1	1	2
			b	1	1	1	2
10	7038	I	a	1	1	1	2
			b	1	1	1	2
			a	1	1	1	2
		II	b	1	1	2	3
			a	1	1	1	2
			b	1	1	2	3
11	7502	I	a	1	1	1	2
			b	1	1	2	2
			a	1	1	2	2
		II	b	1	1	2	3
			a	1	1	1	2
			b	1	1	2	3
12	7738	I	a	1	1	1	2
			b	1	1	1	2
			a	1	1	1	2
		II	b	1	1	2	3
			a	1	1	1	2
			b	1	1	2	3
13	8443	I	a	1	1	1	2
			b	1	1	1	2
			a	1	1	1	2
		II	b	1	1	2	2
			a	1	1	1	2
			b	1	1	2	2





Table 6. The optimal production time of a cow producing 3752 kg milk replaced by heifer cow producing 4116 - 7037 kg milk.

Taulukko 6. Optimaalinen tuotantoaika, kun 3752 kg:n tuotostasolla oleva lehmä korvataan 4116 - 7037 kg:n tuotostasolla olevalla ensikolla.

Milk yield of heifer cow, kg Ensikon maidon tuotos, kg	Price of milk Maidon hinta	Cost per feed unit Rehuyksikö- kustannus	Price of heifers / Hiehojen hinta																		
			84930 q	111750 q	163900 q	200000 q															
4116	I	a	1,01	1,05	1,14	1,18	1,01	1,05	1,14	1,18	1,01	1,05	1,07	1,14	1,18	10	11	11	12	12	
	II	b	1	1	1	1	5	5	6	7	11	10	40	10	11	10	11	11	11	11	12
5159	I	a	1	1	1	1	7	7	10	11	10	11	11	11	11	11	11	11	11	12	12
	II	b	1	1	1	1	7	7	10	11	10	11	11	11	11	11	11	11	11	12	12
6356	I	a	1	1	1	1	1	1	1	1	1	2	2	5	6	6	5	5	9	11	11
	II	b	1	1	1	1	1	1	1	1	3	5	6	6	6	6	6	6	6	7	11
7037	I	a	1	1	1	1	1	1	1	1	1	5	5	5	5	7	5	5	7	11	11
	II	b	1	1	1	1	1	1	1	1	1	5	5	5	7	9	5	7	9	11	12
6356	I	a	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	4	4	5	5
	II	b	1	1	1	1	1	1	1	1	1	1	2	2	2	4	5	5	5	5	7
7037	I	a	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
	II	b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7037	I	a	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
	II	b	1	1	1	1	1	1	1	1	1	2	2	2	2	4	5	5	5	5	7

## 1) SELOSTUS:

## LYPSYLEHMIEN TALOUDELLINEN TUOTANTOAIKA

## 1. Johdanto

Lypsyylehmät muodostavat siinä määrin oleellisen osan kotieläimistössä, että niiden taloudellista tulosta arvioitaessa ne voidaan rinnastaa kiinteisiin tuotantovälineisiin. Näin ollen voidaan kysyä, kuinka tulisi määrittää optimaalinen lehmän tuotannossa pitoaika, jonka jälkeen se tulisi korvata uudella eläimellä. Taloudelliselta kannalta katsottuna olisi suositeltavaa, että lehmä olisi tuotannossa mahdollisimman kauan, jolloin lehmän hankinnasta johtuva kustannus olisi vuotta kohti pienempi ja rasittaisi tällöin vähemmän maidontuotannosta saatavaa taloudellista tulosta. Lehmän tuotosvuosien myötä tapahtuu kuitenkin luonteellisia muutoksia maitotuotoksessa, eläimen teurasarvossa, rehun käytössä, hedelmällisyydessä ja terveyden tilassa. Nämä tekijät lyhentävät käytännössä lehmän taloudellista tuotantoaika. Niinpä jokainen maidontuottaja joutuu päättämään, missä vaiheessa kukin tuotantoeläin on aiheellista poistaa ja korvata uudella.

