MAIZE – A KEY CROP FOR THE IMPLEMENTATION OF THE ARABLE FARMING STRATEGY 2035

DMK

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WELL-POSITIONED WITH MAIZE IN THE CROPPING ROTATION

Maize is one of the oldest crops in the world and, along with wheat and rice, one of the most important food crops known to mankind. In the course of just a few decades maize has become one of the most important arable crops in Germany, only second to wheat.

The reasons for this are successful plant breeding in terms of yield and quality, progress in production technology, high economic value as well as the manifold uses of the harvested products for human nutrition, feeding of livestock, as well as for the non-food sector. More recently, the production of fuel, electricity, and heat from maize in biogas plants has been implemented. Organic agriculture's growing interest in maize is also evidenced by its steadily rising acreage, especially in the dairying segment.

The discussion paper "Ackerbaustrategie 2035 – Perspektiven für einen produktiven und vielfältigen Pflanzenbau" ("Arable Farming Strategy 2035 – Perspectives for Productive and Diverse Crop Production"), recently published by the German Federal Ministry of Food and Agriculture (BMEL), outlines an arable farmaing system that aims to meet economic, ecological and social demands. The following outlines to which extent maize can contribute to the efficient and sustainable development of arable farming for the future. Special reference is made to the framework conditions defined as guiding principles in the BMEL discussion paper.

Maize is the second most important arable crop in Germany after wheat.

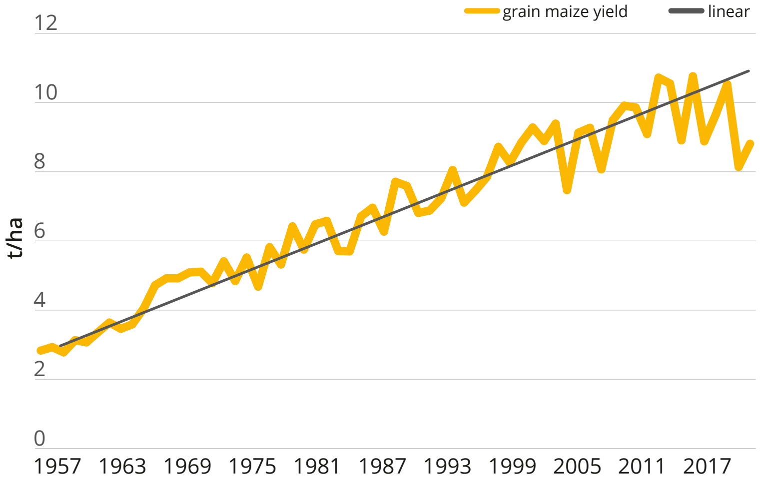
I. Maize cultivation is invaluable for the security of food, feed for livestock, and biogenic raw material

The immense increase in the cultivation of maize in Germany was made possible by enormous breeding advances in terms of yield, cold tolerance and early maturity. In 2020, maize accounted for roughly 2.7 million hectares, with maize for silage being the dominant use with a share of 80 %. About 20 % of the maize silage is used for beef production while the remaining share is used in equal parts as fodder in the dairy sector and for biogas production.

The majority of the total amount of grain maize processed in Germany (production and import), is used for producing animal feed. With the quantity that remains on farms for feeding, this amounts to about 70 %. Almost 20 % is directly or indirectly used in the food sector via processed starch. Smaller quantities are utilised in the production of ethanol and in technical applications, such as the production of biodegradable plastic.

The yield of grain maize has risen steadily over the years.

Grain maize in t/ha – yield growth between 1957 and 2019



Source: Destatis, DMK

On average, grain maize yields are nowadays 25 % higher than those of wheat. In Germany, the annual breeding-related increase in grain yield amounts to a 1.8 % rise. In silage maize, the annual breeding progress has increased the dry matter yield[1] by almost 0.8 %. Over the last 60 years, the average yield of grain maize has increased from about 3 t/ha to more than

1 Laidig et al., 2016

10 t/ha, and with silage maize it has risen from about 30 t/ha fresh matter to 45 t/ha.[2] Hence, the yield increase in silage maize is lower than that in grain maize. This is due to the fact, that silage maize was also grown on less favourable sites, as a consequence of expanding the acreage. Therefore, the question of site suitability for the cultivation of maize will become increasingly more important in the future.

