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Corn Growth Model Based on Yield Statistical Model

Adityan Kumare[*]

Griffith University, Australia

[*]*corresponding author*

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Abstract: Corn is one of the main agricultural crops in China, but the agricultural technology conversion rate of corn cultivation is not high. The growth cycle of corn is longer and the process is more complicated. In addition to being affected by internal physiological mechanisms, the growth of maize has a great influence on its growth environment, especially the light environment. During the growth process, the interaction between corn and light environment is constantly underway. Corn planting time is also an important factor affecting corn yield. The difference in sowing date directly affects the growth and development stages of corn. The purpose of this paper is to study the growth pattern of corn based on a statistical model of yield. In terms of methods, it is proposed to use the inverse ray tracing algorithm to calculate the light energy reflected and absorbed by the corn, and establish a model to analyze the sensitivity of the area, mainly in terms of leaf area index, temperature, and moisture to analyze corn yield. Establish a corn growth model, and construct it from four aspects: yield, photosynthesis, temperature, and moisture. Finally, comprehensive supplements were made, and planting conditions continued to be optimized at planting density. In terms of experiments, the meteorological data and soil parameters of the plantation site were investigated. Finally, the experiment was divided into four groups, one was for home planting; the other was for planting at different intervals, the other was normal; the three were for drip irrigation, and the other was normal Four groups were planted using the improved strategies proposed in this paper. It is concluded that under drip irrigation conditions, the grain filling rate can be significantly increased, which will lead to an increase in 100-grain weight during maturity. With the increase of the population density, the competition among individuals within the group for light, temperature, water, and fertilizer is intensified. For better individual development, the individual plant height and ear height have been continuously increased in order to obtain more light energy resources. This is the instinctive response of plants to avoid each other. It was concluded that the planting density of corn reached its maximum under the condition of 80,000 plants / ha, and when the density increased further, the yield began to decrease. The improved planting model in this paper is superior to the other three planting models, followed by planting at different densities, followed by drip irrigation and normal planting.

1. Introduction

China has only 7% of the world ’s cultivated land, and it still has to feed nearly one fifth of the world ’s population, which requires us to be not only a big agricultural country, but also a strong agricultural country. The total area of arable land in China is 2.03 billion mu, of which the area of corn cultivation is nearly 300 million mu. However, the production efficiency of corn is not ideal. China is the second largest country in corn production in the world, with an annual corn output of more than 100 million tons. At the same time, China's corn consumption is also huge, reaching the world's first, and more than 90% is supplied by domestic planting and production. Crop growth simulation began in the 1960s, and it is a discipline that has gradually grown with the development of crop physiology and computer technology. After half a century of continuous development, crop growth simulation research has yielded fruitful results, and has now entered the application stage. The United States and the Netherlands are countries with mature crop growth simulation models.Research in this area started late in China. In the late 1980s and early 1990s, the American model was introduced into China and localized, and the corn growth process was simulated. the study. At present, there are some problems in corn simulation research in China. Since most of the simulation models are based on existing models from abroad, based on the experimental data of our country, the parameters are modified and adjusted, resulting in large errors; there is no uniform method and standard for the corn simulation model, which forms a blossoming landscape. Hundreds of schools of contention, but at the same time lead to poor compatibility between many excellent models, each fighting, can not absorb the essence of each other; corn models, including other crop models, have strong regional characteristics, often a model is only for one or a few The species and region are poor in transplantability and adaptability. How to improve the adaptability and versatility of the model has become one of the research focuses.

In addition to being affected by its own physiological mechanism, the growth and development of corn also has a great relationship with the growth environment (especially the light environment). During the growth process, the interaction between corn and light environment is constantly underway. However, it is not easy to test and simulate the light environment of corn. If a three-dimensional corn model is established on a computer to simulate the transmission and reflection of light between corns, it can be studied accurately and intuitively. Therefore, it is very important to simulate a realistic and effective light environment when performing corn growth simulation. Corn growth simulation is a process of using computer programs to simulate the use of light energy resources to combine water and carbon dioxide to produce organic matter under natural environmental conditions. Based on the basic principles of capacity conservation theory, crop physiology and agrometeorology, the physiological processes of dry matter accumulation such as photosynthesis and respiration in corn are studied, and the yield model of corn is developed based on this. In recent years, great progress has been made in the research of maize models in terms of growth, development, and yield. It has entered the practical application from theoretical research, and has contributed to the cultivation, breeding, and yield of modern information agriculture. Through computer simulation of corn growth, the effects of agronomic measures can be quickly determined and experimental research currently unavailable in the field can be implemented to realize the digitalization and scientificization of corn growth dynamic prediction, analysis and evaluation, condition control and management decisions, in order to realize digital farming Design provides method and theoretical basis. Through the acquisition, processing, management, and utilization of information in corn production, the digital expression of information flow in the process of corn growth is realized, so that corn production management changes from qualitative understanding to quantitative analysis, conceptual models to digital models, expert experience to optimal decision-making, and achieves Digital and precise farming information management and decision support for timing, quantification, and positioning.

