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Optimization and Preparation of Soil Mixture with Agricultural Residue Maize Stalk for Cultivating Maize Seedling

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ABSTRACT

In mainland China, maize is widely planted in large areas and maize yield ranks the second in the world. With increasing of people's living standards, the demand for crop quality is rising. Improving maize quality via new agronomic methods is the goal of the farming industry. Cultivating maize seedlings and transplanting them into farmland field is suitable in cold areas in the North of China because an early frost can be avoided, maize seedlings are stronger than those obtained with conventional method, and maize growth period is extended. However, a large amount of farmland soil is consumed via this method, thereby inevitably damaging farmland. On the other hand, maize stalks are one of the main by-products in the maize-growing region. The yield of maize stalk is high, but its utilization rate is low. Environmental damage due to burning maize stalk has attracted increasing attention. Exploring new methods to recycle maize stalks helps with energy conservation, emission reduction and sustainable development. To reduce environmental damage caused by consuming farmland soil in cultivating maize seedlings, and to allow recycling of maize stalks as an agricultural residue in great numbers, three tests were designed and conducted to obtain the best ratio of soil mixture with maize stalk for cultivating maize seedlings. The agronomic traits of maize seedlings such as plant height, stem diameter and dry weight were analysed. The proper materials were determined in the single-factor test, and the best ratio of soil mixture with maize stalk was obtained in the quadratic general rotary combination test, which was checked and verified by the verification test. Results demonstrate the best ratio of the soil mixture is farmland soil, maize stalk powder, phosphogypsum powder and ground charcoal at 1: 0.12: 0.71: 0.36. Analysis of agronomic traits of maize seedlings shows that the plant height, stem diameter and dry weight in the best group are significantly higher than those in the other groups, including the pure farmland soil group. This study provides a basis for preparing the soil mixture for cultivating maize seedlings and for exploring a new method for recycling maize stalk, which is of dual significance of decreasing damage to farmland soil and recycling maize stalks.

INTRODUCTION

Maize is one of the most widely planted crops throughout the world. In 2015, maize was planted in mainland China over 38 million hectares, which produced about 220 million tons of yield. Currently, increasing crop yield by increasing the planting area is not practical in China (Li et al. 2015b, Gao et al. 2016). New agronomic methods for increasing total grain yield and quality has proved to be effective when no land for planting additional maize is available. Traditional sowing method of maize is direct scattering seeds into soil. In recent years, a new method of cultivating maize seedlings in greenhouse and then transplanting them into farmland field was used in cold regions in the North of China. In 2015, the planting area of maize in Heilongjiang in the Northeast of China was about 6.7 million hectares, where the method has found an effective application. This method is an efficient technique for maize, because an early frost can be avoided, maize seedlings are stronger than those obtained via the conventional method, and maize growth period is extended, furthermore, its reliability was proven by agricultural experts after several years of practice (Wei et al. 2011, Zhou et al. 2014a). In the common method of cultivating maize seedlings, farmland soil is used. About 1 m^3 high-quality farmland soil is used for 667 m^2 maize field (Geng et al. 2002). Large amount of farmland soil is consumed for cultivating maize seedlings, which causes water and soil loss and environmental damage. Many experts and scholars are working on adding additives in the farmland soil and cultivating maize seedlings with soil mixture with different ingredients. Many research findings are available, but most focus on cultivating rice seedlings (Lin et al. 2015, Jin et al. 2014, Zhou et al. 2007, Song et al. 2013), and other researchers investigate in maize seedling transplanter (Zhou et al. 2014b, Zhang et al. 2012, Niu et al. 2014). No systematical reports on preparing soil mixture for cultivating maize seedlings are currently available.