2 Destatis, own calculation, 2020

II. Maize cultivation is important for the revenue within the agricultural sector

The mere fact that maize, also known as corn, is nowadays the second most frequently cultivated crop in Germany underlines its economic importance. The associated welfare gains do not only benefit the farmer who grows the crop but also favour economic growth in rural areas. The regional and application-oriented flexibility of corn therefore leads to a very high economic value that is characterised by both high yield security and low labour costs. In addition, low monetary costs for crop protection and fertilisers combined with a pronounced yield stability in times of water shortage and high temperatures are of increasing economic importance in terms of risk management and climate change. In comparison to many other crops, corn's low sensitivity to early summer drought and the resulting yield stability in conjunction with the highest water use efficiency makes this crop an integral component of future farming systems.

Maize is an important economic factor in rural areas.

III. Maize aids the protection of our environment and our natural resources

Successful under-sown catch crops in maize take up about 50 kg nitrogen and potassium per hectare via shoots and roots and bind about 350 kg of organic carbon per hectare without yield losses to the maize crop.

3.1 Adapting fertilisation to demand and avoiding nutrient surpluses

Grain maize as well as silage maize are remarkable in terms of high nitrogen use efficiency and the lowest nitrogen requirements per ton of dry matter of all relevant crops in Germany. Since the reduction of nitrogen surpluses and the use

of chemical crop protection products are key future tasks for agricultural production systems, maize can enhance the value of cropping systems with a high percentage of cereals in the rotation. This, in combination with additional measures, such as the use of catch crops and under-sown grass, contributes to increasing the nitrogen utilisation of the entire cropping system. Studies in narrow rotations of rapeseed and wheat have shown that silage maize following winter wheat can absorb about 130 kg of nitrogen per hectare from the residual soil nitrogen without any fertilisation because the maximum N requirement of maize in the months of July/August coincides exactly with the period of maximum mineralisation rates in the soil..

As a positive side-effect in crop rotations previously dominated by winter cereals, catch crops are used to reduce both nitrate leaching and soil erosion, thus conserving nutrients over winter and often even allowing for an additional use as fodder, prior to planting the maize.

The use of catch crops before and after, or under-sowings in maize can also lead to considerable positive environmental effects (erosion control, humus performance, N-conservation).

The use of modern technology for the application of organic fertilisers can reduce the need for, or even replace, a mineral side dressing while also reducing ammonia losses.

2. Enhancing integrated pest management and reducing unintended environmental effects

Compliance with necessary levels of chemical crop protection products is a key requirement of integrated pest manage-

Overview of treatment indices (average from 2016–2019)

Maize	1,8
winter wheat	5,4
winter barley	4,3
winter rape	6,7
potatoes	12,7
sugar beets	3,9

PAPA – Panel Pflanzenschutzmittel-Anwendungen/Panel Application of Plant Protection Products (Julius Kühn-Institut, own calculations)

As a crop row, maize offers very favourable conditions for the use of mechanical weeding systems.

ment. The necessary level describes the application intensity of pesticides, which is needed to safeguard the economically viable cultivation of crops. It is assumed that all other practicable means for control and suppression of harmful organisms are exhausted. The intensity of the application of plant protection products can easily be shown by means of a treatment index. In comparison to other important arable crops, maize clearly has the lowest treatment index (see graph). As maize is fairly susceptible to competition with other plants and to pests in its juvenile stage, weed control as well as sustainable and responsible seed treatment is required, as one of the few indispensable crop protection measures.

Despite the already low use of pesticides, there are successful, forward-looking approaches for maize cultivation to further reduce the application of chemical crop protection products. These include decision support systems for the selection and application of herbicides that are as environmentally friendly as possible, as well as the development of mechanical weeding systems. As a row crop, maize offers very favourable conditions for the use of mechanical methods which can be effectively used in practice either on their own, in addition to, or in combination with partially reduced herbicide applications (illustration: picture – maize hoe in use). The use of equipment is also further optimised by means of GPS-automated steering.

The use of digital systems has also significantly contributed to expanding biological control of the corn borer with the parasitic wasp Trichogramma. With GPS-controlled multi-copters, capsules containing ready-to-hatch Trichogramma can be rapidly and precisely applied where necessary and at the optimal point of time, (illustration: image – copter over maize stand, ideally with a still flowering field margin in a diverse landscape). The combination of biological control and digital systems is trend-setting for arable farming at large.