Bingbing Xia proposed to use the meteorological data and yield data of Liaoning Province from 1981 to 2005 to use the WOFOST model to simulate and improve crop growth, establish a statistical forecast model for corn growth dynamics, conduct forecast verification, and simulate the ground dry weight and ears of the corn. The dry weight is compared with the actual yield [1]. F. Fan proposed to analyze the economic benefits and reasons of the two utilization modes under different silage varieties and densities in order to realize the rational and effective utilization of silage corn. The author adopted a split-zone test design, using Beijing Branch Silage 516 and Agricultural University 108 Maize varieties under different density conditions at the stage of milky maturity, the yield of grains at maturity, and the difference in economic benefits were taken as the research objects, and the relevant analysis of variance and comparative studies were carried out [2]. Noel Cressie proposed that by using high-scoring No. 1 remote sensing satellite imagery and MODIS NDVI products, after pre-processing such as atmospheric correction, geometric correction, relative radiation correction, and masking, two production estimation methods based on environmental yield models and biomass models were combined with the The obtained various influencing factor parameters were used to estimate the summer maize yield in Yucheng in 2016, and the accuracy of the estimated yield results was verified and evaluated [3].

In terms of methods, it is proposed to use the inverse ray tracing algorithm to calculate the light energy reflected and absorbed by the corn, and establish a model to analyze the sensitivity of the area, mainly in terms of leaf area index, temperature, and moisture to analyze corn yield. Establish a corn growth model, and construct it from four aspects: yield, photosynthesis, temperature, and moisture. Finally, comprehensive supplements were made, and planting conditions continued to be optimized at planting density. In terms of experiments, the meteorological data and soil parameters of the plantation site were investigated. Finally, the experiment was divided into four groups, one was for home planting; the other was for planting at different intervals, the other was normal; the three were for drip irrigation, and the other was normal. Four groups were planted using the improved strategies proposed in this paper.

2. Proposed Method

2.1. Inverse Ray Tracing Algorithm Flow

The reverse ray tracing algorithm borrows the main ideas of the ray tracing algorithm. However, it is completely different from the ray tracing algorithm.The ray tracing in the reverse ray tracing algorithm starts from the light source. First, multiple rays are emitted from the light source position into the scene, and then each ray is traced.Finally, according to the intersection of the surface of the object To determine whether to generate reflection or transmission, or to stop ray tracing. The inverse ray tracing algorithm first uses the bisection inner bounding box technique to remove some redundant surfaces that do not want to intersect with the ray, and then uses the inverse ray tracing to calculate the number of mutual occlusions between the leaves, which is to define the given occlusion factor. At the same time, using Inverse Ray Tracing can also find the reflection angle after the blade and light intersect, and then continue to trace the light until the termination condition is met, and the reverse ray tracing process ends [4]. The flow design of the IRT algorithm is divided into two parts: the first part judges whether the corn intersects the inner bounding box of the bisection to perform pre-processing, and enters the second part after removing a large number of disjoint faces; the second part calculates the light reflected and absorbed by the corn can.

2.2. Model Sensitivity Analysis in Regions

Leaf area index is an important parameter to characterize crop growth, which largely controls the physiological and biochemical processes of crops such as photosynthesis, respiration and carbon cycle. Crop growth requires a certain temperature. Proper temperature promotes growth, and conversely restricts crop growth. Water is the root of life. Most of the available water for regional crops comes from natural precipitation, so the amount of precipitation has a certain impact on the growth of regional crops. For a certain region, the overall relationship between corn yield and LAI is positive, that is, corn yield increases (decreases) with LAI increasing (decreasing), but the amount of change varies from region to region. The daily maximum temperature, daily minimum temperature, and the maximum carboxylation rate of the main parameters of the model also show the same trend.At the same time, the effect of daily maximum temperature on corn yield is greater than the effect of daily minimum temperature, and the increase (decrease) of daily maximum temperature causes increased corn yield. The decrease (decrease) is greater than the increase (decrease) in the daily minimum temperature leading to the increase (decrease) in corn yield [7]. On the whole, changes in climatic factors such as daily precipitation and relative humidity have caused little change in maize yields, with a change of almost zero, but there have been slight changes in some areas.

Statistical analysis was performed throughout the region, and the results showed that if LAI increased by 10% (other parameters unchanged), the region's output increased by an average of 860 kg / km2 (23.3%); LAI decreased by 10% (other parameters unchanged), the region's output The average reduction is 532kg / km2 (15%). The daily average maximum temperature increases by 1 degree Celsius (the other parameters remain unchanged), and the region's average production increases by 283 kg / km2 (8.3%); the daily average maximum temperature decreases by 1 degree Celsius (the other parameters remain unchanged), and the region's average output decreases by 242 kgkm2 (6.3%)). The daily average minimum temperature increases by 1 degree Celsius (the other parameters remain unchanged), and the region's average output increases by 171 kg / km2 (4.4%); the daily average minimum temperature decreases by 1 degree Celsius (the other parameters remain the same), and the region's average output decreases by 136 kg / km2 (3.5%). The degree of response of maize yields in these areas to the daily maximum temperature and daily minimum temperature is consistent. The maximum value of the parameter increases by 10%, and the average yield of the region increases by 596 kg / km2 (16%); the maximum value of the parameter decreases by 10%, and the average yield of the region decreases by 535 kg / km2 (14%). The corn yield in this region is sensitive to the parameter value The degree is more consistent [8].

LAI is mainly affected by climate factors such as temperature and precipitation. At the same time, the maximum carboxylation rate is also a function of temperature. The sensitivity analysis results can show that the improved model can simulate the effect of regional temperature on corn yield. Therefore, under the existing conditions, if it is necessary to increase corn yield, it is relatively difficult to increase the corn LAI, and it is relatively easy to increase the corn yield by increasing the temperature, which is also consistent with the existing facts.