On the other hand, as an agricultural residue, maize stalks are produced in large amounts. When the residue-to-product ratio was 1.25 for maize (Cai et al. 2011), the yield of maize stalks in China was about 275 million tons in 2015, under conservative estimation. Governments and farmers in maize-growing regions are challenged on how to dispose the huge amount of maize stalk (Shi et al. 2014). With the transformation of agricultural production mode and farmer lifestyle, maize stalk surplus has become a serious regional, seasonal, and structural problem. Thus, maize stalks are always discarded and burnt, which not only wastes resource, but also contaminates the environment, endangers traffic, triggers fire, and damages farmland ecosystem (Fang et al. 2015, Bao et al. 2014). Maize stalks can be recycled in several ways, such as returning to soil, used for generating clean energy, used for paper production, used as a source of alcohol and building materials, and used as a source of life energy for farmer (Liang et al. 2017). Cellulose, hemicellulose and lignin are present in maize stalk, which is permeable to air after ground. In recent years, some scholars have been investigating preparation of soil mixture with maize stalk to cultivate crops. Li et al. (2015a) studied the use of maize stalk as a suitable component of mixed substrate and as a part substitute for peat and vermiculite in cultivation of virus-free potato seedling. The favourable material and ratio for growth of virus-free potato seedling were determined. Meng et al. (2007) cultivated cucumber using maize stalk block without soil and proved that this method was feasible. Using the uniform design, Xia et al. (2011) optimized and analysed the preparation of maize stalk as substitutes to cultivate Lentinula edodes, and the dosage limit of maize stalk powder was determined. Zhang et al. (2015) investigated the influence of seedling matrix with maize stalk as the main raw material on rice seedlings, and a special seedling substrate with maize stalk for rice machine transplanter was successfully developed, and its use was proven reliable through experimentation. Zhang et al. (2008) studied the influence of new soil amendment on biological and vegetal characteristic of the summer maize, and the test results proved that the soil amendment with maize stalk helped with the growth of the summer maize. All these research works show that soil mixture added with a proper amount of maize stalk is appropriate for cultivating crop seedlings.

MATERIALS AND METHODS

Materials

Maize seed with the variety named Demeiya Number 1 was the specimen in the tests, which was widely planted in Daqing, Heilongjiang, the Northeast of China. Four industrial and agricultural by-products were beneficial to maize seedlings and were easily obtained. Thus, they were selected for test besides the farmland soil and the maize stalk powder. The four materials were phosphogypsum, ground charcoal, sawdust and coal gangue powder, which were bought from a nearby shop in Daqing. The farmland soil and maize stalk were picked from a maize field in Daqing Fourth Oil Production Plant. All tests were conducted in a mini greenhouse, as shown in Fig. 1. The plastic copulate tray was the container for cultivating maize seedlings, as shown in Fig. 2.

All of the materials were dried, ground and sifted by a sieve with 2 mm-diameter holes. The basic physical properties of all materials are presented in Table 1, and the chemical substance contents of all materials are shown in Table 2.

Methods

Three tests were designed to obtain the ratio of soil mixture with maize stalk for cultivating maize seedlings. The single-factor test aimed to find the most proper materials for maize seedlings except the farmland soil and the maize stalk powder. Subsequently, the quadratic general rotary combination test was designed and operated to determine the best ratio of soil mixture with maize stalk. Finally, a verification test was conducted to ensure that the best ratio of soil mixture from the quadratic general rotary combination test was correct and reliable.

All tests were operated in the mini greenhouse under the same condition. The temperature, humidity and illumina-

Fig. 1: Mini greenhouse.

Fig. 2: Plastic copulate tray.

Table l: Basic physical properties of all materials.

Material	Density (g/cm^3)	Total porosity (%)	Aeration porosity (%)	Water-holding porosity (%)	Gas-to-water ratio	pH
Farmland soil	0.85	61	12.4	48.6	0.49	5.97
Maize stalk powder	0.07	89	27.14	60.28	0.48	5.02
Phosphogypsum powder	0.75	50	13.54	36.46	0.37	6.42
Ground charcoal	0.51	66	20.5	45.5	0.45	8.21
Sawdust	0.18	87	18	69	0.26	6.93
Coal gangue powder	0.43	72	22	50	0.44	6.53

Table 2: Chemical substance contents of all materials.