Vuonna 1987 maidontuotanto muodosti 13.5 % maailman koko maataloustuotannosta ja 17.4 % myyntituotannon arvosta. Puolan maataloudessa maidontuotanto on yksi perustuotantosuunnista. Tästä huolimatta lehmien keskituotoksen on arvioitu olevan hyvin alhaisella tasolla maassamme. Vuonna 1987 koko maan keskituotos oli vain 3 062 l/lehmä. Yksityisillä tiloilla, joilla on 87 % koko maan lehmämäärästä, keskituotos oli tätäkin alhaisempi, 2 964 l/lehmä. Taloudellisesti kehittyneissä maissa tämä tuotostaso on saavutettu jo 30–40 vuotta sitten. Asiantuntijoiden mukaan puolalaisten lehmien alhainen tuotostaso johtuu mm. seuraavista tekijöistä: liian laajaperäinen ja riittämätön organisaatio karjankasvatuksessa, mikä tulee esille erityisesti pienkarjojen kohdalla (yksityisillä tiloilla keskimääräinen karjakoko on 1.9 lehmää), alhainen erikoistumisen taso (vain kolmella prosentilla yksityisistä maidontuottajista karjakoko on yli 10 lehmää), rehuntuotannon keho organisaatio ja maidontuotannon vähäinen koneellistaminen (taul. 1).

Kun otetaan huomioon maitotuotteiden kasvanut kysyntä ja lehmämäärän väheneemisestä johtuva tarjonnan pysähdystila tai jopa pudotus, lehmien keskituotoksen taso tulee olemaan yksi suurimmista ongelmista maamme maataloudessa. Yritykset ratkaista ongelma hallinnollisin toimenpitein ovat epäonnistuneet. Ainoa tehokas

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1) Artikkelin on englannista vapaasti suomentanut Maija Puurunen, MTTL.

tapa lisätä viljelijöiden kiinnostusta maidontuotantoon on nostaa sen taloudellista kannattavuutta. Eräs keino maidontuotannon taloudellisen tuloksen parantamiseksi ilman, että maitotuotteiden hintoja tarvitsee nostaa, on pyrkiä pidentämään lypsylehmien tuotantoaikaa.

Tässä artikkelissani pyrin vastaamaan kysymykseen, kuinka pitkä on lypsylehmän minimaalinen, optimaalinen ja maksimaalinen tuotantoaika taloudelliselta kannalta katsottuna. Maidontuotannon taloudellisen kannattavuuden huomioon ottaen lehmän vähimmäistuotantoaika saavutetaan, kun tuotto peittää vastaavat kustannukset. Optimaalinen tuotantoaika saavutetaan, kun tuotto saavuttaa maksimaalisen arvonsa ja maksimaalinen tuotantoaika, kun tuotto on alentunut jälleen kustannusten tasolle.

## 2. Lähdeaineisto ja tutkimusmenetelmät

Tutkimukseni perustuu Lowland Black and White -lehmä koskeviin tarkkailutietoihin, jotka Puolan Jalostuskeskus (the Central Station of Animal Breeding) on julkaissut vuosilta 1983–1987. Lisäksi tutkimuksessa on jouduttu käyttämään myös kaikkia lehmä koskevia tiedostoja, jotta lypsylehmien tuotantoaikaa koskevat odotukset, todellinen tuotantoaika ja syyt epätydyttävien lehmien poistamiselle on voitu selvittää. Minimi-, optimi- ja maksimituotantoaikojen selvittämiseksi on kerätty tiedot yli 10 kertaa poikineista lehmistä sekä niistä lehmistä, jotka on teurastettu vuosina 1983–1987. Näitä tietoja on käytetty lehmän maidontuotantoa kuvaavien funktioiden parametrien laskemisessa ja elopainon selvittämisessä lehmän tuotantoaikana. Muut laskelmissa tarvittavat parametrit on estimoitu käytännön maataloutta koskevien normi- ja standardilukujen perusteella.

Lehmän taloudellinen vähimmäistuotantoaika on laskettu tarkastelemalla eri pituisilta tuotantoajoilta saatua nettotuloa. Laskelmissa on otettu huomioon myös lehmän hankinnasta aiheutuneet kustannukset. Tutkimuksessa on sovellettu STEFFENin & KELLNERin kehittämää optimi- ja maksimi-tuotantoaikoja koskevaa laskentatekniikkaa, joka on johdettu neoklassisesta tasapainomallista voiton maksimointia koskevin edellytyksin. Tutkimuksessa on verrattu lehmän todellisenä tuotantoaikana antamaa nettotuloa siihen nettotuloon, mikä olisi voitu saavuttaa lehmän tuotostason ja muut tekijät huomioon ottaen taloudellisesti sopivampaa tuotantoaikaa soveltaen.