2.3. Establishing a Corn Growth Model

Simulation is the use of physical or mathematical models to imitate the real system and its evolution process, to find a way to find laws and solve problems. Its basic idea is to establish an experimental model, which contains the main characteristics of the system under study, and obtains the necessary information of the system under study by running the experimental model. Simulation can be divided into physical simulation and mathematical simulation. Physical simulation is to imitate the actual system and its physical system with similar functions, such as experimental field planting. Physical simulation usually takes longer and has a longer period, and it is difficult to change the system structure and coefficients on the physical model. Mathematical simulation is to use mathematical operations to simulate the operation of the system under certain assumptions. Modern mathematical simulations are based on computer systems, so they are called computer simulations. The advantage of computer simulation is that it can be performed repeatedly, and it is easy to change the structure and coefficients of the system [9]. Today's computer simulation technology has already developed into one of the new technologies involving the most modern disciplines. The disciplines it covers not only include mathematics (including numerical analysis), but also statistics, operations research, systems theory and systems engineering, management, and so on.Its development has involved almost everything including agriculture. All areas.

(1) Yield target model

As a major crop of grain, feed and industrial raw materials, corn has an irreplaceable role in the development of the national economy. Today's scholars regard the amount of corn per capita as the main symbol of the living standards of a country and people. Corn is one of the three major grain varieties in China, and its output accounts for about a quarter of the country's total grain output. After entering the 1990s, due to the increase in planting area and the widespread adoption of hybridization technology, China's corn production has developed rapidly. There are many factors that affect corn yield, such as variety, soil, geographical location, climate, fertility level, irrigation level and management level, etc. These factors constitute a complex system of corn growth and development [10]. Simulating the growth process of corn is to simulate this complex system. Through experiments and simplifications, the computer is used as a tool to simulate major ecological factors such as light, temperature, and moisture and management levels. Photosynthetic production potential was then corrected step by step through temperature, moisture function, fertilization level, irrigation level, and management level and other influencing factors to calculate the yield target. The average corn yield in the first three years is defined, and the yield target is compared with the average corn yield in the previous three years to obtain the yield increase coefficient.

(2) Photosynthetic production potential

The increase of maize yield depends on the combined effects of the genetic basis of maize and the natural environment, as well as people's cultivation methods. Light energy and photosynthetic products are the fundamental sources of corn yield. Corn has good photosynthetic efficiency.The effective photosynthetic product (yield) of corn in an ecological region comes from factors such as the solar radiation energy of the local corn during its growth period, the photosynthetic conversion efficiency of corn, and the energy consumption of the corn itself. Over time, photosynthesis of corn is more vigorous, the productivity of light energy is large, the accumulation of dry matter is more, and the yield can be high [11]. There is a difference in solar radiant energy between latitudes. The main factors of the difference include the long day, the intensity of sunlight, and the factors such as shade and rain.

(3) Temperature correction

Temperature is one of the important environmental factors for photosynthesis of corn.In a certain temperature range, for example, from the cold limit temperature of the photosynthesis to the optimal temperature, the photosynthesis rate appears to increase with the increase of temperature. 10 degrees Celsius, the photosynthetic rate can be doubled. Below the cold limit temperature and above the heat limit temperature, there will be various adverse effects on photosynthesis. Therefore, the adverse effects of temperature on photosynthesis include low temperature and high temperature. Low temperature can be divided into two types: cold injury and freezing injury. At the temperature of cold damage, the photosynthetic rate of corn decreased significantly. Freezing damage refers to the temperature below zero, which caused the corn cells to freeze and damage the corn. When the temperature is higher than the optimum temperature of photosynthesis, the photosynthetic rate obviously decreases with the increase of temperature. The importance of temperature to photosynthesis of maize can be seen [12]. Corn is a warm temperature crop.The optimal temperature for seed germination is 26 ~ 30 degrees Celsius, the average daily temperature required for jointing is above 18 degrees Celsius, and the average daily temperature from tasseling to flowering is 26 ~ 27 degrees Celsius. It is required to keep the temperature at 20 ~ 24 degrees Celsius. Maize varieties can be roughly divided into three types: early maturity, middle maturity, and late maturity. The accumulated temperature requirements are 2000 ~ 2400 degrees Celsius, 2400 ~ 2700 degrees Celsius, and 2700 ~ 2900 degrees Celsius. To establish a yield target model, the temperature correction function is one of the key influencing factors. In order to perform temperature correction, different scholars have proposed many temperature correction coefficients or functions. When the photosynthetic production potential is obtained to further calculate the light temperature production potential or the climate production potential, a temperature correction function needs to be determined.

(4) Moisture correction

The growth and development of corn cannot be separated from water. Water is the raw material for the production of organic substances.The amount of water affects the photosynthesis of corn and affects the absorption and transport of nutrients in corn.Water is the largest component of the corn itself.It makes corn have transpiration, which is used to regulate plant body temperature and the Physiological processes, water also affects flowering, pollination, fertilization, and pests of corn. Therefore, the effect of water on the growth of corn plays an extremely important role. The water requirement of different stages of corn growth and development is different, and the soil water content should be adjusted according to the water requirement of corn at different periods.

