RESEARCH STATUS AND DEVELOPMENT TREND OF MECHANIZED STRAW RETURNING TECHNOLOGY. A REVIEW
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秸秆机械化还田技术研究现状与发展趋势综述

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ABSTRACT
As the application of agricultural mechanized production technology becomes more and more extensive, the application of mechanized straw returning technology has become more and more valuable. The mechanized return of straw to the field is a time-saving and labor-saving technology. It is an effective way to achieve sustainable agricultural development and is of great significance to the development and progress of modern agriculture. This article analyzes the current research status of mechanized straw returning to the field, discusses the process structure and characteristics of different mechanized straw returning methods, and focuses on the analysis of the composite technology of straw returning to the field. At the same time, the key problems of straw returning to the field, such as the length of straw not meeting the standard, the shallow depth of straw returning to the field, and the uneven distribution of straw, are put forward and analyzed. By taking the cover and burial rate of straw on the soil surface and the spatial distribution uniformity of straw in the soil as the performance evaluation indexes of straw mechanized field return, each index is elaborated. Finally, two major development trends are proposed: the development of mechanized straw returning to the field from a single process to a composite process, and the effect of straw returning to the field towards uniform mixed burying and precise control.

摘要
随着农业机械化生产技术的应用越来越广泛，秸秆机械化还田技术的应用也愈来愈变得有价值。秸秆机械化还田是是一项既省时又省力的技术，是实现农业可持续发展的有效途径，对现代农业的发展进步有着极为重要的意义。文章对当前秸秆机械化还田技术研究现状进行分析，探讨了秸秆不同机械化还田方式工艺结构与特点，重点对秸秆还田的复合工艺方式进行分析。同时，提出了秸秆长度不达标、秸秆还田深度浅以及秸秆分布不均匀等秸秆还田存在的关键问题，并对其展开分析。通过将地表秸秆的覆盖率与埋覆率以及土壤中秸秆的空间分布均匀性作为秸秆机械化还田的性能评价指标，并对其各指标展开阐述。最后提出了秸秆机械化还田由单一工艺向复合工艺发展，秸秆还田效果向均匀混埋和精准调控发展的两大发展趋势。

INTRODUCTION
The general term for the stems and leaves of crops after mature threshing is straw. The crop stalks in China are widely distributed, large in quantity, and diverse in variety. At present, the total amount of crop straw produced in our country each year is nearly one billion tons, accounting for about one-third of the total amount of straw in the world, ranking first in the world, of which corn, rice and wheat straw are mainly used. The total straw of these three major food crops accounted for nearly three-quarters of the total crop straw in the country (*Qiao, 2020; Zhao, 2019*). With the continuous improvement of the national economy, farmers' harvests are getting better and better, and the output of crop stalks is also increasing (*Chang, Bian, 2015*). The crop straw is rich in a lot of nutrients, which is a good fertilizer and renewable energy (*Xu, 2020*). The treatment of crop straw resources has always been an important issue in agricultural production. The existing treatment methods for crop straw resources are mainly picking up and bundling, burning and returning to the field. The way of picking up and bundling greatly increases operation and transportation costs, and incineration will pollute the environment and cause serious ecological problems. Therefore, returning straw to the field has become an effective way to rationally use straw resources (*Huang et al., 2021*). Returning straw to the field can effectively promote the maintenance of soil nutrients and is an important management method to increase crop yields (*Chen et al., 2017*).

Returning straw to the field can not only increase the content of soil organic matter and increase soil fertility, but also increase soil porosity, reduce soil bulk density, and improve soil permeability, which has important economic and ecological benefits (*Wang et al., 2013; Hu et al., 2012*).

