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Insights into Increasing Biomass Yield in Energy Maize

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Abstract The study mainly summarizes some key factors and optimization methods for improving energy corn biomass yield. Appropriate planting density and row spacing can significantly increase the aboveground yield of corn. But how to plant it depends on the corn variety and local climatic conditions, and it cannot be a one-size-fits-all approach. In addition, the amount of nitrogen fertilizer and the time of harvest are also very important. Applying more nitrogen fertilizer appropriately and choosing the right time to harvest can increase the yield and biomethane output. From 1983 to 2017, thanks to new breeding techniques and increased planting density, corn biomass yield increased by about 30%. Among them, breeding has a greater impact on yield than planting density. In heavily polluted soils, applying some humic acid can also help, which can significantly increase corn dry matter yield and energy output. If the management input is high, such as enough fertilizer, the biomass yield will also be higher; however, with moderate input, the energy utilization rate may be better. Some new technologies now, such as remote sensing combined with crop models, can also help us more accurately estimate corn yields over a large area. This is very useful for adjusting field management. If you want to increase the yield of energy corn, it is very important to choose the right variety, arrange the planting density, manage the fertilizer, grasp the harvesting time, and add the help of some modern technology.

Keywords Energy corn; Biomass yield; Planting density; Nutrient management; Breeding optimization

1 Introduction

As the demand for renewable energy continues to rise, biomass energy has received more and more attention. It is not only renewable, but also widely available and low-cost, and is an important part of the current energy structure transformation. Corn is a high-yield crop with many uses. It is the main material for producing biomass energy, especially in the production of clean energy such as biogas and methane (Herrmann and Rath, 2012; Jankowski et al., 2020; Wyszkowski and Kordala, 2024). Countries like Germany and Poland are growing more and more areas of energy corn, which has become the main raw material for power generation and heating (Herrmann and Rath, 2012; Jankowski et al., 2020). In addition, energy corn can be grown on contaminated land, not only producing energy, but also helping to improve soil (Wyszkowski and Kordala, 2024).

The purpose of this review is to sort out the key factors that affect the yield of energy corn. These factors include genes, planting methods and environmental conditions. We hope to clarify several issues through this article: for example, how to improve corn varieties to increase yields, whether it is more appropriate to plant densely or sparsely, how much fertilizer to apply and how to irrigate best, and how light and soil conditions affect yields. At the same time, we will also look at how different management methods and molecular breeding techniques can work together to increase yields. Finally, we will discuss possible directions for achieving high yields in the future, which usually require cooperation among multiple disciplines (Yang et al., 2019; Li et al., 2020; Du et al., 2021; Du et al., 2024; Yan et al., 2024; Saenz et al., 2025).

This review talks about a whole set of research results from the genetic level to field planting. We will discuss how genetic improvement of maize affects biomass distribution and photosynthesis efficiency (Li et al., 2020; Saenz et al., 2025), and how planting more densely and using different nitrogen fertilizers affect yield (Du et al., 2021). In terms of irrigation, we will talk about how drip irrigation and integrated water and fertilizer technology can help maize grow faster and accumulate more biomass (Du et al., 2024). In terms of the environment, whether there is enough sunlight and whether the soil is polluted will also affect maize yield (Yang et al., 2019; Wyszkowski and Kordala, 2024; Yan et al., 2024). We will also discuss the chemical composition of maize, when to harvest, and what varieties to choose, which also affect biogas production and energy conversion efficiency (Herrmann and Rath, 2012; Jankowski et al., 2020). Finally, we combined research from different disciplines and proposed several cutting-edge ideas, hoping to help further increase the biomass yield of energy corn.

2 Energy Maize: Biology and Biomass Potential

2.1 Botanical background

The biomass yield of corn is closely related to its physiological and structural characteristics. The stalk is the main part of corn biomass, accounting for about half of the total dry weight. How thick the stalk is, how tall the corn grows, how thick the epidermis is, and the number and size of vascular bundles all affect the amount of biomass and energy (Mazaheri et al., 2019). In addition, leaf area and tillering (that is, how many branches grow) will also affect the efficiency of photosynthesis, which in turn affects the growth and yield of corn. These traits vary greatly between different corn varieties. These differences are caused by genetic diversity and are a good resource for breeding (Rincent et al., 2014; Mazaheri et al., 2019).