Material	Nitrogen (mg/g)	Phosphorus (mg/g)	Potassium (mg/g)	Sodium (mg/g)	Copper (mg/g)	Zinc (mg/g)
Farmland soil	2.64	1.64	0.77	0.80	15.07	0.067
Maize stalk powder	5.64	3.45	1.26	2.49	20.32	0.115
Phosphogypsum powder	0	5.29	0.77	4.64	258.23	0.126
Ground charcoal	21.69	5.88	3.23	4.70	18.24	0.147
Sawdust	4.36	6.43	2.41	1.92	15.39	0.023
Coal gangue powder	5.29	4.13	2.69	3.43	14.72	0.078

Table 3: Material and ratio in single-factor test.

Group	Farmland soil (%)	Maize stalk powder (%)	Phosphogypsum powder (%)	Ground charcoal (%)	Sawdust	Coal gangue powder (%)
T1	67	33	0	0	0	0
T2	67	0	33	0	0	0
T3	67	0	0	33	0	0
T4	67	0	0	0	33	0
T5	67	0	0	0	0	33
CK	100	0	0	0	0	0

Note: The ratio is volume ratio for all groups. Group T1 to Group T5 were the soil mixtures with additives, and CK is control group consisting of pure farmland soil.

Table 4: Design test code in quadratic general rotary combination.

Coding	X_1 Farmland soil (g)	X_2 Maize stalk powder (g)	X_3 Phosphogypsum powder (g)	X_4 Ground charcoal (g)
+r(2)	126.4	55.0	89.4	15.6
1	94.82	33.8	67.0	11.7
0	63.2	22.5	44.7	7.8
-1	31.6	11.2	22.4	3.9
-r(-2)	0	0	0	0
Δj	31.6	11.2	22.4	3.9

tion simulated the actual circumstances in the greenhouse in spring before sowing. All samples were watered with the same volume once a day. Daytime temperature was about 20°C-25°C, and night temperature was > 10°C. When the temperature was > 30°C, the film of the greenhouse was rolled up for ventilation.

Single-factor test: To investigate the influence of each material on the growth of maize seedlings, the single-factor test was designed, in which the single material was mixed only with the farmland soil. The soil mixture was grouped into six with three repeats in each group, as shown in Table 3.

As shown in Table 3, the farmland soil to additive ratio is 3: 1. Before this test, farmland soil to additive ratios of 1: 1, 2: 1 and 3:1 were all tested. The 3: 1 ratio was deemed the best for maize seedlings because it led to the highest budding ratio and was thereby utilized for the single-factor test.

Quadratic general rotary combination test: The single-factor test was not enough to obtain the best ratio of soil mixture for maize seedlings. From the single-factor test, maize stalk powder was the best material for cultivating maize seedlings, and phosphogypsum powder and ground charcoal were also the proper materials for maize seedlings. Therefore, using farmland soil, maize stalk powder, phosphogypsum powder and ground charcoal, the quadratic general rotary combination test was designed. Maize seeds, soil, test apparatus and test condition were the same as those in the single-factor test. Four factors and five levels were designed in the test. Twenty-six different mass ratios were obtained for all soil mixture with three repeats in each group, and the test code is shown in Table 4, in which X_1, X_2, X_3, and X_4 are the dosage of various materials.

As presented in Table 4, the dosage of each material was determined by the volume of the cup in the plastic copulate tray. The design scheme of this quadratic general rotary combination is shown in Table 5.

Verification test: To check the best ratio of soil mixture for maize seedlings obtained from the quadratic general rotary combination test, the verification test was conducted. The best ratios were tested with fifteen repeats, and the control group of the pure farmland soil was also conducted with fifteen repeats.

RESULTS

Maize seedlings in the soil mixture grew slightly faster than those in pure farmland soil. For example, in the single-factor test, maize seeds budded in soil mixture Group T1 at 4 days after sowing, and maize seeds budded in pure farmland soil Group CK at 5 days after sowing. At 7, 8 and 10 days after sowing, one leaf, two leaves and three leaves and one bud were retained in maize seedlings in the soil mixture Group T1. Eleven days were required for maize seedlings to grow to the three leaves and one bud stage in the pure farmland soil Group CK.

