

# Fifty years of forage supply on dairy farms in the Netherlands

Van Dijk H., Schukking S. and Van der Berg R.  
*Lelystad, the Netherlands*

## Abstract

Dairy farming in the Netherlands has shown big changes during the last 50 years as a consequence of various technical, economic and social developments. The cost of labour has increased greatly and therefore labour productivity has also increased. In order to achieve a reasonable financial income on the mainly small family farms, scaling up and intensification of those farms was necessary. Agricultural research and extension services significantly contributed to realising these goals. In particular, there was a need to increase the productivity of farmland, and both the quality and utilisation of the crops. The application rate of fertilizers, particularly nitrogen, increased strongly, as did the use of organic manures. Quality of grassland improved (due to re-sowing and use of high quality grass-seed mixtures) and the management was intensified. Planned grazing systems and new methods of hay and silage making led to significantly improved forage quality and a higher milk production. Including silage maize and concentrates, as well as the effects of breeding further contributed to increased milk production. All these changes meant that, over a period of 50 years, the average number of dairy cows per farm increased ten-fold, to about 85, the average milk production per cow doubled to somewhat more than 8,000 kg, the milk production per ha trebled to about 15,000 kg ha<sup>-1</sup> and there was a ten-fold reduction in the number of dairy farms to about 18,000. These developments have coincided with the introduction of modernised cow houses, mechanisation and automation. The introduction of milk quota in the EU led to a slowdown in the developments. EU rules with regard to derogation, manure residues and N content of ground water, but also national rules with regard to environment and nature, have during the last years limited the further scaling-up and intensification of dairy farms.

**Keywords:** fifty years, forage supply, the Netherlands

## Introduction

The Netherlands is a small and densely populated country. There are about 16.8 million inhabitants on about 4.15 million ha. This corresponds to 406 inhabitants km<sup>-2</sup>. The area of cultivated land amounted to 2.3 million ha in 1960, but in somewhat more than 50 years this area decreased by about 500,000 ha due to conversion into urban areas, industrial areas and nature areas. The area available for grassland and forage crops also changed. At the moment there are about 990,000 ha of grassland and the area of land with forage maize has increased from nil in 1950 to 230,000 ha.

Agriculture was and still is of great economic importance for the Netherlands. The country is more than self-sufficient in many agricultural products. The total value of exports of all agricultural products amounted to about 75 milliards Euro annually during recent years. Cattle husbandry contributed significantly to that export, e.g. via dairy products, cattle and beef.

Dairy cattle husbandry developed quite strongly, especially during the last 30 years. This is illustrated in Table 1, where a number of key parameters for the period 1960-2013 are shown. They will be explained in more detail in the following paragraphs.

## Grassland

Grass is the most important agricultural crop in the Netherlands. In 1960, the area of grassland was still 1.33 million ha. However, this area gradually reduced to the present area of about 990,000 ha, mainly due

Table 1. Developments in dairy cattle husbandry in the Netherlands.

	1960	1975	1985	1995	2005	2010	2013
Agricultural area ( $\times 1000$ ha)	2,317	2,082	2,019	1,965	1,938	1,872	1,848
Grassland area ( $\times 1000$ ha)	1,327	1,286	1,083	1,048	976	951	932
Forage maize area ( $\times 1000$ ha)	0.5	77	177	219	235	229	230
Number of dairy farms ( $\times 1000$ )	183	91.5	58	37.5	23.5	19.3	18.5
Number of dairy cows ( $\times 1000$ )	1,628	2,218	2,367	1,708	1,433	1,479	1,553
Number of cows farm <sup>-1</sup>	8	24	41	46	61	75	84
Kg milk cow <sup>-1</sup> yr <sup>-1</sup>	4,205	4,650	5,330	6,610	7,550	8,000	7,990
Kg concentrate cow <sup>-1</sup> yr <sup>-1</sup>	800	1,590	2,280	2,210	2,020	2,060	
Kg milk ha <sup>-1</sup> yr <sup>-1</sup> ( $\times 1000$ )	5.5	8.86	12.51	12.02	12.56	14.07	
Kg milk farm <sup>-1</sup> yr <sup>-1</sup> ( $\times 1000$ )	37	112.5	217	302	460	597	671
Kg milk in Holland yr <sup>-1</sup> (mill. Mg)	6.7	10.3	12.5	11.3	10.8	11.9	12.2
Kg milk hr <sup>-1</sup> labour	8	37	72	89	128	150	
Dairy cows ha <sup>-1</sup> grass and forage crops	1.2	1.6	1.8	1.3	1.2	1.2	1.3

to converting grassland into maize. The area for maize increased rapidly after 1970 and amounts to about 230,000 ha at the moment. Furthermore, a lot of grassland was and still is being converted into extension of roads, urban areas, industrial areas and nature conservation areas. Grassland is not only used for dairy production, and part of the grassland area is also utilised by sheep, beef cattle, horses, etc.