2.2 Yield components

The composition of biomass corn and ordinary grain corn is significantly different in yield. Biomass corn mainly focuses on the yield of dry matter of the whole plant, such as stems, leaves, bracts and cobs, while grain corn focuses more on the yield of grains (White et al., 2012; Ambrosio et al., 2017). Generally speaking, biomass corn grows taller and has thicker stems, and the nutrients of the plant are more distributed to the stems and leaves, so the grains are relatively less. Studies have found that there is a trade-off between these two yields. If the stems and leaves grow more, the grains may be less (White et al., 2012). In addition, management methods such as the amount of nitrogen fertilizer and the density of planting have different effects on biomass yield and grain yield (White et al., 2012; Ambrosio et al., 2017).

2.3 Cultivar types

High-biomass hybrid corn and ordinary grain corn have many differences in variety sources and appearance traits. For example, some high-biomass varieties are hybrids of temperate and tropical varieties. This type of corn grows taller, matures later, has thicker stalks, and contains more sugar in the stalks, making it more suitable for use as an energy crop (White et al., 2012; Rincent et al., 2014). The nutrients of these high-biomass varieties are mainly concentrated in the stems and leaves, while traditional grain-type varieties focus more on grain yields (White et al., 2012). Through genetic and morphological analysis, it was found that different corn hybrid groups, such as Dent and Flint, also have many differences in biomass yield. This shows that there is still potential to increase energy corn yields through breeding and hybridization methods (Rincent et al., 2014).

3 Genetic Basis of Biomass Accumulation

3.1 QTL mapping and GWAS studies.

The researchers used QTL positioning and GWAS methods to find some genetic loci that control maize biomass accumulation. They used high-throughput phenotyping technology and 50k SNP chips to find 12 major trait-associated loci (MTA) and 6 pairs of interaction loci at different growth stages of maize. This shows that biomass accumulation is controlled by multiple genes with small effects, and the expression of these loci is different at different stages (Muraya et al., 2017). In the two maize varieties, Dent and Flint, the study also found some QTLs related to biomass, plant height, and flowering time. However, these QTLs are not very stable under different environments, but overall, they show rich genetic differences, which is a good thing for breeding (Rincent et al., 2014). In addition, a study conducted a GWAS analysis specifically on stalk biomass and structural characteristics, and found 16 potentially related genes, which are related to processes such as gene expression and cell division (Mazaheri et al., 2019).

3.2 Candidate genes and pathways

Some key genes related to maize biomass accumulation have been found. Most of them are related to processes such as cell division, hormone regulation, and cell wall formation (Zafar et al., 2022). Among them, lignin synthesis and cell wall modification are very important for the increase of biomass and the degradation of biomass. Some transcription factors and miRNAs can activate these related genes, thereby helping the cell wall to grow better (Carpita and McCann, 2008; Xie and Peng, 2011; Zafar et al., 2022). In addition to the structural aspect, carbon allocation and photosynthesis efficiency also affect biomass accumulation. For example, GLK transcription factors can regulate chloroplast development and photosynthesis-related genes, so that plants can accumulate more carbohydrates and increase biomass (Li et al., 2020). In addition, plant hormones such as auxin can also affect cell stretching, thereby promoting overall plant growth and biomass increase (Wang et al., 2019).

3.3 Molecular breeding

Now, molecular techniques are also used in breeding, such as marker-assisted selection (MAS) and genomic selection. These methods have been used to improve the biomass trait of corn. By collecting a large amount of genotype and trait data, researchers use genomic selection technology to predict biomass with a moderate accuracy of about 0.39 (Muraya et al., 2017), but it can already provide great help for breeding. The key sites and candidate genes found by GWAS and QTL also provide the basis for MAS (Rincent et al., 2014; Mazaheri et al., 2019). In addition, some modern technologies, such as hybridization and gene editing, have also been used to improve the yield and adaptability of corn (Zafar et al., 2022). These methods can help us screen higher-yielding and more energy-efficient corn varieties to meet the needs of bioenergy (Rincent et al., 2014; Mazaheri et al., 2019; Zafar et al., 2022).