Single-factor test: When the maize seedlings developed to three leaves and one bud, they could be transplanted into farmland fields. At this time, the agronomic traits of seedlings including plant height, stem diameter and dry weight were tested. Plant height was measured with a ruler, and

Table 5: Quadratic general rotary combination test design.

No. of group	Coding				Dosage			
	X_1	X_2	X_3	X_4	X_1 (g)	X_2 (g)	X_3 (g)	X_4 (g)
1	1	1	1	1	94.8	11.7	67.0	33.8
2	1	-1	1	1	94.8	11.7	67.0	11.2
3	1	1	1	-1	94.8	3.9	67.0	33.8
4	1	-1	1	-1	94.8	3.9	67.0	11.2
5	1	1	-1	1	94.8	11.7	22.4	33.8
6	1	-1	-1	1	94.8	11.7	22.4	11.2
7	1	1	-1	-1	94.8	3.9	22.4	33.8
8	1	-1	-1	-1	94.8	3.9	22.4	11.2
9	-1	1	1	1	31.6	11.7	67.0	33.8
10	-1	-1	1	1	31.6	11.7	67.0	11.2
11	-1	1	1	-1	31.6	3.9	67.0	33.8
12	-1	-1	1	-1	31.6	3.9	67.0	11.8
13	-1	1	-1	1	31.6	11.7	22.4	33.8
14	-1	-1	-1	1	31.6	11.7	22.4	11.8
15	-1	1	-1	-1	31.6	3.9	22.4	33.8
16	-1	-1	-1	-1	31.6	3.9	22.4	11.8
17	-2	0	0	0	0	7.8	44.7	22.5
18	2	0	0	0	126.4	7.8	44.7	22.5
19	0	0	-2	0	63.2	7.8	0	22.5
20	0	0	2	0	63.2	7.8	89.4	22.5
21	0	0	0	-2	63.2	0	44.7	22.5
22	0	0	0	2	63.2	15.6	44.7	22.5
23	0	-2	0	0	63.2	7.8	44.7	0
24	0	2	0	0	63.2	7.8	44.7	55.0
25	0	0	0	0	63.2	7.8	44.7	22.5
26	2	-2	-2	-2	126.4	0	0	0

Table 6: Agronomic traits of maize seedlings in single-factor test.

Group	Plant height (cm)	Stem diameter (mm)	dry weight (g)
T1	31.20	3.86	0.80
T2	22.80	4.02	0.75
T3	32.40	3.44	0.70
T4	18.30	3.22	0.50
T5	21.60	3.86	0.60
CK	17.30	3.06	0.45

stem diameter was measured with a vernier calliper. Dry weight of the plant was obtained by first washing the seedlings and then placing them into a drying baker at 105°C for de-enzyming. Subsequently, the temperature was maintained at 60°C until the dry seedlings were at constant mass. The agronomic traits of maize seedlings are presented in Table 6, which shows the test average result of the three repeats in the same group.

As shown in Table 6, the agronomic traits of the maize seedlings in Group T1 to Group T5 are all greater than those in Group CK, and those in Group T1, T2 and T3 are greater than those in Group T4 and T5. The data show that the mixture made up of soil, maize stalk powder or the other proper additives is helpful to maize seedlings. Thus, Group T1, T2 and T3 were selected for the following test. The additives are composed of maize stalk powder, phosphogypsum powder and ground charcoal.

Quadratic general rotary combination test: Excel 2003 and DPS 7.05 were used to analyze the data in this test. Average subordinate function method was used to analyze the agronomic traits of maize seedlings in each group. The formula of the subordinate function here is:

$$F_{ij} = (X_{ij} - X_{\min}) / (X_{\max} - X_{\min}) \quad ...(1)$$

Where, F_{ij} is the subordinate function of the agronomic traits of maize seedling of No. j in Group of No. i; X_{ij} is the average agronomic traits of maize seedling of No. j in Group of No. i; X_{max}, X_{min} are the maximum and minimum agronomic traits of maize seedling among all the groups, respectively.