RESULTS OF THE RESEARCH

STRAW MECHANIZED RETURNING TO THE FIELD BACKGROUND

Distribution of Crop Straw Resources in our Country

Due to China complex geographic environment, the distribution of crop straw resources also shows obvious regional differences (*Zhang, 2019*). Looking at the distribution of crop straw resources in our country, it shows a stepped distribution characteristic of "high in the east and low in the west, high in the north and low in the south". China's straw resources are mainly concentrated in the Northeast, North China and the middle and lower reaches of the Yangtze River. Among them, corn straws are mainly distributed in North China and Northeast China. The distribution of rice straw resources appears at two levels: the northeast region with Heilongjiang as the gradation center and the Jiangnan region with Hunan and Jiangxi as the gradation center (including the middle and lower reaches of the Yangtze River, southwest and southeast). Wheat straw resources are mainly concentrated in North China, with Shandong and Henan as the center, with short-term spreading from north to south, and extending to the west along the Hexi Corridor in depth. Except for the straws of the three major food crops, although the straw resources of other crops do not account for much, they also show obvious regional enrichment. More than half of the cotton straw resources are concentrated in Xinjiang. Among them, Shandong, Hebei, Hubei and other places in North China and the middle and lower reaches of the Yangtze River are also rich in cotton. North China is the main enrichment area of peanut straws, most of which are concentrated in the three provinces of Henan, Shandong and Hebei. The middle and lower reaches of the Yangtze River and the southwest are the areas where rape straw is enriched, and Hubei, Hunan and Sichuan are the most concentrated (*Cong et al., 2019*).

Biological characteristics of main crop straw

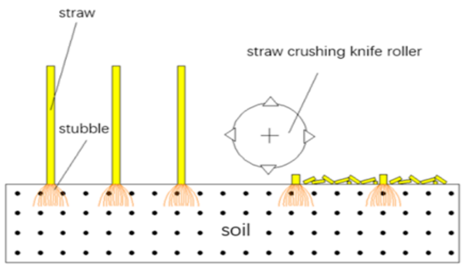
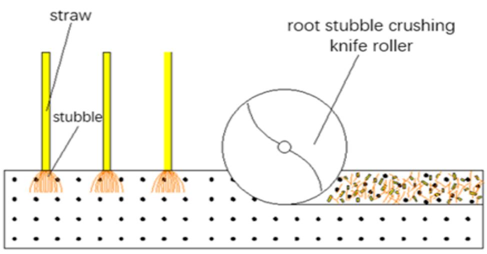
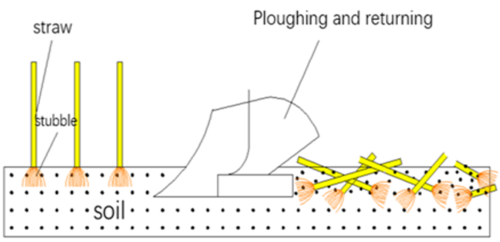
Corn straw is composed of roots, stems and leaves, of which the proportion of stems is the largest, and there are differences in different components (*Xu., 2019*). The potassium content of corn straw is about 2.28%, the nitrogen content is about 0.6%, the phosphorus content is 0.27%, and the organic matter content can reach about 15% (*Dai et al., 2019*). When the rice is harvested and threshed in the sun (the water content of the rice is not more than 16%), the total weight of the straw and the rice is basically 1:1, and the ratio between them is related to the water content and the height of the stubble at harvest. The rice is firm. There is a great relationship between rate and maturity, and there is no absolute value. Under normal circumstances, the stalks of wheat and rice are relatively thin and soft, and the above-ground parts generally have 5-6 nodes, which are large tortuous and elastic; while the stalks of maize are relatively tall, and the number of above-ground nodes can generally reach 17-18. The internodes are thick, hard, and not easy to break (*Li et al., 2019*). The stem of wheat stalk is hollow with only the outer skin layer, while corn stalk contains the middle layer, but the middle is the medulla part, which is lighter in texture (*Huo et al., 2012*). There are structural differences between rice straw and wheat straw. The cross section of rice straw is generally flat, and the cross section of wheat straw is basically elliptical, not standard cylindrical (*Guo, 2017*). The outer skin of rape stalks is dense and smooth, and has good air permeability. Under normal circumstances, the straw coefficient of rapeseed is 2.87, second only to cotton (3.0) among large-scale cultivated crops in my country, and higher than rice (1.00), wheat (1.17), corn (1.04), peanut (1.14), and beans (1.60) and other crops. Rapeseed has a large amount of straw, high grass-to-grain ratio, thick stalk, high stubble, dense and thick root system, and it is difficult to treat the root stubble（*Luo, 2013; Li, 2014；Zhang et al., 2014*）