4 Physiological and Morphological Traits Affecting Biomass

4.1 Photosynthetic efficiency

Corn is a C4 plant. This plant has a relatively high photosynthetic efficiency and can convert carbon dioxide into organic matter more quickly, which is an important reason why it can grow a large amount of biomass. Studies have found that the appearance characteristics of leaves, such as area, width, and leaf area index (LAI), are closely related to internal indicators such as chlorophyll, pigment, and total nitrogen content. These factors will affect the effect of photosynthesis and determine whether corn can better utilize sunlight, water, and nutrients to accumulate more biomass (Lindsey et al., 2018; Ibraheem and El-Ghareeb, 2019). After the C4 metabolism and leaf structure of corn are optimized, it can photosynthesize faster and use less water. In this way, it can grow well even in drought or other adverse environments (Lindsey et al., 2018).

4.2 Stem architecture and internode elongation

The corn stalk is the main part of its biomass. The thickness, length, thickness of the epidermis, and density of the vascular bundles of the stem all affect whether it can stand firmly, that is, its support and flexibility (Mazaheri et al., 2019; Pratikshya et al., 2025). Studies have shown that traits such as thick stems and high corn growth are closely related to yield. Moreover, these traits vary significantly between different varieties, which also provides a lot of room for selection in breeding (Rincent et al., 2014; Mazaheri et al., 2019). Some genes, such as Zmm22, not only affect the height of corn, but also other traits, such as the number of branches in the inflorescence (Mazaheri et al., 2019). The ratio of cellulose to lignin in the stem is also critical. More lignin will make the stem harder and less likely to fall; but a higher cellulose ratio is more conducive to later biomass processing. There should be a good balance between the two, ensuring both mechanical strength and convenient utilization (Pratikshya et al., 2025).

4.3 Root system architecture

The root system is the key part of corn to absorb water and fertilizer. Its structure will directly affect whether the aboveground part can grow well, and it is a basic condition affecting biomass accumulation. How the roots grow and how they are distributed will determine whether it can adapt to harsh environments such as drought or soil pollution, thereby affecting overall growth (Kränzlein et al., 2021; Deng et al., 2024) (Figure 1). When encountering drought or heavy metal stress, varieties whose roots can still remain active and have strong water absorption capacity can often retain higher biomass (Kränzlein et al., 2021; Deng et al., 2024). In addition, if the root system can absorb nutrients efficiently, it will also drive the leaves and stems to grow together, and the whole plant can accumulate more biomass. This synergy between aboveground and belowground growth is an important mechanism in maize growth (Borrás and Vitantonio-Mazzini, 2018; Ibraheem and El-Ghareeb, 2019).