Grassland can be found on all soil types of the Netherlands: clay, sand, peat and loess. The peat areas, with relatively high ground-water levels (mainly in the western and northern part of the Netherlands), are predominantly used as grassland. Before 1970 the majority of the grassland was permanent grassland, i.e. more than five years old. Rotation of crops hardly occurred. However, during the last 20 years the area with permanent grassland has dropped to about 70%, mainly due to rotation with maize or exchange of land with arable farmers for cultivation of potatoes, flower bulbs, etc.

In the past, the botanical composition of many grasslands left a lot to be desired, especially on plots far from the farm. The main reasons for this were low levels of fertilisation and mowing at a late stage of growth. Those grasslands mainly consisted of grass species of medium and low quality. After 1970, grass improvement received more attention as a result of the necessary intensification on dairy farms. Higher yields and better forage quality were then needed. Fields with moderate or low quality grass species were ploughed up and resown. At the same time the fields concerned were levelled and both fertilisation and drainage were improved. Sod sowing of grassland mainly occurred on low and moist fields where ploughing was not possible. It was also used to improve the quality of existing grassland by sowing good, productive varieties, e.g. after a severe winter. A lot of grassland was also improved in a re-allotment project. As a result of allotment more paddocks became available in the vicinity of the farm. This also improved the general management of those paddocks: more alternation of grazing and cutting. When maize was introduced in the Netherlands many fields with medium or low quality grassland were ploughed up and utilized for maize. After one or more years those fields were then resown with grass. At the moment, on average about 10% of all grassland is resown annually. The actual annual resown area is related to the damage caused by drought or frost. In order to limit N leaching, it is obligatory to resow in spring on sandy soils and before 15 September on other soils.

For grassland improvement, mainly mixtures of good and productive grass species and varieties are used. There are many mixtures available, which mainly contain perennial ryegrass varieties, both mid-late

and late heading. Sometimes timothy and clover seeds are used as well. The use of specific mixtures is increasing, e.g. mixtures for mowing only, for grazing and mowing, with additional structure and with clover. There are also mixtures for sod sowing and/or temporary grassland. Diploid varieties are increasingly being replaced by tetraploid varieties.

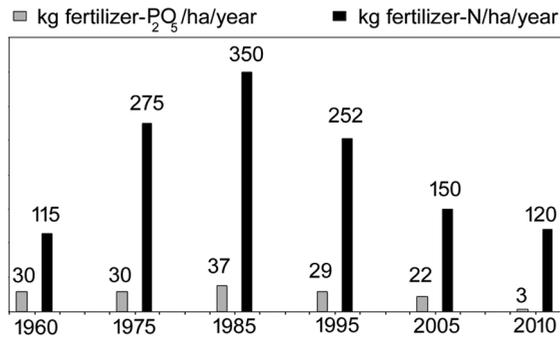
Good quality grassland can easily produce 11-13 Mg DM (gross weight) ha<sup>-1</sup> when it is intensively managed. With the best grass species and varieties a gross yield of 14-16 Mg DM ha<sup>-1</sup> is possible and on very high quality soils even more. However, it is not the gross yield that is most important, but the final utilisation of the forage by the cattle. Restriction of losses during grazing and silage making is then crucial, of course.