WAYS OF RETURNING STRAW TO FIELD BY MECHANIZATION

Aiming at the mechanized return of straw to the field, at present, the main methods at home and abroad include straw directly smashed and returned to field, rotary tillage of stubble, crushing and returning, use of plowing to return to the field, whole straw burying and returning to field and so on (*Chief, 2007*). The technological structure and characteristics of different mechanized methods of returning straw to the field are summarized as follows:

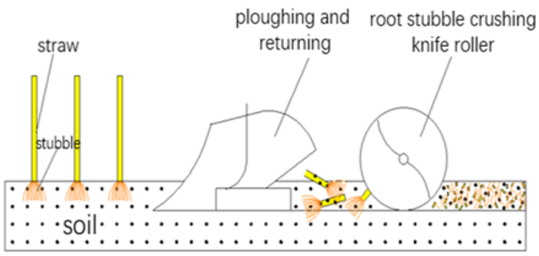
Table 1

Process structure and characteristics of different mechanized return methods of straw

The way	Process schematic	Structure chart	Features
Direct smash			The straw is crushed by a flinger or the straw is picked up and transported by a picker to a crushing roller to complete the crushing, and then thrown directly on the ground. The structure of the whole machine is simple and light. The length of chopped straws is less than 10 cm, but the straws are located on the ground and are piled up by wind. The distribution is uneven and the decomposition is insufficient, which is easy to cause the congestion of the seeding opener in the later stage (*Qiu et al., 2015*).
Rotary crushed			The root stubble and soil are cut, crushed, mixed and covered with a rotary tiller. It not only completes the return of straw to the field but also realizes soil plowing, the operation efficiency is high, but for the high-stalk and high-density straw such as rice, it is easy to cause the stalk entanglement of the knife shaft, and the problems of seeding, trenching, congestion, and seed beds (*Zhang, 2014*).
Plowing			The tractor is used to pull the plow to complete the soil buckle and straw burial. When the length of straw is less than the depth of plowing, the burial effect is significant, but when the length of straw is greater than the depth of plowing, the part of the straw that exceeds the depth of plowing stays on the surface of the adjacent soil and can't be buried. The root system is brought to the surface, which affects the construction of subsequent planting beds.

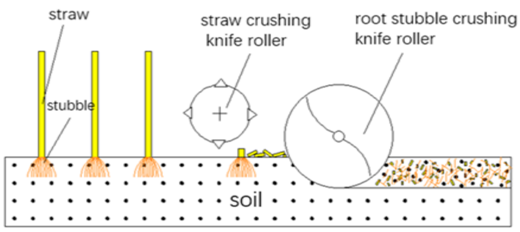
The way	Process schematic	Structure chart
	Features	

Plough and rotary tillage compound



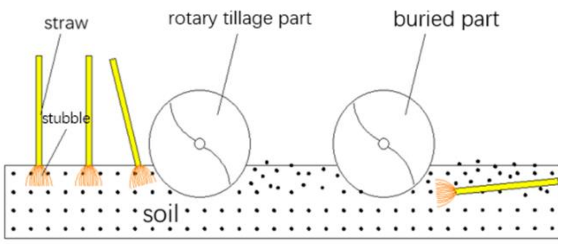
The turning and burying of soil and straw are realized by the plow, and the cutting and crushing of the soil and straw are completed by the rotary tillage tool. The advantages of large ploughing depth (below 20 cm) and good burying effect are brought into play, and the advantages of rotary tillage tools for crushing soil and roots and mixing are used, and the crushing and burying effect is good. The turning and disturbance of the soil by the split plough changes the mechanical properties of the soil and reduces the power consumption of rotary tillage and crushing (*Qin et al., 2016; Heinze et al., 2016*).