2.4. Integrated Management

The crop production system is a complex and unique multi-factor dynamic system. It is affected by many factors such as weather, soil, variety, diseases, insects, weeds, and cultivation techniques, and has significant regional and spatial-temporal variability. Factors affecting the growth and development of maize, in addition to light, temperature and moisture, also include nutrient supply levels, cultivation management levels, and pest control levels.

Nutrients are necessary and irreplaceable substances for corn in completing its life activities or in the process of growth and development. From the perspective of nutrients and their circulation, it is divided into solid, liquid and gaseous nutrients. The proportional relationship between the three affects the agricultural ecosystem. From the perspective of nutrient uptake, it is divided into organic, mineral and adsorption-exchange nutrients. Normal growth of corn requires a variety of nutrients, and the essential elements are indispensable nutrients for corn at any stage of growth and development. In addition to the essential elements, there are some beneficial elements that are essential for corn under certain conditions. Shortage and excess of nutrients in corn are detrimental to its growth. A shortage of an essential element will affect the normal growth of corn; an excessive amount of an essential element will also adversely affect the growth of corn, so the proportion balance between various essential elements and the sufficient amount of an essential element are equally important. The supply of essential nutrients should be balanced with the demand and consumption. The application of various fertilizers is to maintain the nutrition balance. The supply of nutrients is determined by the level of soil fertility and the amount of nutrients required at different stages of corn growth. The growth process of corn is divided into four stages: seeding-jointing, jointing-big bell mouth, big bell mouth-silking, silking-maturity, according to the required nutrient content of corn and soil nutrient content and nutrient supply in different growth periods The amount determines the level of nutrient supply.

Cultivation management refers to a series of field management measures such as land preparation, seeding, seedling fixation, seedling repair, weeding, and timely harvesting. The fixed seedling and supplementary seedling guarantee the reasonable planting density of corn and increase the yield. If you are reluctant to remove the extra strong seedlings, causing unreasonable dense planting, or severe lack of seedlings in the field, it will have a certain impact on yield. Therefore, it is necessary to calculate whether the density is suitable for the fertility level and variety characteristics when determining seedlings. If the density is too high, seedlings should be thinned again until a reasonable density is reached. For sporadic lack of seedlings, double seedlings with consistent growth can be left at the ends of the missing seedlings. For broken ridges or large pieces of seedlings, old seedlings can be transplanted with soil in the afternoon and watered in time to ensure survival. The planting density of corn is mainly determined by the variety characteristics, fertility level, management level and sowing date. Normally, spring sowing is thin, and summer sowing is dense; the soil is fertile and fertilization is high; the varieties with tight stems and leaves and short growth period should be dense; otherwise, it is thin. Weeds are non-consciously cultivated plants in farmland. From the perspective of ecological economy, under certain conditions, all plants that are more harmful than beneficial can be called weeds and should be included in the control. The damage of weeds is mainly manifested in two aspects. One is that weeds compete with crops for sunlight, moisture and nutrients, which can seriously affect the yield and quality of crops. The second is that some weeds are intermediate hosts of crop diseases and insect pests, helping to spread and spread the diseases and insect pests. So weeding is very important to increase corn yield. Corn grains began to be filled, and the upper-filled part was solid, and there was a clear boundary with the unfilled part of the lower part, which was called milk line or filling line. With the progress of grouting, the milk line gradually moved downward. When the milk line disappears, it is the best harvesting time. At this time, the harvest yield is the highest, and it should be harvested in time.

Corn is often harmed by various diseases and pests during the growth process. There are many types of diseases and pests that harm corn. The main diseases are large spot disease, small spot disease, smut, bacterial wilt disease, ear rot disease and virus disease. Areas of serious harm are sheath blight, brown spot, rust, round spot, gray spot, etc .; the main pests are corn borer, ground tiger, slimeworm, red spider and so on. If the pests and diseases cannot be controlled in time, it may cause severe reduction in production. For example, in the epidemic years of maize leaf disease, the yield can be reduced by 15-30% due to disease, and the yield of severely diseased fields is reduced by more than 50%; the harm of corn borer usually reduces corn yield by about 10%, and in severe years by 30%. It can be seen that pest control has a very important role in ensuring yield. Pest control begins with the selection of maize varieties, and disease-resistant varieties can be selected, which are resistant to some diseases and insect pests, and the latter is mainly chemical control.

3. Experiments

3.1. Collecting Meteorological Data

Obtain meteorological data during the growing period of the test site in the year of the test; obtain historical weather data for a total of 30 years from 1990 to 2019 at the meteorological site, including: daily sunshine hours, daily maximum temperature, daily minimum temperature, daily rainfall, etc. (also Including: daily atmospheric relative humidity and daily average wind speed).

3.2. Obtaining Soil Parameters

Soil samples were taken at the test site to determine soil physical and chemical indicators. The soil parameters required by the model include soil physical properties: soil bulk density, permanent wilting coefficient of the crop, field water holding capacity, soil texture; chemical properties: soil basic fertility (ammonium and nitrate nitrogen content), and pH. The required soil data are mainly soil moisture content, soil texture, and soil bulk density.

3.3. Field Observation and Indoor Examination

Measure the latitude, longitude and altitude of the test site. Record previous crops, fertilization time, fertilization amount, cultivation management measures (tillage, weeding, etc.). Record the growth period of crops, including: seeding period, emergence period, flowering period, physiological maturity period, harvest period, etc.