## **Fertilisation of grassland and forage maize**

A strong intensification took place in Dutch agriculture from 1960 onwards, mainly because of greatly increasing labour costs. This necessary intensification was stimulated by research and extension services, e.g. by demonstration farms and so-called Nitrogen Pilot Farms in the majority of the Dutch provinces. Around 1950, grassland was fertilized with limited amounts of stable and liquid manure and a limited amount of additional fertilizer. By 1960 the N fertiliser rate was 115 kg N ha<sup>-1</sup> of grassland and it increased to 350 kg N ha<sup>-1</sup> by 1985. On sandy soils the N fertilisation was higher, but on peat soils lower because of additional N mineralisation from the soil. In addition to the 350 kg N ha<sup>-1</sup>, 60-100 kg active N ha<sup>-1</sup> became available from applied animal manure. Due to the increasing fertilisation and better management, both production of grassland and the number of cows ha<sup>-1</sup> increased. In the same period many cubicle houses were constructed, which led to a change from solid and liquid manure to slurry. In addition, the number of pigs and poultry increased strongly, in particular in the sandy areas. This meant an enormous increase of the amount of animal manure. On the farms concerned, storage facilities for manure were often very limited and much of this manure was, therefore, not applied during the growing season. Of course, this manure caused an additional burden on the environment and soil. In 1987, the government therefore drew up rules for storage and application of manure in order to limit NH<sub>3</sub> emission and N leaching to ground and surface water. Amongst others, this meant covering of manure storage, changes in method of manure application (sod application or manure injection to reduce emissions) and the period of manure application (during the growing season only) and limiting the amount of animal manure per ha. Differentiations were made for various soil types and land use with respect to maximum fertilisation. In addition, standards for use and losses of N and P per ha grassland and ha forage maize were set.

The Netherlands is allowed by the (EU) derogation arrangement to apply 250 kg N from animal manure per ha grass and forage maize. The total fertilizer standards for the amount of N, and of P as well, have been gradually sharpened during the last years, in particular for those areas with sandy soils where the nitrate content in the ground water still is too high. As a consequence of the maximum amount of animal manure, application of N and P fertilizer sharply decreased in practice (Figure 1). In the years 2010-2012, about 120 kg N fertilizer ha<sup>-1</sup> was applied on grassland. The amount of applied fertilizer P ha<sup>-1</sup> decreased also (Figure 1). From 2014 onwards, application of fertilizer P on grass and forage maize is forbidden.

Due to the abolition of the milk quota in 2015, new rules apply for farmers that wish to enlarge or to intensify their farms. The additional amount of manure produced by the enlarged herd needs to be applied on the farmer's own land in a justified way or processed and removed from the farm. For a dairy farmer it will also be important to restrict the supply of N and P in imported concentrates and roughage and to utilize all farm manure as efficiently as possible in order to produce high amounts of forage and to maintain a high level of milk production within the rules.



Source : A. van den Ham, LEI

Figure 1. Fertilizer P and N use ha<sup>-1</sup> grassland yr<sup>-1</sup> in the Netherlands in the period 1960-2010.

In the past, forage maize was always fertilized with a lot of manure, supplemented with a restricted amount of fertilizer. Application of 100 Mg of slurry ha<sup>-1</sup>, or sometimes even more, occurred in practice until 1987. After that, the amounts of N and P, both from animal manure and fertilizer, have been restricted by rules. Nowadays, fertilization in maize rows is more and more common practice for optimum utilization of minerals and a high yield of forage maize.

## Grazing

In the past all dairy cattle used to graze in summer time. In spring, cows went outside and they came back into the cow house in autumn; in summer time they were milked in the field. However, over the course of years a lot changed: the number of cows per farm increased (see Table 1) and both land and cattle needed to produce more. Management of grassland changed strongly as well. Until about 1970 mainly extensive grazing systems were practised (continuous grazing or extensive rotational grazing), such as grazing on one large paddock for a couple of weeks. A limited area of grass was cut at a rather late stage of growth for forage in winter time, mostly as hay. Both yield and quality of that hay left much to be desired.

Both research and extension services stimulated farmers to adapt the grazing and forage production. New grazing systems and new forage production systems became available. In addition, more cubicle houses were constructed where the dairy cows were milked inside instead of outside. This created the possibility to keep the cows inside for a longer period and to feed them there. Especially after 1990 the number of dairy farms decreased and the remaining farms increased in size. This led to changes in the grazing systems (Figure 2).

For cattle, various grazing systems can be applied that vary in:

- number of hours grazing per day;
  - day and night grazing;
  - grazing only during day time, housing at night, feeding additional maize or grass silage and sometimes fresh grass;
- number of days grazing per paddock;
  - intensive or strip grazing: cows get once or twice a day a new plot for grazing;
  - rotational grazing: cows get a new plot each 2 to 6 days;
  - continuous grazing: cows graze for a longer period of time (3-6 weeks) on a large paddock. The grass allowance of the paddock can be kept relatively stable by adapting the land area or by supplemental feeding.

Next to grazing, there are also farmers that keep their cows inside for the whole summer and feed them freshly cut grass (zero-grazing) or silage (summer feeding). Various combinations of systems can be found in practice as well. Each of the systems has pros and cons. The best system for a certain farm mainly depends on the infrastructure of the farm, available man-power, number of cows, stocking rate and allocation of grassland. The best system can also change during the year. Consistent management is important for all grazing systems.