While these approaches enabled the achievement of significant successes in practical maize cultivation over the past 10 years, reliable and broad pre-emergence protection can currently be only achieved

Application of Trichogramma capsules with a GPS-controlled multi-copter.

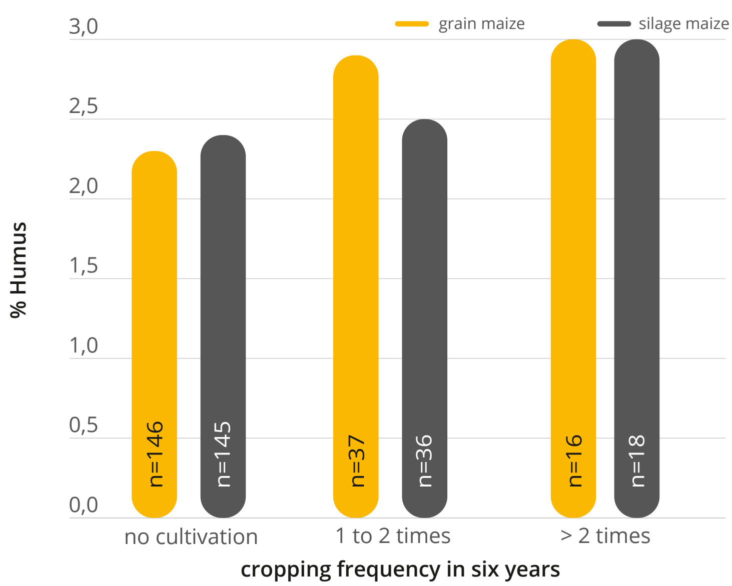
with suitable chemical seed dressing agents. Alternative methods and the use of so-called bio-stimulants, for the control of soil-borne pests and for the protection of germinating seed, are being tested but cannot yet be classified as equivalent in securing adequate field emergence.

3. Securing stable organic matter contents and protecting the soil

Organic carbon ("humus"/"soil organic matter") has a crucial influence on soil fertility and thus on crop yield. Humus content and its development are determined by soil type, climate and arable use. Crop rotation, type and intensity of tillage and the amount of organic fertilisation are key parameters for this. According to VDLUFA, maize has a humus requirement of between 560 and 800 kg C per hectare for the humus reproduction. Where maize is grown for grain or CCM the crop residues return more organic matter to the field than what is consumed by cultivation. In farms with animal husbandry, there is an additional return of organic matter via farmyard manure, allowing for a stable humus level even with a high percentage of silage maize in the crop rotation (see figure). Only when maize is continuously grown over a long-term, which as a rule should be avoided, is there a need to counteract C loss by using humus-producing crop rotations , for example with under-sown crops or catch crops.

Soil protection in maize production requires particular attention. Adequate soil cover is crucial in the period between the harvest of the preceding crop and maize sowing, as well as during the early growth of the maize crop. In Germany, many farmers take advantage of the benefits of winter greening prior to maize, provided that there is sufficient seasonal rainfall and that the soils are not too wet for cultivation in autumn. For this purpose, mixtures of summer catch crops susceptible to frost can be used, even though recent results indicate that this may be associated with increased emissions of nitrous oxide. Winter catch crops such as green rye or ryegrass can also be used and then be utilised as whole-crop silage. When frost resistant catch crops are used in arid areas, the water balance needs to be carefully observed.. However, this method usually requires the application of a broad-spectrum herbicide when the soil is tilled without ploughing, for example strip tillage, with the additional effect of high carbon storage in the soil. With strip tillage, only the soil in the seed rows is loosened. The soil between the loosened strips, which is approximately two-thirds of the area, remains undisturbed and covered with plant residues.

Organic matter content as a function of the cultivation frequency of maize



Humusmonitoring Nordrhein-Westfalen/Organic Matter Monitoring North Rhine-Westphalia (Jacobs, 2011)

Maize fields serve as habitat, food source and refuge for a large number of animals.