Investigate leaf age and leaf area index in each growth period.

(1) Sowing date: the date of corn sowing day, expressed in day / month.

(2) Germination stage: more than 90% of seedlings with a plant height of 2-3 cm in the whole field (when 50% of the plants show the traits indicated by this indicator, they are considered to enter this physiological stage).

(3) Jointing stage: more than 60% of the plant's base stem nodes begin to elongate; there is induration when touched, and the growth cone of the male ear begins to elongate.

(4) Booting stage: more than 90% of the plants in the field have large bell-shaped upper leaves; dissect and observe that the male ears enter the tetrad stage and the female ears enter the floret differentiation stage.

(5) Tasseling stage: more than 90% of the whole plant's tassel was completely drawn, the female ear was silked, and the leaves were all unfolded.

(6) Silking stage: The date when the female silk filaments protruded from the bract leaves 1 ~ 2cm long. Under normal circumstances, the corn silking stage and the tassel flowering stage are synchronized or 2 to 3 days later.

(7) Physiological maturity period: the date when the female panicle leaves become yellow and loose, the grains show the inherent shape and color of the variety, and the black layer forms at the pointed crown below the seed embryo.

(8) Full growth period: the number of days from sowing or emergence to physiological maturity of seeds.

Plant Character Survey

(1) Plant height (cm): After tasseling, all the leaves are unfolded, and the height from the ground to the top of the tassel is measured.

(2) Stem thickness (cm): Measure the diameter of the oblate side of the 3rd internode above the ground.

(3) Number of unfolded leaves: The leaf pillow of the plant leaves is exposed from the sheath of the unfolded leaves, that is, the unfolded new leaves. The newly expanded leaves and the lower expanded leaves are added together to obtain the number of expanded leaves.

(4) Number of extended leaves: New leaves are exposed 1-2 cm before jointing, and 5 cm leaves are exposed after jointing.

(5) Number of visible leaves: number of unfolded leaves and number of expanded leaves

(6) Leaf area: Leaf area.

(7) Leaf area per plant: The total leaf area of all leaves of the plant.

(8) Leaf area index: The ratio of the leaf area per unit land group to the unit land area.

Indoor test items

(1) Ear length (cm): The length of the ear (including bald tip).

(2) Ear thickness (cm): the middle diameter of the ear (or the perimeter of the ear near the major

end of the ear axis).

(3) Number of ear rows: The number of grain rows in the middle of the ear.

(4) Number of rows of grains: the number of grains of medium length per ear and the average.

(5) Number of spikes: the product of the number of spike rows and the number of spikes.

(6) Thousand kernel weight (g): Take two portions of the dried seeds, mix them thoroughly, weigh 500 grains each. Adding the two is the 1000-grain weight (if the weight of the two samples differs by more than 4 ~ 5g, you must add one and add the two similar numbers).

(7) Seed yield: The percentage of dry weight of kernels to dry weight of ears.

3.4. Experimental Design

Divided into multiple groups, planted separately, and finally observe the effect of planting. One group was planted for home use; the second group was planted at different intervals, the others were normal; the third group was drip irrigation, the others were normal, and the fourth group was planted using the improved strategy proposed in this paper.

4. Discussion

4.1. Analysis of Cold Damage Index

The area of corn divided according to the accumulated temperature of the activity.First, the average development period of each development period of different varieties is obtained from the data of corn development period. Mature) daily caloric index, and then calculate the average caloric index during development. Different latitudes and different topography reflect different heat indexes, so the anomaly percentage is used to make it more universal.

Using the heat index of different development stages of corn, the three base point temperatures of different development stages of corn are shown in Table 1.

Table 1. Minimum, maximum and suitable temperatures for each stage of corn development

Corn development stage	lowest temperature	Maximum temperature	Suitable temperature
Emergence-horse chestnut	9.5	28.5	22
Buckeye-Tasseling	13	32	25.5
Tasseling-Milky	14	31.5	26
Milky mature	10	30	20

4.2. Effect of Drip Irrigation on Distribution of Corn Dry Matter in Various Organs

From the analysis of the dry matter accumulation of the above-ground organs of each plant in each treatment in Figure 1, it can be seen that the distribution rules of the organs in the above-ground part of the corn plant in each treatment are basically the same, that is, with the development of the corn growth period, Organ dry matter accumulation gradually increased. Maize is mainly vegetative in the early growth stage (seedling stage-large bell stage), and mainly accumulates the dry matter of leaves, leaf sheaths and stems. At the seedling stage, there was little difference in dry matter accumulation among the treatments, and the dry matter mass of the leaves was mainly accumulated; at the jointing stage, the growth of corn was dominated by the growth of vegetative organs (leaf, sheath, stem), of which the accumulation of leaves was the largest It accounts for 45.3% -49.4% of the dry matter accumulation of a single plant. From the jointing stage to the big trumpet stage, although corn is still dominated by vegetative growth. However, the dry matter allocation ratio of leaves and sheaths decreased, and the allocation ratio of stems increased, and the proportion of stem matter in the large bell mouth accounted for 39.77-41.67% of the whole plant. The stage of common growth of reproductive organs, and the proportion of dry matter distribution of reproductive organs began to increase; the dry matter accumulation of female ears accounted for 27.45% -30.6% of the dry matter mass of the whole plant; after the filling stage, the growth of corn was mainly reproductive. Mainly, the dry matter accumulation of leaves, sheaths, and stems did not increase significantly; after maturity, the dry matter accumulation of reproductive organs (female ears) increased significantly until it reached the maximum ratio of 52.73% -58.98%, however The dry matter accumulation of leaves, sheaths and stems of vegetative growth of maize was basically unchanged, or even decreased. This may be due to the yellowing of corn leaves during maturity, and the distribution of corn dry matter shifted from vegetative organs to reproductive organs. It can be seen that the change of maize growth center is the main factor affecting the dry matter accumulation and distribution ratio of the organs above ground.