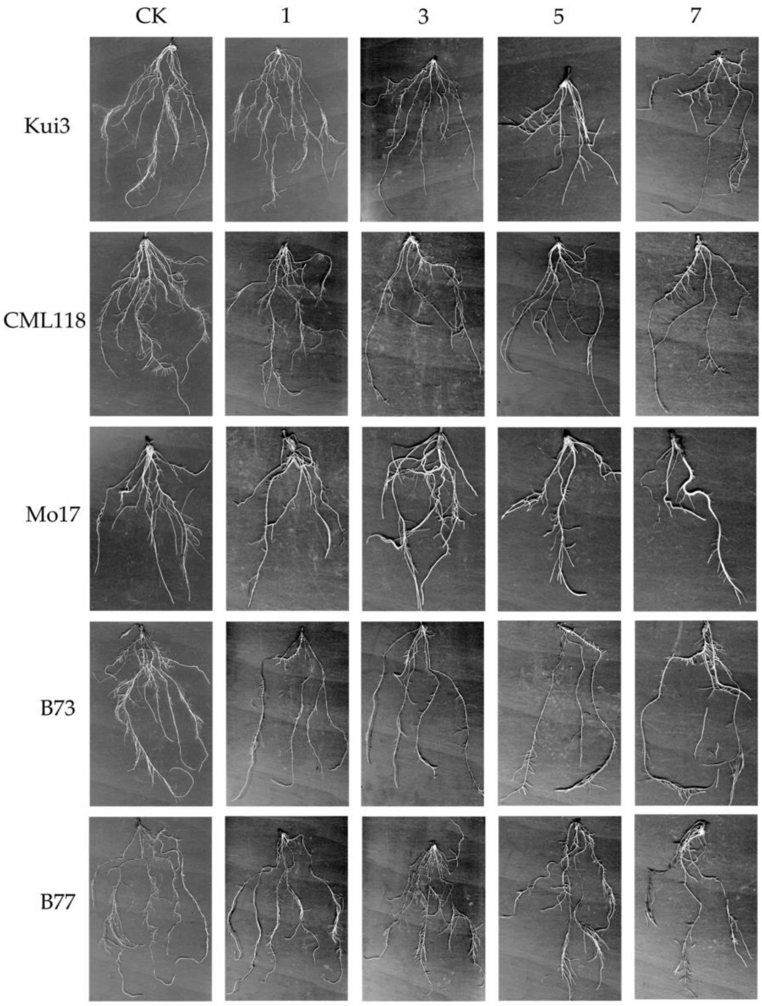

Figure 1 Root scan map. From top to bottom are the different inbred lines. In order: Kui3, Mo17, CML118, B73, and B77. From left to right are the different concentrations of Cd treatments. In order: 0 (CK), 1, 3, 5, and 7 mg L^{-1} (Adopted from Deng et al., 2024)

5 Agronomic Practices to Enhance Biomass Yield

5.1 Sowing density and planting patterns

Increasing the planting density of corn is an important way to increase overall biomass and yield. Global studies have shown that if the planting is denser, the total yield of corn can be increased by about 11.2%. This is mainly because during the period from seedling to heading, the dry matter accumulated by corn increased by 22.9%, and the efficiency of transferring dry matter to grains also increased by 12.6% (Shao et al., 2024). Planting densely can better utilize sunlight, which is conducive to the rapid growth and high biomass of corn in the early stage, but the yield per plant and root growth may be reduced. To solve this problem, you can choose compact varieties and arrange the density reasonably, so that you can plant more and not affect the light (Shao et al., 2024; Lei et al., 2025). Another effective method is to properly trim the top leaves, such as cutting off the top two leaves. This allows the lower leaves to get more sunlight, is not easy to age, and has better photosynthesis. Studies have shown that after such treatment, grain yield can be increased by 13% to 19% (Raza et al., 2019). Different regions have different climates and soils. It is best to adjust the density according to local conditions, and then combine it with precision irrigation and scientific farming to maximize the yield (Lei et al., 2025).

5.2 Fertilization strategies

In terms of fertilization, nitrogen fertilizer plays a decisive role. Studies have shown that applying nitrogen in batches and controlling the dosage can increase the yield by 13.9%, and the dry matter accumulation can also be increased by 27.1% (Shao et al., 2024). If the management methods of reasonable density, batch fertilization and deep tillage are combined, especially in fields with good soil fertility, corn can continue to accumulate a lot of dry matter and nitrogen after silking, accounting for 60% and 43% of the total, respectively, which is good for both yield and nitrogen fertilizer utilization (Zhou et al., 2019). In 2022, Galindo's team also found that inoculating some beneficial bacteria, such as nitrogen-fixing bacteria *Azospirillum brasilense*, can help corn absorb more nitrogen even if nitrogen fertilizer is reduced by half, and can also increase yield by 7%, while also having better economic benefits (Galindo et al., 2022). Another way is to apply silicon fertilizer. It can make plant leaves contain more chlorophyll, help photosynthesis, and thus increase biomass. Even if nitrogen fertilizer is reduced to 100 kg per hectare, the yield can still be very high (Galindo et al., 2021). Scientific fertilization can not only increase production, but also improve the efficiency of nitrogen fertilizer use, so as to achieve high yield and environmental protection (Wang et al., 2014; Zhou et al., 2019; Galindo et al., 2021; Galindo et al., 2022).

5.3 Irrigation and water use efficiency

In arid or semi-arid areas, reasonable irrigation and water-fertilizer integration technology are very important. Methods such as drip irrigation and fertigation not only save water, but also improve fertilizer efficiency. Studies have shown that this can increase yields by about 16.9%, while also helping corn accumulate and distribute more dry matter (Shao et al., 2024; Lei et al., 2025). The use of precision irrigation and reasonable density together is particularly effective in some specific areas, such as the irrigation belt in the northwest. It can greatly increase the potential for yield (Lei et al., 2025). These technologies not only improve water utilization, but also reduce the negative impact of drought, allowing corn to maintain stable and high yields even under adverse conditions (Shao et al., 2024; Lei et al., 2025).