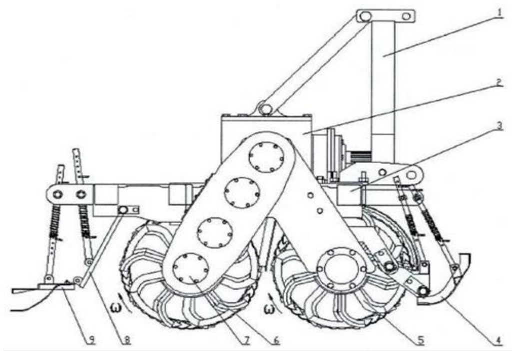
Crushing and rotary tillage compound



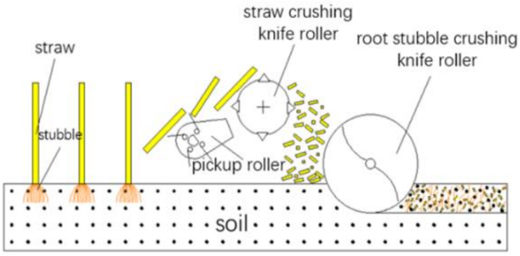
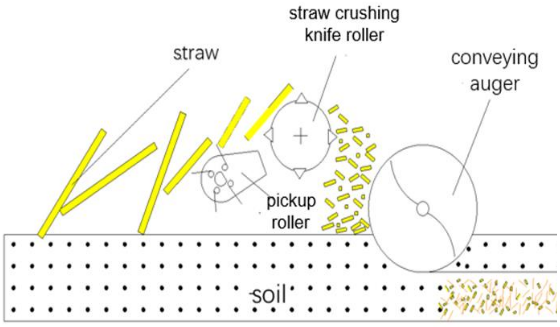
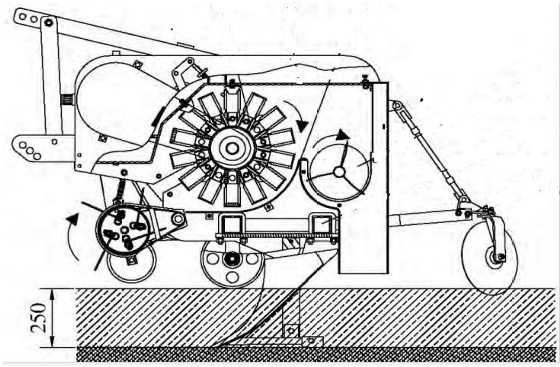
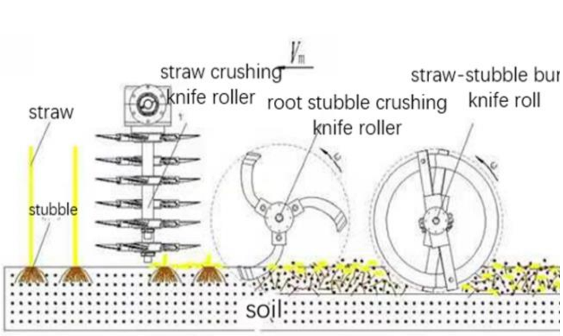
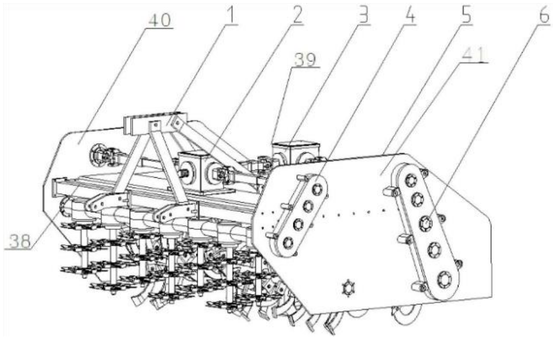
The straw is crushed by the scalpel, and the cutting, crushing and burying of the straw stubble and the soil are completed by the rotary tillage tool. Under the combined action of the straw crushing tool and the rotary tillage tool, the straw crushing length is smaller and the burial distribution is more uniform, which helps to improve the straw burial and decomposing effect.

Rotary tillage and mulching





The cutting and smashing of straw stubble and soil are completed by rotary tillage tools, and straw-soil mixing and burying are completed by burying rollers. It is especially suitable for returning high-stubble straws in paddy fields to realize the whole straw burial of rice straw with high burial rate.