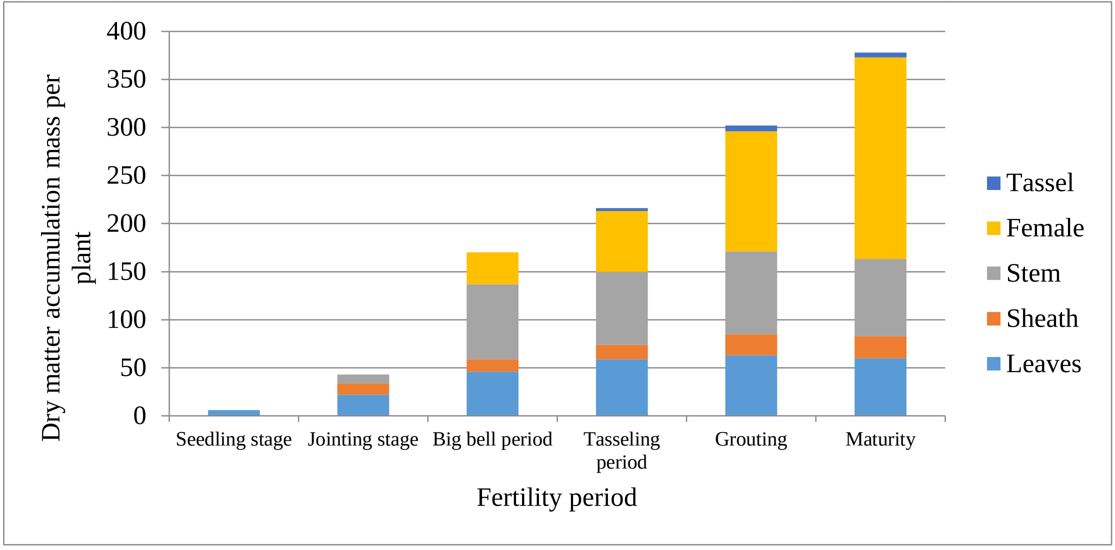

Figure 1. Effect of drip irrigation on dry matter accumulation in above-ground parts of corn

4.3. Effect of Drip Irrigation on Grain Filling Rate of Maize

It can be seen from Figure 2 that the grain filling rate of each treatment after pollination showed an upward trend and then a downward trend. From 7d to 28d after pollination, the grain filling rate of each treatment increased rapidly. By 28d after pollination, the grain filling rate of S treatment increased by 151.4%, C treatment increased by 183%, and CK treatment increased by 162% compared to 7d after pollination. The faster the grain filling rate, the higher the dry matter accumulation efficiency of the grain. Since the 28th day after pollination, the grain filling rate of corn began to increase slowly. The maximum grain filling rate of C treatment appeared at 28-35d, which was 0.99, while the maximum value of the grain filling rate of S treatment and CK treatment appeared at 35-42d after pollination. From 28d to 42d after pollination, there was no significant difference in grain filling rate between S treatment and C treatment, both between 0.95 and 0.98, and both were higher than CK treatment. After 42 days after pollination, the filling rate of each treatment began to slowly decrease, until 56 days, the filling rate of CK treatment decreased to 0.21, C treatment decreased to 0.41, and S treatment decreased to 0.53, of which S treatment decreased the slowest. Under drip irrigation conditions, the grain filling rate can be significantly increased, which will lead to an increase in 100-grain weight during maturity.