Tutkimuksessa on sovellettu pääomittamiseen ja jaksottaisten suoritusten nykyarvon laskentaan liittyviä menetelmiä. Pääomittamista koskevan menetelmän mukaisesti optimaalinen lehmän tuotantoaika on kohdassa 'N', jossa kokonaispääoman arvo (WK) saavuttaa maksiminsa. Tällöin on oletettu, että lehmä korvataan

samalla tuotostasolla olevalla ensikolla. Sitä vastoin jaksottaisten suoritusten nykyarvoon liittyvässä menetelmässä optimaalinen tuotantoaika saavutetaan kohdassa, jossa viimeisimpänä vuotena saatu nettotulo (ZK) on yhtä suuri kuin vuotta kohti keskimäärin saadun nettotulon (ZS) maksimi (kuvio 1). Kaavioita sovellettaessa maidontuotanto on ajateltu jatkuvaksi prosessiksi ja vanhat lehmät korvattaviksi uusilla vastaavanlaisilla. Jos poistettava lehmä korvataan korkeam-pituotoksisella ensikolla, optimaalinen tuotantoaika saavutetaan kohdassa, jolloin uuden lehmän antama keskimääräinen nettotulo (ZS) ensimmäisen kerran on korkeampi tai sama kuin poistetun lehmän antama nettotulo (ZK) viimeisenä vuotena.

Lehmän optimaalista tuotantoaikaa koskeva ongelma on jossain määrin erilainen kertaluontoiseen investointiin rinnastettavissa tapauksissa kuten esimerkiksi silloin, kun viljelijä harkitsee maidontuotannon keskeyttämistä tai lopettamista. Tällaisessa tapauksessa optimaalinen tuotantoaika on sama kuin maksimaalinen aika, mikä saadaan, kun kokonaispääoman arvo (WK) saavuttaa maksimiarvonsa ja viimeisimpänä vuonna saatu nettotulo (ZK) on nolla (kuvio 2).

### 3. Tutkimuksen tulokset

Tutkimusaineistona olevat maidontuotannon tarkkailutulokset vuosilta 1983–1987 kattoivat 95.5 % valtion tilojen lehmistä, mutta ainoastaan 2.4 % kannattavimpien yksityistilojen lehmistä. Tilojen keskituotos vuonna 1987 oli 4 350 kg maitoa ja rasvapitoisuus oli 3,97 %. Lehmien elinikä oli tutkimusjakson aikana yksityistiloilla keskimäärin 7.17 vuotta ja keskimääräinen tuotantoaika 4.93 vuotta ja vastaavasti valtion tiloilla 5.87 ja 3.33 vuotta. Näin lyhyt keskimääräinen tuotantoaika johtuu huomattavassa määrin siitä, että lehmiä on jouduttu poistamaan heikon hedelmällisyyden tai tapaturmien takia, ja vähäisemmässä määrin myös heikon tuotostason takia (taul. 2).

Lypsykarjatalouden kannattavuus riippuu useista eri tekijöistä, joista tärkeimmät lukeutuvat seuraaviin ryhmiin:

1. Jalostukseen liittyvät tekijät: biologinen edistyminen ja eläinten valinta
2. Biologiset ja organisatoriset tekijät: eläinten rotu, poikimisikä, maitotuotos yksittäisillä laktaatiokausilla ja lehmän elinaikana, hoitoon ja ruokintaan liittyvät järjestelyt ja karjakoko
3. Taloudelliset tekijät: tilalla tuotetun ja ostetun rehun kustannukset, hiehon kasvatuskustannukset tai hankintahinta, työkustannukset, maidon tuottajahinta, vasikoiden laatu ja elinikää koskevat riskitekijät.

Tämä tutkimus on todellisuudesta konstruoitu malli, jossa vain muutamia pääasias-  
sa taloudellisia tekijöitä on voitu ottaa huomioon. Tällaisia tekijöitä ovat mm.  
maitotuotoksen taso, tuottajahinta, hiehon hankintahinta tai kasvatuskustannus  
ja pääoman korko. Pääomaa koskevissa laskelmissa on otettu rahan arvon muutok-  
set huomioon.