<table>
<tr><th>The way</th><th>Process schematic</th><th>Structure chart</th></tr>
<tr><th></th><th colspan="2">Features</th></tr>
<tr><td>Picking up, smash, and bury</td><td>
</td><td></td></tr>
<tr><td></td><td colspan="2">The straw is picked up and transported to the crushing knife roller by a picker, and then crushed and thrown on the ground. Then the soil, stubble cutting, crushing and mixing are completed by a rotary cutter. This method uses a feed crushing knife roller to crush the straw. The length is short and uniform. Under the action of rotary tillage tools, the burial rate is high and the soil mixes evenly, which helps to accelerate the decomposition of straw, especially suitable for straw with large amount of straw and thick stalk.</td></tr>
<tr><td>Pick up and smash the ditch to bury</td><td>
</td><td>
</td></tr>
<tr><td></td><td colspan="2">The surface straw is picked up by the picker and transported to the crushing knife roller to complete the crushing, and the straw is conveyed through the churn to both sides of the compartment ditch deep burial, which solves the blockage of the opener and the seeds entering the soil during the subsequent sowing process. The unreal problem also has the function of "drainage ditch" and "retaining nitrogen".</td></tr>
<tr><td>Straw stubble crushing and burying</td><td>
</td><td>
</td></tr>
<tr><td></td><td colspan="2">The straw is crushed by vertical or horizontal straw crushing knives, the soil and root stubble are cut, crushed and mixed by rotary knives, and the straw-root stubble is mixed and buried in the soil by buried knife rollers. It is especially suitable for rape and other straw with high stubble, high grass to grain ratio and strong stalk. The special mixed burying knife roller improves the burying rate and uniformity of straw, and accelerates the decomposition of straw.</td></tr>
</table>

ANALYSIS OF THE KEY PROBLEMS OF MECHANIZED STRAW RETURNING TO THE FIELD

The purpose of returning straw to the field is to bury the decomposed straw, and the speed of decomposing is the key. Different methods of returning straw to the field have different rates of straw decomposing. Returning parameters such as straw crushing length, buried depth and straw distribution uniformity had significant effects on straw decomposition rate.

Straw length is not up to standard

Different crops have different characteristics of straw, but almost all satisfy the rule that the shorter the length of straw, the faster the decomposing rate. Yang Xuying found that rape straw with length less than 10 cm decomposed faster than that with length greater than 10 cm (*Yang, 2014*). Pang Lidan found that the decomposition rate of 3~5 cm corn straw was higher than that of 5~10 cm corn straw (*Pang, 2017*). Qian Feng proposed that for small crops such as wheat and rice, the crushing length of less than 15 cm is qualified, while the crushing length of sorghum and corn is less than 10 cm (*Qian, 2018*). For each crop straw, due to its different characteristics, the most suitable length of straw crushing after returning to the field needs further study. Relevant studies have shown that when the length of straw crushing is too long, it will affect the plowing effect of returning straw to the field, which will not only cause the soil to be overhead, but also lead to residual straw on the ground, which will affect the sowing and rooting of seedlings (*Dong, 2019*).

Shallow depth of returning straw to field

After the straw is buried and returned to the field, the decomposition of the straw mainly depends on the action of the microorganisms in the soil, and the microorganisms in the soil are mainly concentrated in the 0~10cm soil surface. Hu Hongxiang and others found that the decomposition rate of rice straw returning at 5cm depth was faster than that returning at 10cm depth and surface layer (*Hu, 2012*). If the straw is buried in the shallow layer of soil after returning to the field, the shallow layer of soil will be too loose, resulting in insufficient mixing of the straw and the soil, and the phenomenon of stacking of the straw, which will affect the quality of sowing. For paddy fields in South China, part of straw in shallow layer will float on the water surface, which seriously affects the quality of transplanting rice. Crop straw itself carries pathogens and pests. After straw returning, pathogens and pests will be buried underground. Straw returning depth is too shallow, which is more conducive to the survival and reproduction of diseases and pests. It will cause the continuous accumulation of diseases and pests in the soil, which is easy to induce diseases in the next crop and greatly affect the crop yield. Straw buried deep into the field can effectively improve the soil's ability to retain water, fertilizer and supply fertilizer, and it can also promote the distribution of roots, which is conducive to the growth of crops (*Liu et al., 2021*).