6 Environmental and Climatic Factors

6.1 Climate adaptation

When temperatures rise, maize biomass and yield generally decrease. Many simulations and studies have shown that global warming is not very friendly to maize. For every 1°C increase in temperature, maize yields will decrease by an average of about 0.5 tons/hectare (Bassu et al., 2014; Liu et al., 2020). High temperatures will make maize grow faster, but will also make it mature earlier, reduce photosynthesis efficiency, and ultimately affect biomass accumulation (Chekole and Ahmed, 2022; Kim and Lee, 2023) (Figure 2). Changes in rainfall are also a key issue. Drought and lack of water will affect maize emergence, growth, photosynthesis, and flowering and fruiting. Leaves tend to curl, plants do not grow tall, and yields will also decrease (Chekole and Ahmed, 2022; Kim and Lee, 2023; Dahri et al., 2024). However, if irrigation is applied properly during critical periods, such as once during the reproductive growth period, the yield can be significantly improved, up to 55% (Dahri et al., 2024). Photoperiod also affects the growth and development of maize. However, there is currently a lack of research directly explaining its specific impact on biomass.

6.2 Soil health and microbiome interactions

The quality of the soil and the strength of microbial activity will affect the accumulation of maize biomass. Nitrogen fertilizer management is a key point. If nitrogen fertilizer is used properly, it can not only increase yields, but also help maize better adapt to high temperatures and rainfall changes (Falconnier et al., 2020; Olasogba and Duckers, 2020; Chekole and Ahmed, 2022). In low-input agricultural systems, simulating the supply and loss of soil nitrogen can help us determine the impact of climate change (Falconnier et al., 2020). Although there are not many studies directly discussing biofertilizers or mycorrhizal symbiosis, there is some evidence that soil microorganisms such as mycorrhizal fungi can improve crop performance under stress and improve its water and nutrient use efficiency, thereby indirectly increasing biomass (Yang et al., 2023).

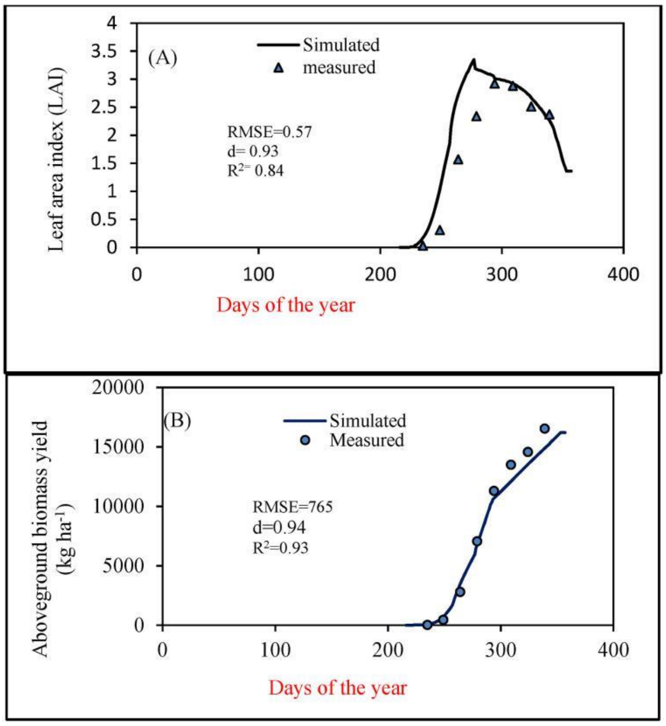

Figure 2 Comparison between simulated and measured leaf area index (A) and aboveground biomass yield (B) of melkasa-2 maize cultivar during model calibration at Harbu wereda, Ethiopia (Adopted from Chekole and Ahmed, 2022)

6.3 Carbon sequestration and ecosystem services

Corn is not only an energy crop, but also plays a role in the ecosystem, such as helping to fix carbon and protect soil. Climate change will affect corn yields and change its carbon emissions and net energy output (Olasogba and Duckers, 2020). If we can optimize field management, such as less tillage and reasonable fertilization, we can reduce carbon emissions while maintaining yields. This approach can make corn output more energy than input, which helps to improve the sustainability of biomass energy (Falconnier et al., 2020; Olasogba and Duckers, 2020). Corn cultivation can also help the soil store more carbon and increase soil organic matter. This is good for the ecosystem and is in line with the goals of low-carbon agriculture and sustainable development (Olasogba and Duckers, 2020).