During the last 15 years the number of cows that graze in summer time has decreased (Figure 2). In 1997 somewhat more than 92% of all cows were grazing in summer, whereas by 2013 this percentage had decreased to 70%. In addition, both the number of days and hours  $d^{-1}$  that cows are grazing has decreased. In particular, large dairy farms apply less grazing. As a result of scaling and increasing use of milking robots, it may be difficult to maintain the percentage of grazing cows at 70%.

Currently, grazing of cows is encouraged in the Netherlands. Dutch people like to see dairy cows in grassland. The dairy industry is stimulating grazing by paying an additional 0.5-1 eurocent  $kg^{-1}$  milk produced by grazing cows. It was possibly as a consequence of this higher milk price that the percentage of grazing cows did not further decrease in 2013. New initiatives, e.g. for farmers with milking robots, are now being undertaken to provide further stimulation to dairy cow grazing.

### Forage utilisation

Forage utilisation strongly changed between 1960 and 2015 (Figure 3). In the years between 1960 and 1970 hay was the main forage for winter time. Grass for hay was mostly cut at a rather late stage of growth and particularly on fields that were far away from the farm. The quality of that hay was often

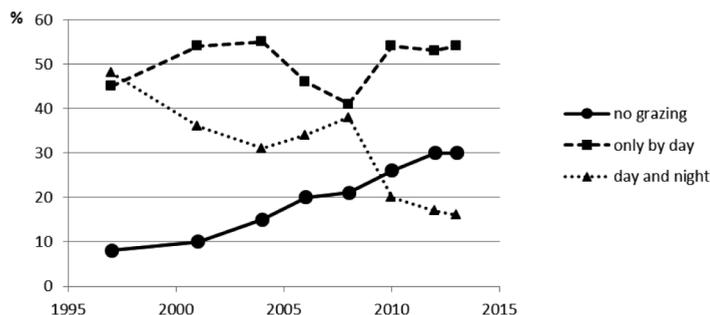


Figure 2. Grazing, % of dairy cows in the Netherlands in the period 1997-2013; source: CBS, 2014.

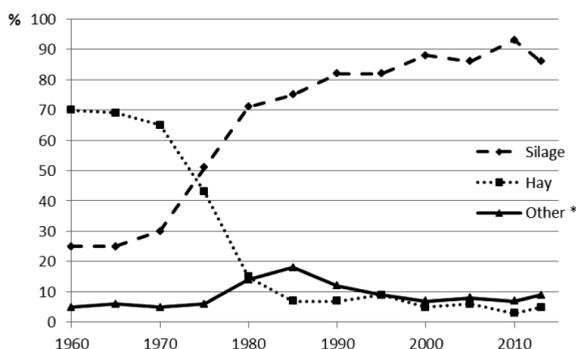


Figure 3. Destination of mown grass in the Netherlands, 1960-2013. \* = mostly summer feeding and artificial drying (1-3%), source: CBS.

low, partly as a consequence of the variable climate in the Netherlands. In order to limit the weather risk, farmers increasingly switched to silage making. This change was also stimulated by new and better silage making methods. The switch from hay to silage gave an improvement in forage quality. In addition, it also improved the overall grassland management. More plots were cut at a younger stage of growth and in addition grazing and mowing were more alternated. Most plots were cut at least once, and often twice for winter forage. As a consequence, cows could regularly have young and clean grass.

## **Hay making**

Making dry hay in the traditional way often meant a long field-period (5-7 days) and associated chances of unfavourable weather. To reduce weather risks new ways of making better hay were tried. By putting half-dry hay on a kind of tent constructed of sticks, the weather risk could be reduced. However, this method was rather labour intensive. Thereafter, barn drying of hay was developed and practised on farms for some time. Hay with a dry matter content of 60-65% was dried in a barn or haystack with cold or sometimes even with warm air. The field period was shorter, the weather risk less, and the quality of the hay better. However, this method often required an investment in hay storage. A general problem of hay storage is the risk of heating.

As a result of the development in making silage and storage of silage, the amount of hay strongly decreased after 1970. In the last 10 years only 5% of all grass cut for forage for use in winter-time is conserved as hay. That hay is generally made under favourable weather conditions and is compacted as small or large bales. A considerable quantity of hay is harvested in nature-protected areas as well. A limited amount of hay is also attractive for a number of farms as a reserve stock for calves, sick animals, etc.