Uneven distribution of straw

After the straw is returned to the field, the amount of straw that can be decomposed per unit volume of soil is limited. Improving the uniformity of the straw distribution in the soil will help to further increase the decomposition rate of the straw (*Hu et al., 2012*). If the straw distribution is uneven, the phenomenon of stacking and clustering appears, the sowing will be uneven and the seed depth is different, which seriously affects the sowing quality. At the same time, the straw after returning to the field will affect the contact between the seed and soil after sowing, which will lead to the loose contact between the seed and soil, and then affect the rooting and germination of the seed. At present, the main performance parameters of the straw returning machine are the returning depth and burial rate. Obviously, this parameter cannot accurately and comprehensively reflect the characteristics of the decomposing rate. To this end, *Shi Yong* divided a certain volume of soil into units of the same volume, and measured the amount of straw in each unit to establish a straw burial uniformity evaluation system, and used different rice straw lengths (5 cm, 12.5 cm, 20 cm). Experiments show that the length of straw has a significant effect on the uniformity of burial, but the two do not show a simple positive correlation (*Shi, 2015; Li, 2020*). It can be seen that improving the uniformity of burial is very important to increase the decomposing rate, and the suitable length of straw crushing also needs further study.

PERFORMANCE EVALUATION INDEX OF STRAW MECHANIZED RETURNING TO FIELD

Coverage rate of ground straw

According to the positional relationship between the straw and the soil, the straw return operation can be divided into: straw on the soil surface (the straw is crushed and thrown directly on the ground), and the straw is under the soil (the plow opens the ditch to buckle the surface straw and the soil, and it is buried deep into the field.) And the straw and the soil are evenly mixed (the soil and the crushed straw are relatively evenly mixed by rotary tillage) (*Zhou et al., 2019*).

The mulch of ground straw can effectively maintain and improve the function of the soil (*Akhtar et al., 2019*). The state of the surface soil and the distribution state of the straw after returning the straw to the field are the main evaluation indicators for the quality of the straw returning to the field. The coverage rate of surface straw is recognized as an important technical indicator of conservation tillage technology. Coverage refers to the proportion of straw covering the ground in a unit measurement area. At present, there are many calculation methods for the surface straw coverage rate. The traditional method before is to use manual rope measurement, the calculation formula is as follows:

$$\mu = \frac{N_0}{N} \times 100\% \quad (1)$$

Among them: N_0 is the number of nodes with straw under the intersection of the rope and the rope; N is the number of the summary point of the intersection of the rope and the rope.

Although this method is relatively simple to operate, it is not accurate and labor-intensive. Nowadays, people are more inclined to use image processing technology to calculate the surface straw coverage, which is also the more accurate measurement method at present. However, when the number of straws is large, the distribution is uneven, and the overlap is serious, large errors will occur. At the same time, the color of some straws with more serious corrosion will be similar to the soil, which will also cause certain errors. Based on the existing image processing method, Li Jia, Lv Chengxu and others proposed an automatic recognition method of straw coverage combining fast Fourier transform and support vector machine, which can effectively solve the impact of real field complex environment on straw and soil recognition, with small measurement error and high performance (*Li et al., 2019*). Obviously, after the straw is returned to the field, the surface straw coverage rate cannot accurately reflect the quality of the straw returned to the field, so other indicators need to be evaluated and analyzed.

Burying rate of ground straw

At present, regardless of whether the straw is returned to the field for plowing or rotary tillage, the burial rate is an important indicator to measure the quality of straw returning to the field. After returning the straw to the field, by measuring the quality of the straw per unit area before and after ploughing at the sampling point, and then calculating according to formula (1), the burial rate η of the surface straw after returning the straw to the field can be obtained.

$$\eta = \frac{m_q - m_h}{m_q} \times 100\% \quad (2)$$

In the formula:

m_q is the straw mass per unit area of the sampling point before ploughing, g.

m_h is the straw mass per unit area of the sampling point after ploughing, g (*Wang et al., 2010*).

The current measurement of the burial rate of straw returning to the field is mainly calculated based on the change in the quality of the straw per unit area before and after the operation, which is also a more accurate measurement method commonly used at present. However, when the straws on the local surface are unevenly distributed and stacked on top of each other, there will be large errors in the measurement of the straw quality per unit area before and after ploughing. Therefore, the method of measuring the straw burial rate needs further research.