7 Technological Innovations and Phenotyping Tools

7.1 High-throughput phenotyping

In recent years, unmanned aerial vehicles (UAVs) combined with multiple sensors, such as hyperspectral, thermal imaging, and LiDAR, have become important tools for studying corn phenotyping. These devices can quickly collect a lot of field data during corn growth without damaging the plants. By integrating different types of data together and combining them with deep learning methods, researchers can more accurately predict important traits such as dry matter, ear weight, and nitrogen fertilizer use efficiency. Studies have found that combining hyperspectral and LiDAR data can solve the problem of "saturation" of a single remote sensing method, that is, it can better identify complex traits such as biomass. Moreover, when using multi-task deep learning models, multiple traits can be predicted at the same time, and the effect is also good. These technologies provide practical methods and theoretical basis for breeding and field management (Nguyen et al., 2023). Some crop-safe remote sensing methods, such as spectral reflectance or infrared thermal imaging, are also often used to check corn's resistance to adverse environments such as drought or low nitrogen (Masuka et al., 2012).

7.2 Omics approaches

Integrating different types of “omics” data (such as transcriptome, proteome and metabolome) can help us better understand the genetic causes that affect maize biomass. By combining genetic information and trait data of different maize varieties or hybrids, researchers can find out which genes or regions are related to biomass, flowering time, plant height and other traits. These findings can provide important clues for molecular breeding and precision seed selection (Rincent et al., 2014). Wu's team (2019) showed in their study that through genetic modification, such as making the zmm28 gene more expressed, maize can grow faster, photosynthesize more, use nitrogen fertilizer better, and finally have higher yields in the field.

7.3 Data-driven modeling

Nowadays, many studies use data modeling methods to predict maize yield and biomass. Among them, machine learning and deep learning are the most used. Researchers input various data from remote sensing, such as vegetation index, structural index and heat index, into models such as support vector machines, random forests and convolutional neural networks, and can make accurate predictions for many corn traits. The prediction effect of some traits is very good, with an R^2 value of up to 0.85 (Nguyen et al., 2023). When the number of samples is relatively small or the data classification is not balanced, the use of multi-task deep learning models, coupled with data augmentation methods, can also improve the accuracy of predictions. Combining genetic data and phenotypic data for modeling (also called mixed model association analysis) can also help us find new QTLs related to biomass, which is also helpful for breeding decisions (Rincent et al., 2014).

8 Biotechnological Interventions

8.1 Transgenics and gene editing

The use of genetic engineering methods to regulate photosynthesis-related genes in corn has been shown to significantly increase biomass yield. For example, the continuous expression of the GLK (GOLDEN2-LIKE) transcription factor in corn will increase the chlorophyll content and improve the efficiency of light absorption by the plant. Experiments have found that this has increased the yield of transgenic rice by 30-40% (Li et al., 2020). Although there is no direct report on the use of CRISPR/Cas technology to edit corn cell wall components, this technology provides us with a new idea. It can precisely regulate the synthesis of cell walls, help increase biomass, and lay the foundation for future research and application.

8.2 Synthetic biology approaches

The goal of synthetic biology is to redesign or optimize the metabolic pathways of plants, so that corn can grow faster and produce more biomass. Although there is no literature specifically studying its application in energy corn, some research results can illustrate its potential. Scientists have successfully increased yields by regulating plant photosynthesis, nutrient absorption, and stress resistance (Li et al., 2020; Du et al., 2024; Ji et al., 2024). One study used drip irrigation combined with integrated water and fertilizer technology, and the average biomass of corn increased by 26.8% over four years (Du et al., 2024). Other studies have found that treating soil with biomass carbon dots can affect microbial communities and ion flows, making corn more drought-resistant and increasing yields by up to 40.5% (Ji et al., 2024).

8.3 Challenges and ethics

Although biotechnology looks promising, there are still many difficulties in its actual promotion. The relevant policies on genetic modification and gene editing are becoming more and more stringent, and the approval process is complicated, making it difficult for many new technologies to be promoted quickly. Secondly, many people still have concerns about genetically modified crops, worrying that they will have an impact on health or the environment, so public acceptance is not high, which also affects the progress of commercialization. Synthetic biology and gene editing have also raised some ethical issues, such as gene drift and species diversity protection, which need to be carefully considered and balanced in the policy and promotion process.