## **Ensiling grass**

In the course of the years various silage making systems have been practised. In the beginning (1950-1960), it was mainly the traditional 'warm' method that was applied. During a period of 2-3 weeks an amount of grass was put on a heap, and grass was added almost daily. The intention was to create a certain temperature in that heap in order to realize an acceptable conservation. The result was mostly disappointing and involved great losses. Because of these disappointing results more and more farmers switched to a so-called 'cold method' whereby grass was ensiled over a short period (1 or 2 days) with an additive. In the beginning the AIV method was used (developed by the Finnish Professor A.I. Virtanen, about 1930), whereby a mixture of hydrochloric acid and sulphuric acid was added to the rather moist grass. This method usually resulted in a good conservation, but it was also rather labour intensive and it was dangerous because of the rather aggressive acids used. Around 1950 the so-called Hardeland method, originally a German method, became popular for some time. In this method, grass was ensiled, within a few hours, with a stationary chopper and addition of fodder beet or molasses. This method gave very good results, but was also rather labour intensive. Ensiling with a flail type forage harvester was therefore more attractive. Grass was mown, bruised and loaded in one operation. Conservation results were mostly good. It was important that the grass was somewhat older (contained some stems) and contained sufficient sugars. Ensiling young grass rich in leaves and protein often led to less-good results. The relatively low dry matter content of the silage was a disadvantage and the silage effluent also sometimes presented a problem.

The wilting method had already become popular by the 1960s. After a field period of 2 to 3 days the grass was ensiled at a dry matter content of 35 to 45%. Wilting leads to a higher osmotic pressure in the grass cells which inhibits unwanted bacteria to develop in the silage. Wilting appeared to be the best and cheapest conservation method for young, protein-rich grass. Basically, for this ensiling method additives are not needed and there are no problems with environmental pollution caused by silage effluent, while intake of the silage by cattle is quite good. However, a quick ensiling is important (preferably in one day)

and an air-tight silage storage. The rise of the forage wagon and of good quality plastic sheets contributed a lot to a quick expansion of the method. Hay making decreased rapidly. In the last 10-15 years, 85-90% of all grass cut for winter forage has been ensiled, mainly as wilted silage.

### **Silage additives**

In the Netherlands silage additives are used to a limited extent. In the past, mostly acids, salts or molasses were applied. In recent years mainly mixtures of bacteria are used. Additives are applied only if less-good conservation results are expected, for instance when the grass is not sufficiently dry, high in protein or low in sugars, or when the field period lasted too long. High dry matter silages can heat up when they are opened. Prevention of this problem is possible: sufficient compaction during ensiling, correct airtight storage and sufficiently rapid feeding of the silage. There are also special mixtures of bacteria that can restrict heating of the silage. Such mixtures are used in practice on a limited scale. Overall, 5-10% of wilted silages are treated with bacteria.

### **Mechanization of forage management**

Mechanization in silage making increased strongly, particularly after 1975. The first simple machines for mowing, tedding, raking, loading and transport were followed by larger machines with a higher capacity. Larger machines were also needed because of the increasing size of farms. The rise of the forage wagon and the self-propelled chopper (particularly for maize) were especially important. Many farms still use their own machinery for harvesting activities. However, increasingly, contract workers are involved, who take care of loading and transport. Contract workers have available large forage wagons, choppers and balers and can execute all the activities at reasonable costs per ha. In general, contracting costs are lower than the farmer's own mechanisation costs.

Initially, self-propelled choppers were exclusively used for harvesting maize, but gradually they were also used for grass. Chopping of grass has a positive effect on the preservation and density of the silage due to the bruising and mixing during chopping. Ensiling large bales (both round and rectangular, both with and without plastic covering) also became popular in the Netherlands. It is estimated that 15-25% of grass is ensiled in this way. The method is particularly attractive to store special lots separately and in case silage needs to be sold. In addition, it is not necessary to immediately transport the bales to the storage yard after pressing and wrapping them.

### **Storage of silage**

As a consequence of the strong extension of silage (grass and maize) on farms, storage of silage significantly changed. Before 1960 the limited amount of silage was mainly stored in round heaps or in low, round silos. The silages were covered with plastic plus soil or with a complete plastic cover. After that, storage in clamps, plus plastic and soil, became popular. However, when the silage was mechanically removed from the clamp in winter, it appeared that a concrete surface for the clamp was needed. Removal of the soil cover from the silage led to more objections: much time required, a heavy job and problems during frost. Gradually, the soil cover was replaced by an additional sheet of plastic or by a special, thicker sheet that also provided protection against damage by birds or wind. In the period from 1975 till 1990 larger farms built quite a few tower silos and combined this with mechanical feeding. The majority of these tower silos are no longer used, or have already been dismantled due to their moderate filling capacity, the high investments and the vulnerability of the entire system. Today, most silage is stored in large clamps on concrete surfaces or in bunker silos. In particular, the number of large bunker silos has increased during the last years. Advantages of those silos are the limited investments, correct storage and various machinery available for filling the silo and removing the silage.