Spatial distribution uniformity of straw in soil

At present, there are many studies on the distribution of straw on the ground, but there are few studies on the spatial distribution of straw in the soil. Previous related studies mainly used stratified sampling to determine the mixing ratio of straw in each layer of straw, that is, the mass percentage of straw in the soil per unit volume was used as the evaluation index, without further exploring the true distribution of straw in the soil status. The uniformity of the spatial distribution of straw in the soil is the best reflection of the quality of straw returning to the field. Under normal circumstances, the burial rate is very limited in evaluating the burial uniformity and cannot be accurately reflected. For this reason, Chen Qingchun and Shi Yong etc. constructed the spatial distribution uniformity rate of the straw along the depth of the soil, the straw-soil mixing effect, and the surface flatness in the plough width to evaluate the quality of straw returning to the field, and used Pro-Engineering soft to show the space of the straw distribution status (*Chen et al., 2015*).

The uniformity of straw burial is determined by the spatial distribution characteristics of straw in the soil. Through the study of the distribution law of straw crushing, rotary tillage, burial and mulching, the spatial distribution uniformity of straw in the soil is further explored. Through field experiments, using the method of layered stripping measurement, collecting the three-dimensional coordinates of the two ends of the straw in the soil, the analytical formula of a certain section of straw in the soil can be obtained, and the spatial distribution state of the straw community in the soil can be mathematically analyzed (Fig. 1), furthermore, the spatial distribution characteristics of the straw community such as the position of the straw (indicated by the center point), the range of length and the ratio, the range and ratio of the three-way included angle, and the amount of straw per unit volume are analyzed.

(1) The position of the straw (indicated by the center point)

Assuming that there are n straws in the 1m^3 test field, the measured three-dimensional coordinates of the two ends of a certain section of straw are respectively: $a_1(x_{1_a}, y_{1_a}, z_{1_a})$ and $b_1(x_{1_b}, y_{1_b}, z_{1_b})$, the linear equation of this section of straw in space can be expressed as formula (3).

The coordinates of the midpoint of this section of straw can be calculated as: $c_1\left(\frac{x_{1_a}+x_{1_b}}{2}, \frac{y_{1_a}+y_{1_b}}{2}, \frac{z_{1_a}+z_{1_b}}{2}\right)$, that means the spatial position of the straw, by analogy, the spatial position of the nth straw can be obtained as: $c_n\left(\frac{x_{n_a}+x_{n_b}}{2}, \frac{y_{n_a}+y_{n_b}}{2}, \frac{z_{n_a}+z_{n_b}}{2}\right)$. By measuring the position of all the straws, the distribution status of the straws in the soil space can be roughly reflected.

$$\frac{x - x_{1_a}}{x_{1_b} - x_{1_a}} = \frac{y - y_{1_a}}{y_{1_b} - y_{1_a}} = \frac{z - z_{1_a}}{z_{1_b} - z_{1_a}} \tag{3}$$

(2) The range of length and the ratio

Knowing the three-dimensional coordinates of the two ends of n straws, the length of each straw can be obtained by formula (4), respectively denoted as l_1, l_2, l_3, $l_4 \cdots\cdots l_n$. Taking the straw length range as 0~5, 5~10, 10~15, 15~20 cm one can calculate the length ratio of each straw length range. The appropriate length of straw is very important for the decomposition of straw in the soil. By measuring the length of each straw and its range ratio, it is helpful to analyze the uniformity of the spatial distribution of straw in the soil.

$$l_n = \sqrt{(x_{n_a} - x_{n_b})^2 + (y_{n_a} - y_{n_b})^2 + (z_{n_a} - z_{n_b})^2} \quad (n = 1, 2, 3, 4 \cdots\cdots) \tag{4}$$

(3) The range and ratio of the three-way included angle

Measure the angle between each straw and the three coordinate axes of x, y, z, respectively denoted as: θ_{x_n}, θ_{y_n}, θ_{z_n}(n=1, 2, 3 …). The angles with the three coordinate axes are all on the side of ≤90°. For each coordinate axis direction, the angle range is: 0°~30°, 30°~60°, 60°~90°, the range and ratio of the angle between the straw and the three coordinate axes of x, y and z can be calculated. By measuring the three-way included angle of the straw, the state of the straw can be further accurately indicated. By analyzing the range and ratio of the three-way included angle of the straw, the approximate direction and inclination state of the straw after the rotary tillage operation can be known.

(4) The amount of straw per unit volume

Divide the test field into 64 square fields of equal volume, and measure the quality of all straws in each field and record it as: m_1, m_2, m_3......m_{36}, by comparing the straw quality of each field, it can clearly show the spatial distribution characteristics of the straw in the soil, and the more the fields are divided, the more obvious the spatial distribution characteristics of the straw. However, when dividing the fields, there will be certain touches on the stalks that are in or across the dividing line, and certain errors will inevitably occur.