IV. Cultivating maize contributes to enhancing biodiversity and species richness in agricultural landscapes

In cash crop farms with narrow crop rotations, maize can enable widening of the cropping sequence. Particularly in regions with low levels of livestock, where arable farming prevails, the integration of maize in the crop rotation will lead to enhanced cultivation diversity. Problems may arise however, to increase the maize crop in regions with high levels of animal husbandry, where a large part of the land use has already shifted to maize, , or in regions where maize-specific pests have become established. As with any other type of crop, cultivation as a large-scale monoculture has a negative impact on landscape and biodiversity, as well as on the resilience of the respective cultivation systems. Compensatory measures should be used wherever possible, such as ample flower strips, (which often are subject of offers under the second pillar of the EU agricultural policy in the German federal states), especially in regions with a high proportion of maize, large fields and few fringe structures in order to meet the requirements for adequate flora and fauna biotope network systems in agricultural landscapes. More recently, the mixed cultivation of maize and beans has also gained in importance. This increases the proportion of flowering plants, which in turn enhances crop diversity.

In principle, habitat diversity in small scale areas is a key for biodiversity in agro-ecosystems. While compensatory measures may become necessary in the case of high maize percentages – as described above – the situation is reversed when maize is expanded into regions previously dominated by cereals. In practice, maize and wildlife do not exclude each other, as maize fields can serve as habitats in different ways. Once the maize stand is established, it offers a variety of habitat functions. The presence of insects, birds and wildlife in maize fields particularly increases after a cereal harvest. After the maize harvest, stubble fields are attractive for cranes and wild geese. Additionally, maize stubble also makes a good winter habitat for partridges, pheasants and field hares.

V. Maize cultivation mitigates climate change and aids the adaptation of agriculture to climate change

The contribution of different crop types and cultivation systems to mitigate climate change clearly depends on the yield potential of the crop, the extent to which production resources with high greenhouse gas potential (mineral fertilisers) are used, and on changes in the carbon stock of the soil. However, considerations at the level of crop type on a given field are not sufficient for a comprehensive classification, as the decisive factor is the relative contribution of emissions caused by the cultivation of a particular crop to the carbon footprint of the end product consumed by humans (in the case of maize e.g. tortilla, polenta, milk, meat, etc.). With regard to the cultivation of maize in Germany, this complexity means the following: In principle, high yields with high nutrient use efficiency can be rated comparatively favourably because the assessment of emissions refers to the product unit on a global scale (energy or protein unit) and not to the area unit (hectare)[3]. Against this background, growing grain maize in the south of the country, in a well-organised crop rotation and with stable yields of 12–14 tons per hectare, for example, is favourable regarding the climate balance and carbon footprint. Also, the production of silage maize on dry sites as fodder for milk production (e.g. alternating with ley farming/grass-clover/alfalfa) causes comparatively low greenhouse gas emissions per unit of energy in fodder due to the yields – which still are relatively high when compared to other arable crops – and their low emissions of nitrous oxide. In contrast, the situation is reversed on ley sites or in lowland areas. There, emissions from soils dominate the carbon footprint of the product, and arable farming is problematic for climate protection reasons due to the necessity of a deep groundwater table in general, and for maize cultivation in particular. This is also true for the extensive cultivation of maize for biogas production. It should be noted, however, that professional maize cultivation at suitable locations always contributes to mitigating climate change.

3 Claus et al., 2013

VI. Cultivation of maize and consequences for social debate

Social acceptance of maize cultivation is characterised by the perception of aspects related to nature and environment. Nature and environment are decisive fundamentals of human life, their protection is as important as food security, and this is reflected in the sustainability goals of the United Nations. The intense increase in maize cultivation in Germany over the past decade is considered incompatible with the values of parts of the civilised society, especially in regions with high proportions of maize. In addition, the tall plant and its resulting dominant appearance enhances its visibility in the cultural landscape and the impression of a landscape that has changed. In contrast, the function of maize as raw material for the production of high-quality food, and its global as well as local contribution to key sustainability goals such as poverty reduction, hunger alleviation, and health and well-being, is hardly extensively reflected in social debates. Changing this situation will require high communication efforts on a scientifically sound basis. This will also include facing the urgent requirements with regard to environmental protection goals such as the reduction of GHG emissions and nutrient inputs into water bodies, or with regard to more livestock-friendly forms of animal husbandry, and contributing to solutions.

Flower strips create additional biodiversity and enhance social acceptance.

It will not be possible to achieve the batch of goals of high productivity, biodiversity, climate and water protection as well as the guidelines for future arable farming in Germany postulated in the arable farming strategy of the Federal Ministry of Food and Agriculture without a comparatively high proportion of maize on the fields. Maize will gain further importance because it is characterised by above-average flexibility of cultivation and use, high climatic and pathogenic resilience, and consistently high breeding progress.

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