## Artificial drying of grass

In the Netherlands artificial drying of grass and lucerne has only been carried out on a limited scale. One of the reasons involved is the high cost of energy. Before 2000, many small drying plants existed. However, only 5-8 larger plants have been left. Of all grass that is cut during a season only 1-3% is artificially dried. The amount of grass that is dried depends on the grass growth in a certain year. In favourable growing years farmers are offering their surplus of grass to drying plants. Previously the dried grass and also the lucerne were mainly stored as bales. For many years a large proportion of the dried products has been pressed into pellets and used as concentrates.

## Forage quality

In the Netherlands, forage quality has been analysed for many years. Every year, many thousands of samples, mainly from silages, are investigated by a few laboratories. The investigation is mainly directed to preservation and feeding value and is often complemented with mineral composition. The many available data show that the net energy value of forage has increased by 5-8% over the years. Various aspects have contributed to this: better fertilization and grassland management, better systems for silage making and for storage. As a consequence of more and better forage produced, milk production per cow and per ha increased strongly. In the period from 1960 till 2014 average milk production doubled from 4,200 to 8,500 kg cow<sup>-1</sup> and the milk production per ha almost tripled from about 5,500 to 15,000 kg ha<sup>-1</sup>. However, we should not forget that cattle breeding also contributed to these production increases.

## Forage crops

Before 1960 fodder beets were the main forage crop, with an area of more than 40,000 ha. The palatable fodder beets were attractive for farms with a surplus of forage. Fodder beet can replace a part of concentrates. However, as a consequence of intensification after 1960, more forage was needed. Fodder beet is a very labour-intensive crop. Much labour is needed for cultivation, storage and processing. Therefore, fodder beet was rather rapidly pushed aside by forage maize.

The area of forage maize increased rapidly and it now amounts to about 230,000 ha. Forage maize is an attractive crop: under favourable conditions it produces 16-18 Mg DM ha<sup>-1</sup> of feed with a high energy value. Cultivation, harvesting and silage making of forage maize are relatively easy. Maize silage also fits quite well in a diet with fresh grass or grass silage, which is rather rich in protein. Many new maize varieties have been developed, which produce more and have better resistance against diseases such as stalk rot (*Fusarium* spp.) and smut (*Ustilago*) and are also tolerant to *Helminthosporium*. In the Netherlands, mainly early and very early varieties are grown because of the climate. Developments with regard to fertilisation, weed control and mechanisation also contributed to a strong extension of the crop. The stage of harvesting changed gradually. In the beginning, maize was harvested when the DM content was 28-30%. In recent years, maize is harvested at 34-36% DM. At this DM content, the starch content is rather high and silage-making losses are rather low. If the silage is well compacted and correctly sealed, the chance of heating is limited. As a consequence of the ever-larger choppers, harvesting of maize can take place in a short time frame. Most maize is grown on sandy soils in the east and south of the Netherlands. Some maize is grown on pig and poultry farms and is often sold to cattle farmers. In addition, a restricted area of maize is harvested as maize grain or CCM (Corn-Cob-Mix).

In the Netherlands the area with lucerne has been about 6,000 ha for many years. Lucerne is mainly grown by arable farmers in the provinces Groningen, Flevoland and Zeeland on a contract basis for drying. The dried product is often processed with other feedstuffs. Other forage crops, like field beans, peas, lupins and soya are hardly grown in the Netherlands, mainly because of the low yields in comparison to maize.

## **Conclusions**

In last 50 years dairy farming has changed greatly in the Netherlands. Farms became clearly larger and the management more intensified. The farmers have been guided by research, extension services and by trade and industry. Grassland has been improved and fertilisation adapted. Grazing systems intensified and for forage management other and better methods with lower losses have been applied. The amount of forage maize in the cow's diet increased. As a consequence of all these changes, yield and quality of forage increased and the milk production per cow and per ha increased as well. These developments have led to a good economic perspective of the dairy farming sector in the Netherlands. The sharpening of EU rules for nature and environment will limit further scaling up and intensification of dairy farms.

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