According to the analysis characteristics of the straw soil distribution, one or more of the above-mentioned spatial distribution characteristics of the straw in the soil are used to evaluate the uniformity of the straw burial, and the relationship between the length of the straw and its distribution on the ground and the parameters of the crushing tool. The relationship between the medium spatial distribution and rotary tillage cutters and straw thrown length and distribution on the surface, and the relationship between the spatial distribution characteristics of the straw soil and the parameters of the burying components, and the system optimization of the parameters of each component to achieve as much as possible the adjustment of the straw burying distribution characteristics (such as Fig. 2) to improve the uniformity of burial.

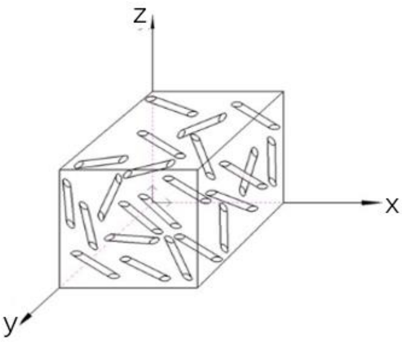


Fig. 1 - Real distribution of straw

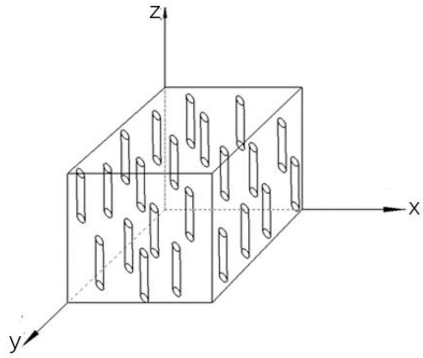


Fig. 2 - Ideal distribution of straw

THE DEVELOPMENT TREND OF MECHANIZED STRAW RETURNING TO THE FIELD

The development of straw returning from a single process to a composite process

Although returning straw to the field can decompose straw, increase soil organic matter, improve soil structure, promote microbial activity and the development of crop roots, and increase crop yields, too high a content of soil straw can also lead to ditching and clogging, improper seed beds, problems such as the increase of germs and the aggravation of crop diseases. How to increase the decomposing rate of straw returned to the field and reduce the impact of straw on the construction of planting and planting beds is the future development direction. Using cutting and crushing, uniform mixing, fixed depth burying, quantitative returning to the field, and adding decomposing agents to speed up the decomposition rate of straw, reducing the impact of straw on the opener and seed bed is an important goal of returning straw to the field. By comparing and analyzing the existing methods of mechanized straw returning to the field, it can be seen that the composite returning technology can integrate the advantages of a single returning technology, which is conducive to achieving the above goals and improving the effect of straw returning to the field. It is the future development direction of the mechanized straw returning technology.

The effect of returning straw to the field is developing towards uniform burial and precise control

The uniformity of straw burial is an important index to evaluate the quality of straw returning to the field. After the straw is mechanized and returned to the field, its spatial distribution in the soil directly determines the uniformity of the straw burial. Related studies have shown that the more uniform the spatial distribution of straw in the soil, the better the mixing effect of straw with the soil, and the higher the rate of straw decomposing in the soil. Reproducing the spatial distribution characteristics of straw in the soil and constructing a comprehensive scientific evaluation method for the quality of straw returning to the field is the key to improving the uniformity of straw returning to the field. In the future development of mechanized straw returning to the field, the realization of uniform mixing of straw and soil and the precise regulation of straw in the soil are the main means to improve the effect of straw returning to the field, and it is also an important direction for future research.

CONCLUSIONS

In the future development of agricultural production, the technology of mechanized straw returning to the field will certainly play a greater role. In the new era of continuous development of society, my country's research in the field of mechanized straw returning to the field requires more technological innovation. It is necessary to further increase the research on the composite multi-functional straw returning machinery, and on the basis of ensuring the safety and reliability of the operation and working efficiency, strive to realize the uniform burial of the straw and the soil, promote the decomposition of the straw, and promote the continuous development of the agricultural economy.

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