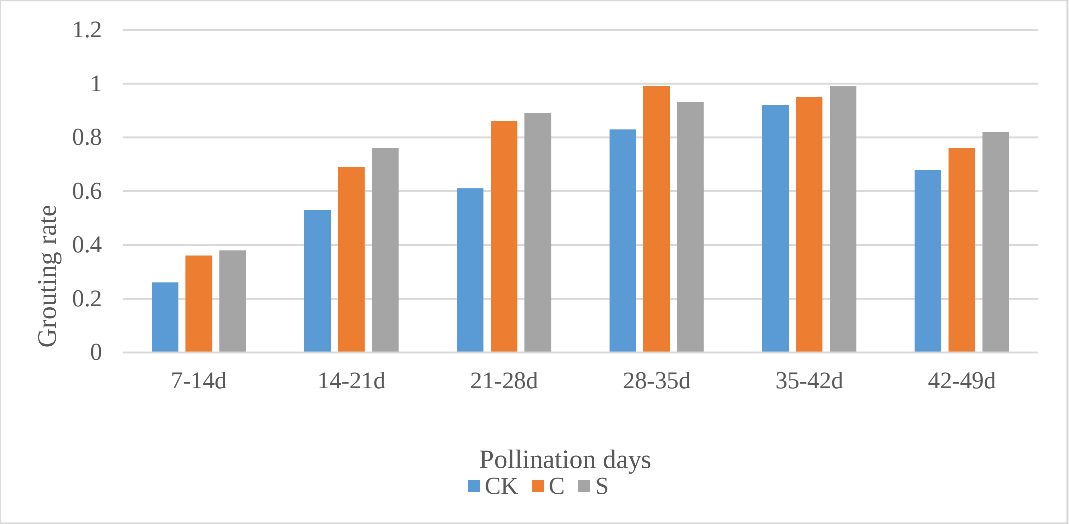

Figure 2. Effect of drip irrigation on grain filling rate of corn

4.4. Effect of Planting Density on Plant Height and Ear Height

It can be seen from Fig. 3 that the plant height and ear height of each maize are different under different planting densities. With the increase of planting density, plant height and ear height increased. However, the increase in plant height is relatively small under the conditions of low density of 60,000 plants / ha and 70,000 plants / ha, and under the high density of 80,000 plants / ha and 90,000 plants / ha, the increase in plant height between them is higher than that under high density Big. As the density increased from 60,000 plants per hectare to 80,000 plants per hectare, the plant height continued to increase, and the panicle height also increased. The analysis of variance showed that under the density of 90,000 plants / ha and 60,000 plants / ha, the difference in panicle height reached a significant difference ($P < 0.01$), while the difference in plant height was not obvious. This shows that as the population density increases, the competition among individuals within the group for light, temperature, water, and fertilizer is intensified. For better individual development, the individual plant height and ear height are continuously increased in order to obtain more light Energy resources, this is the instinctive response of plants to avoid each other.

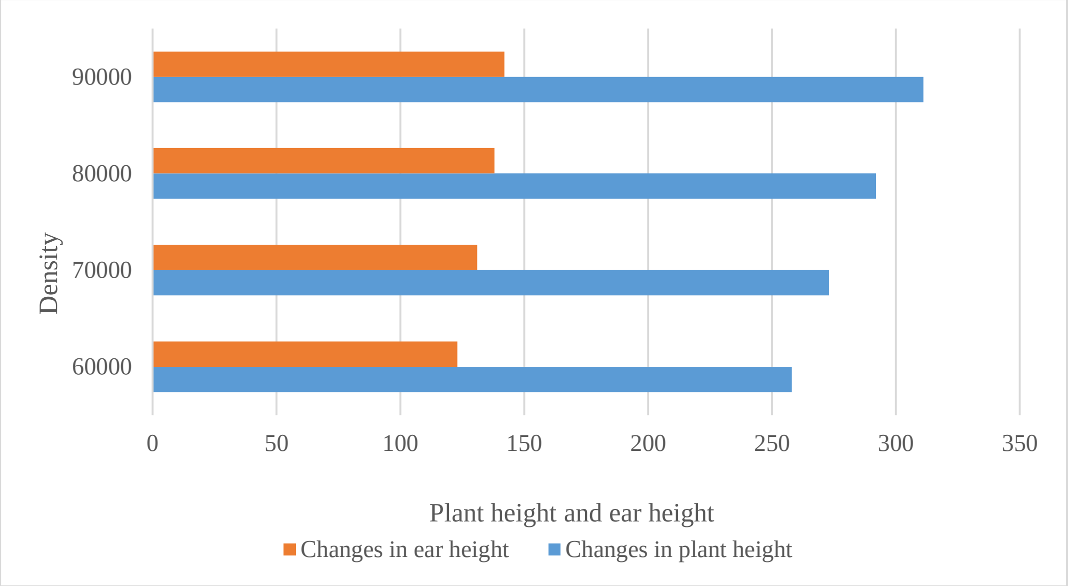

Figure 3. Plant height and ear height changes at different densities

4.5. Effect of Planting Density on Corn Canopy Structure

It can be seen from Table 2 that under the four density conditions, the average light energy interception rate of the lower layer of the leaves is 16% (60,000 plants / ha), 14.8% (70,000 plants / ha), 12.6% (80,000 plants / ha), 9% (90,000, plants / ha), the average light interception rate of the middle layer is 33.1% (60,000 plants / ha), 34.6% (70,000 plants / ha), 28.7% (80,000 plants / ha), 29.6% (900,000 Plants / ha), the average light energy interception rates of the upper layer are 41.6% (60,000 plants / ha), 44.5% (70,000 plants / ha), 51.3% (80,000 plants / ha), 55.6% (90,000 plants / ha), respectively. However, the average difference of the total light energy interception rate is not obvious, and the variation range is 90.7% -94.2%. It can be seen that as the planting density increases, the light energy interception rate of the upper layer also increases, while the light energy interception rate of the middle layer and the lower layer decreases, and the light energy interception rate of the upper layer and the lower layer changes greatly. There were significant differences between the treatments ($P < 0.05$). The light energy interception rate in the group is expressed as the upper light energy interception rate> the middle light energy interception rate> the lower light energy interception rate.The total light energy interception rate is higher than 90% at each density condition, especially at high levels. Under density conditions, it can still maintain a high light energy interception rate, which ensures the increase of photosynthetic radiation and is more conducive to the formation of grain yield. The total light energy interception rate increased first and then decreased under different density conditions. It was concluded that the planting density of corn reached its maximum under the condition of 80,000 plants / ha, and when the density increased further, the yield began to decrease.