9 Case Study: A Regional Success in Biomass Maize Production

9.1 Location

Germany is a representative country in Europe for developing biomass corn. They have been using corn as a raw material for biogas power generation for many years. As the demand for renewable energy increases, Germany has begun to promote corn cultivation throughout the country, using it as the main raw material for anaerobic digestion to produce methane and ultimately provide heat and electricity (Herrmann and Rath, 2012).

9.2 Cultivar and practices used

Farmers in Germany mainly choose hybrid corn varieties that are optimized for methane production. These varieties are different from traditional feed corn, which are specially bred for fermentation and gas production. In terms of management methods, Germany generally adopts high-density planting, scientific use of nitrogen fertilizers, and good harvesting time. Their goal is to produce more biomass and methane per acre. Studies have shown that harvesting time is particularly important. The best yield and gas output can be obtained by deciding when to harvest based on the maturity of the corn (Herrmann and Rath, 2012).

9.3 Yield outcomes

German corn performs very well in methane production. Both the methane produced per hectare (MHY) and the methane produced per ton of biomass (SMY) are higher than those of ordinary feed corn. By breeding better varieties and planting more densely, German farmers have significantly increased the amount of methane produced per unit area. Studies have found that different varieties and different planting methods will affect methane production, but overall, with the right varieties and methods, energy corn can produce much better gas than traditional varieties (Herrmann and Rath, 2012).

9.4 Lessons learned

Germany's experience tells us that if we want to grow energy corn well, we need to pay attention to the following points: Breeding should be aimed at "methane production" rather than just considering feed use (Herrmann and Rath, 2012); planting more densely and using nitrogen fertilizer in a scientific way can significantly increase yields (Herrmann and Rath, 2012; Shao et al., 2024); the harvest time should be well controlled, and corn that is too tender or too old will affect gas production, and the harvest time should be determined according to maturity (Herrmann and Rath, 2012); we should also pay attention to the chemical composition of the corn itself, such as lignin and sugar, which will affect how much gas can be produced in the end. Therefore, variety selection and management methods should be considered together (Herrmann and Rath, 2012).

10 Future Perspectives and Conclusions

To increase the biomass yield of energy corn, it is necessary to combine genetic breeding, environmental adaptation and planting management. Corn has achieved continuous improvement in biomass and grain yield through breeding. Today's hybrid varieties are better at distributing dry matter reasonably, and the yield will naturally increase. But the yield depends not only on the variety, but also on environmental factors. For example, soil pollution, the amount of light, and the amount of rain will affect the performance of corn. It is also critical to use good planting methods, such as drip irrigation and fertilization, denser planting, more scientific nitrogen application, and reasonable arrangement of row spacing, which can make corn grow more biomass and produce more energy. The next research should pay more attention to the synergistic effect of genes × environment × management, select new corn varieties suitable for different regions, and match them with field management methods. Only in this way can we truly achieve high yield and high efficiency. Energy corn is an important renewable energy raw material and is very useful in responding to climate change. There should also be more policy support for its planting. Farmers can be encouraged to use less good land, such as polluted land or marginal land, to grow this kind of corn, which can not only produce energy but also improve the land ecology. At the same time, the government can improve some incentive mechanisms, such as subsidies and carbon trading, to help the biomass energy industry chain develop more healthily.

However, there are still many gaps in research. We are not clear enough about how the genes that form corn biomass regulate each other. It is necessary to study in depth which genes are related to high yield and stress resistance. How corn adapts to difficult environments (such as dense planting, lack of nutrients, and soil pollution) and whether its performance is stable in the long term also need systematic research. Another point is that after the biomass is increased, what is the relationship between energy utilization efficiency and carbon sink? Is the impact between long-term rotation and soil health positive or negative? These are also worth further exploration.

From the current research, combining genetic breeding with dense planting, water and fertilizer management and other methods is the most effective yield increase solution. For example, drip irrigation and fertilization, adjustment of row spacing density, and improvement of soil have all been proven to have a significant effect on increasing biomass. The cultivation of energy corn is not only an agricultural issue, but also related to climate policy and sustainable development strategy. In the future, in addition to continuing to support planting, support should also be provided in terms of policy and industry. In terms of research, we need to further clarify the gene network, enhance the stress resistance of crops, and pay attention to its long-term sustainable performance. Only in this way can energy corn truly achieve high yield, high efficiency and sustainable development.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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