Laskelmia tehtäessä on ollut välttämätöntä tietää teurasarvot ja lehmän tuotan-  
tovuosien maitotuotokset. Lehmien elopainon kehitystä kuvaavat funktiot on mää-  
ritetty viidellä eri tuotostasolla (kuvio 3). Teurasarvot kuten myös elopainot on  
määritetty elävinä myytyjen eläinten myyntihintojen perusteella. Mahdollisesta  
elopainon lisääntymisestä huolimatta eläinten myyntihinnat kuten myös teurasarvot  
alenevat iän myötä.

Myös maitotuotos vaihtelee lehmän iästä riippuen. Tämä voidaan havaita tutki-  
musaineistosta lasketuista 13 eri tuotostasoa kuvaavien funktioiden parametreis-  
ta. Keskimääräinen maidon rasvapitoisuus on 3.5 % ja laktaatiokauden pituus  
305 päivää. Kuten kuvioista 4-7 ilmenee, maksimaalinen vuosituotos on saavu-  
tettu neljästä seitsemään tuotantovuotena, jonka jälkeen tuotostaso on alkanut  
laskea. Tuotoksen aleneminen on nopeinta korkean tuotostason omaavilla lehmillä  
ja toisaalta taas alhaisen tuotostason lehmillä.

Muut tekijät on otettu huomioon laskelmissa vuoden 1987 hintatasossa (taul. 3).  
Laskelmat on tehty RIAD- 35-tietokoneella Maatalousyliopistossamme (Agricul-  
tural University). Otettaessa huomioon kaikki edellä mainitut tekijät lehmän  
minimituotantoaika koskevissa laskelmissa on ollut mukana 208 muuttujaa ja  
optimi- ja maksimituotantoaika koskevissa laskelmissa 1 040 muuttujaa.

**Lehmän minimituotantoaika** eri laskelmien mukaan on ollut yhdestä kahdeksaan  
vuotta. Neljässä tapauksessa tuotanto on ollut kannattamatonta johtuen korkeasta  
hiehon hankintakustannuksesta, korkeista ruokintakustannuksista ja alhaisesta  
maidon tuottajahinnasta. Kun hiehon ostohinta on ollut korkea ja rehu kallista,  
alhaisimman tuotostason (alle 3 263 kg) lehmien minimituotantoaika on muodos-  
tunut pitkäksi, neljästä kahdeksaan vuotta (taul. 4). Pitkä vähimmäistuotantoaika  
on osoitus alhaisesta maidontuotannon kannattavuudesta. Tämä voidaan huomata  
myös vertaamalla edellä mainittua tuotantoaika todelliseen lehmien tuotan-  
toaikaan valtion tiloilla. Parhaiden lehmien (tuotostaso 7 000- 8 000 kg) vähim-  
mäistuotantoaika on yhdestä kolmeen vuoteen ja korkeasta tuotostasosta johtuen  
useimmissa tapauksissa yksi vuosi.

Taloudelliselta kannalta **optimaalinen lehmän tuotantoaika** on viidestä kahteentois-  
ta vuotta, edellyttäen että poistetut lehmät korvataan saman tuotostason lehmillä  
(taul. 5). Tuotanto on ollut kannattamatonta 33 tapauksessa. Tarkasteltaessa  
yksittäisten tekijöiden vaikutusta optimaaliseen tuotantoaikaan voidaan todeta,

että tuotostason kasvu aiheuttaa aluksi tuotantoajan pitenemistä ja korkeimmilla tuotostasoilla tuotantoajan lyhenemistä. Tämä ilmenee myös tuotoskauden maidon-tuotantoa kuvaavien käyrien muodosta. Maidon tuottajahinta ja rehkustannukset eivät oleellisesti vaikuta lehmän tuotantovuosien määrään. Hiehon hankintahinnan nousu on lisännyt lehmän optimaalista tuotantoaikaa vuodella tai parilla. Vastaavasti laskentakoron nostaminen yhdestä prosentista 18 %:iin lisää useissa tapauksissa lehmän tuotantoaikaa niin ikään vuodella tai parilla.

Tutkimuksen laskelmissa poistettavat lehmät korvattiin saman tuotostason omaavilla ensikoilla. Käytännössä kuitenkin viljelijät useimmiten korvaavat vanhat lehmät uusilla korkeampituotoksilla lehmillä. Tällöin optimaalinen tuotantoaika lyhenee. Jos 3 752 kg:n tuotostasolla oleva lehmä korvataan ensikolla, jonka tuotostaso vaihtelee välillä 4 116 - 7 038 kg, seuraa tästä optimaalisen tuotantoajan vaihtelu vuodesta 12 vuoteen. Tuotantoajan pituus riippuu pääasiassa korvaavan ensikon tuotostasosta ja ostohinnasta (taul. 6).