Table 2. Effect of different planting densities on light energy interception rate during leaf filling stage

Density	Lower light energy interception rate (%)	Intermediate light energy interception rate (%)	Upper light energy interception rate (%)	Total light energy interception rate (%)
60000	16	33.1	41.6	90.7
70000	14.8	34.6	44.5	93.9
80000	12.6	28.7	51.3	92.6
90000	9	29.6	55.6	94.2

4.6. Comparison of Effects of Different Planting Environments

It can be seen from the comparison of the four planting modes, as shown in Figure 4 below. Under normal planting, the number of spike rows is 17.9, while the optimal density selected for different density plantings is unchanged, and the number of spike rows is 19.6. The number of spike rows in the drip irrigation planting model was 19.1, and the improved planting model in this paper had the number of spike rows of 20.3. On the 100-seed weight, under normal planting, the 100-seed weight is 47.6, and the optimal density selected for different density plantings remains unchanged. The 100-seed weight is 48.7, and the 100-seed weight of the drip irrigation mode is 49.1. The improved planting model in this paper has a 100-grain weight of 50.3. In terms of yield, under normal planting, the yield is 13.3268, while the optimal density selected for different density plantings remains unchanged, its yield is 13.8327, and the drip irrigation planting model is 13.5935. In the improved planting model in this paper, its The yield is 14.1568. In general, the improved planting model in this paper is superior to the other three planting models, followed by planting at different densities, followed by drip irrigation and normal planting.

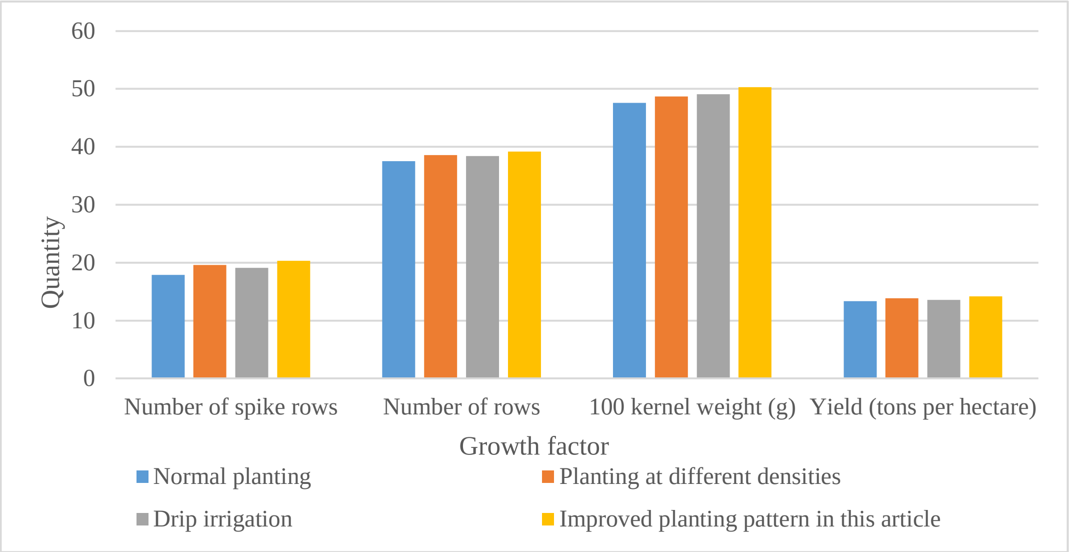

Figure 4. Comparison of effects of different planting environments

5. Conclusion

China is a country with insufficient water resources.However, China is also a large agricultural country. Agricultural water consumption accounts for 73.4% of the total water consumption, but China's water resource utilization rate is only about 40%. It can reach 80%. China's grain is far lower than the world's advanced agricultural technology countries, and the utilization rate of agricultural irrigation water is only half that of developed countries. This shows that China's agricultural water use is being greatly affected by the shortage of total water resources and the serious waste of irrigation water. Therefore, water-saving agriculture is an important requirement for the sustainable development of agriculture in our country, and it is also determined by the lack of water resources and imbalanced allocation of water and land resources in our agriculture. How to greatly improve the efficiency of agricultural water use is of great significance to solve China's water shortage.

In terms of methods, it is proposed to use the inverse ray tracing algorithm to calculate the light energy reflected and absorbed by the corn, and establish a model to analyze the sensitivity of the area, mainly in terms of leaf area index, temperature, and moisture to analyze corn yield. Establish a corn growth model, and construct it from four aspects: yield, photosynthesis, temperature, and moisture. Finally, comprehensive supplements were made, and planting conditions continued to be optimized at planting density. In terms of experiments, the meteorological data and soil parameters of the plantation site were investigated. Finally, the experiment was divided into four groups, one was for home planting; the other was for planting at different intervals, the other was normal; the three were for drip irrigation, and the other was normal. Four groups were planted using the improved strategies proposed in this paper.

It is concluded that under drip irrigation conditions, the grain filling rate can be significantly increased, which will lead to an increase in 100-grain weight during maturity. With the increase of the population density, the competition among individuals within the group for light, temperature, water, and fertilizer is intensified. For better individual development, the individual plant height and ear height have been continuously increased in order to obtain more light energy resources. This is the instinctive response of plants to avoid each other. It was concluded that the planting density of corn reached its maximum under the condition of 80,000 plants / ha, and when the density increased further, the yield began to decrease. The improved planting model in this paper is superior to the other three planting models, followed by planting at different densities, followed by drip irrigation and normal planting.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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