**Maksimaalinen tuotantoaika** on ollut 9 - 12 vuotta, lukuunottamatta tapauksia, joissa maidontuotanto on ollut kannattamatonta. Myös harkittaessa tuotannon keskeyttämistä tai lopettamista voi olla hyödyllistä tietää lehmän enimmäistuotantoaika. Taloudelliselta kannalta katsottuna runsastuottoisilla lehmillä voi tulla kysymykseen jopa edellä mainittua maksimiaikaa pitempi tuotantoaika lähinnä lehmän jalostusarvon ja vasikasta saatavan korkeamman hinnan takia.

Todellinen lehmien tuotantoaika on varsin lyhyt, jos sitä verrataan tutkimuksessa laskettuun optimaaliseen tai minimaaliseen tuotantoaikaan. Valtion tiloilla todellinen tuotantoaika on 3.33 vuotta tuotostasolla 4 017 kg maitoa ja 3.5 % rasvaa. Tutkimuksessa laskettuihin tuotantoaikoihin verrattuna tämä vastaa minimaalista tuotantoaikaa, mikä on vuodesta viiteen vuoteen. Todellisen tuotantoajan tulisi olla sama kuin optimaalinen tuotantoaika silloin, kun poistettavat lehmät korvataan 5 500 - 6 000 kg:n tuotostason ensikoilla, joiden hankintahinnat ovat noin 200 000 zlotia.

Tilanne on parempi yksityisillä tiloilla. Niillä lehmien todellinen tuotantoaika on pitempi kuin tutkimuksessa laskettu minimituotantoaika. Yksityistilojen lehmien tuotantoaika voisi vastata jopa optimaalista tuotantoaikaa, jos poistettavat lehmät korvattaisiin 5 000 - 5 500 kg:n tuotostasolla olevilla ensikoilla. Koska jotkut lehmistä joudutaan poistamaan jo aikaisemmin, vertailuja tehtäessä tulee huomata, että keskimääräinen tuotantoaika ei voi olla sama kuin optimaalinen tuotantoaika. Jalostuskeskuksen (Central Station of Animal Breeding) mukaan 18 % lehmistä ei yllä keskimääräiselle tuotostasolle ja ne tulisi poistaa aikaisemmin. Heikkotuotoksiset lehmät olisi taloudellisesti edullisinta poistaa joko kaksi kuukautta ensimmäisen poikimisen jälkeen tai 100 päivää kestävä laktatiokau-

den jälkeen. Tällöin viljelijä saa korkeamman teurashinnan ja voi käyttää vapautuvan parsipaikan tehokkaimmin.

#### 4. Yhteenveto ja päätelmät

Tässä lehmän taloudellista tuotantoaikaa koskevassa tutkimuksessa ei ole voitu ottaa huomioon kaikkia maidontuotantoon liittyviä tilanteita ja tekijöitä. Todellisuus on tässä esitettyä monisäikeisempää. Niinpä lehmien poistoa koskevaa päätösten tekoa varten tulisi tehdä taloudelliset laskelmat kultakin maidontuotantoon erikoistuneelta tilalta erikseen. Huolimatta useista pelkistyksistä seuraavat päätelmät voidaan tehdä tutkimuksen vaihtelevista tuloksista:

1. Valtion tiloilla lehmien keskimääräinen tuotantoaika on ollut vähän yli kolme tuotokautta ja yksityisillä tiloilla yli neljä tuotokautta vuosina 1983 – 1987. Verrattuna vuosiin 1960 – 1965 lehmien tuotantoaika on lyhentynyt parilla kolmella vuodella, kun taas vuosina 1965 – 1980 tuotantoajoissa ei ole tapahtunut mitään oleellisia muutoksia.
2. Eräs lehmien tuotantoaikaa lyhentävä tekijä on hiehojen korkea poikimisikä. Noin 47 % ensikoista on poikanut 2.5 vuoden ikäisinä tai tätä vanhempina, mitä voidaan pitää puoli vuotta optimaikaa myöhempänä. Tästä päätellen näyttäisi olevan suositeltavaa parantaa vasikoiden ja hiehojen kasvatukseen liittyviä tekijöitä tiloilla.
3. Lehmien tuotantoaikaa lyhentäviä tekijöitä ovat steriliteetti, tapaturmat ja alhainen tuotostaso. Näiden takia joudutaan poistamaan huomattava määrä lehmistä. Jotta lehmien tuotantoaikaa voitaisiin pidentää, nämä ongelmat tulisi ratkaista varmistamalla eläimille suotuisa elinympäristö ja olosuhteet kuten riittävä ruokinta, huolellinen hoito ja kunnollinen navetta.
4. Koska huomattava osa lehmistä joudutaan poistamaan ennen aikojaan, vain pieni osa lehmistä saavuttaa maksimaalisen tuotostasonsa, mikä Lowland Black and White -rotuiset lehmillä on yleensä neljästä kuudenteen tuotokaudella. Liian aikaiset lehmien poistamiset estävät maidontuotannon lisääntymisen ja alentavat tuotannon kannattavuutta.
5. Lehmän tuotantoaika keskimäärin Puolassa erityisesti valtion tiloilla on paljon lyhyempi kuin optimaalinen tuotantoaika. Tämä aiheuttaa huomattavia tuotostappioita ja alentaa maidontuotannon kannattavuutta tai tekee sen jopa täysin kannattamattomaksi.

**MAATALOUDEN TALOUDELLISEN TUTKIMUSLAITOKSEN  
TIEDONANTOJA**

- No 141 KOLA, J. Maatalouden kokonaislaskelman mukainen tuotekohtainen kustannusjakauma: Kiinteä- ja muuttuvakertoiminen panosmalli. Helsinki 1988. 58 s.
- No 142 AJANKOHTAISTA MAATALOUSEKONOMIAA. Kirjanpitotilojen tuloksia, tilivuosi 1987. Helsinki 1989. 46 s.
- No 143 AJANKOHTAISTA MAATALOUSEKONOMIAA. Kirjanpitotilojen tuotantosuunnittaisia tuloksia, tilivuosi 1987. Helsinki 1989. 45 s.
- No 144 ALA-MANTILA, O. Maataloustuotteiden ja maatalouden tuotantopanos-  
tenhintamuutosten vaikutus maataloustuloon vuosina 1983-1987. Helsinki  
1989. 72 s.
- No 145 TORVELA, M. & ALA-MANTILA O. Maatalouden kannattavuus ja  
rahaliike maitotiloilla Etelä-Suomessa vuonna 1986. Helsinki 1989. 43 s.
- No 146 PUURUNEN, M. & TORVELA, M. Katovuoden 1987 tulokset kirjan-  
pitotiloilla. Helsinki 1989. 36 s. 6 liit.
- No 147 AJANKOHTAISTA MAATALOUSEKONOMIAA. Maatalous vaikeissa  
olosuhteissa. Helsinki 1989. 41 s.  
TORVELA, M. Tervetuloa Suomen, Puolan ja Unkarin maatalousekono-  
mian seminaariin Saariselälle s. 5-8.  
KORPI, K. Maatalouden ja maaseutuelinkeinojen mahdollisuudet Lapissa.  
s. 9-22.  
SIREN, J. Valtion rooli ja maatalouspolitiikka Pohjois-Suomen maa-  
taloudessa. s. 21-28.  
HUTTU-HILTUNEN, V. Suomen porotalous. s. 29-34.  
TORVELA, M. Viljelijöiden toimeentulonäkymiä Pohjanmaalla. s. 35-41.
- No 148 PUURUNEN, M. Viljelijäväestön tulokehitys 1980-luvulla. Helsinki 1989.  
83 s. + 1 liite.
- No 149 NIEMI, J. Maataloustuotteiden ulkomaankaupan esteet ja niiden vaiku-  
tukset. Helsinki 1989. 82 s.
- No 150 YLISIPPOLA, T. Viljelijöiden ja pienyrittäjien tulovertailu. Helsinki  
1989. 106 s.
- No 151 SILTANEN, L. & ALA-MANTILA, O. Maatalouden kokonaislaskelmat  
1980-1988. Helsinki 1989. 56 s.
- No 152 AJANKOHTAISTA MAATALOUSEKONOMIAA. Kirjanpitotilojen  
tuloksia, tilivuosi 1988. Helsinki 1990. 50 s.
- No 153 AJANKOHTAISTA MAATALOUSEKONOMIAA. Kirjanpitotilojen tuo-  
tantosuunnittaisia tuloksia, tilivuosi 1988. Helsinki 1990. 47 s.