The average subordinate function was calculated by averaging the subordinate function in each group. The agronomic traits of the maize seedlings and the average subordinate function are shown in Table 7.

As given in Table 7, the subordinate function of agronomic traits of maize seedlings in Group 25 is higher than that of the other groups, and all the subordinate function of seedling height, stem diameter and dry weight is 1.00, indicating that Group 25 demonstrates the best ratio for cultivating maize seedlings. In this group, the material consists of 63.2 g of farmland soil, 7.8 g of maize stalk powder, 44.7 g of phosphogypsum powder and 22.5 g of ground charcoal.

Verification test: In this test, the best proportion of Group 25 from the quadratic general rotary combination test was determined in fifteen repeats (G1 to G15) with the same number of pure farmland soil (CK1 to CK15), and the agronomic traits of maize seedlings are shown in Table 8. The mean value of agronomic traits of maize seedlings and the standard deviation are summarized in Table 9 and Table 10, respectively.

As presented in Table 9, all the agronomic traits of maize seedlings in Group G are greater than those in Group CK. Table 10 demonstrates that the standard deviation of plant height of maize seedlings in Group G is less than that of Group CK, but the standard deviations of stem diameter and dry weight in Group G are slightly greater than those in Group CK. Hypothesis testing is necessary to clarify whether the soil mixture is better than the pure farmland soil for cultivating maize seedlings. Assume all of the agronomic traits of maize seedlings follow the normal distribution, and the mathematic expectation and the variance of this normal distribution are unknown. First, the homogeneity of variance of the two groups is tested, and then the difference of the mean value of the two groups is determined. Taking the height of maize seedlings as an example, and the following hypothesis testing is performed:

(1) Test of the homogeneity of variance:

$$H_0: \sigma_1^2 = \sigma_2^2,\ H_1: \sigma_1^2 \neq \sigma_2^2$$

$$n_1 = 15,\ \bar{x}_1 = 18.16,\ S_1^2 = 1.6641$$

$$n_2 = 15,\ \bar{x}_2 = 16.06,\ S_2^2 = 2.4964$$

$$F = \frac{S_1^2}{S_2^2} = \frac{1.6641}{2.4964} = 0.67$$

When confidence is 95%, the non-confidence α-0.05=0.95

From F distribution, $F_{\alpha/2}(15,15) = F_{0.05/2}(15,15) = 2.86$

$F_{1-\alpha/2}(15,15) = 1/F_{0.05/2}(15,15) = 1/2.86 = 0.35$

$0.35 < F = 0.67 < 2.86$

Therefore, H_0 is accepted and H_1 is refused, and that is $\sigma_1^2 = \sigma_2^2$, indicating that the variance of these two groups is homogeneous.

(2) Test of the difference of the mean value:

$$H_0: \mu_1 \geq \mu_2;\ H_1: \mu_1 < \mu_2$$

Table 7: Agronomic traits of maize seedlings and average subordinate function.

No. of group	Agronomic traits			Subordinate function		
	Plant height (cm)	Stem diameter (mm)	Dry weight (g)	Plant height	Stem diameter	Dry weight
1	11.25	3.70	0.50	0.28	0.82	0.23
2	12.42	3.59	0.57	0.38	0.73	0.35
3	11.70	3.46	0.63	0.32	0.63	0.46
4	12.50	3.13	0.67	0.39	0.38	0.53
5	12.20	3.45	0.57	0.36	0.63	0.35
6	11.50	3.37	0.60	0.30	0.56	0.40
7	11.80	3.50	0.43	0.33	0.66	0.11
8	12.80	3.27	0.43	0.41	0.48	0.11
9	13.80	3.43	0.53	0.50	0.61	0.28
10	13.80	3.38	0.67	0.50	0.57	0.53
11	13.50	3.51	0.60	0.47	0.67	0.40
12	13.32	3.57	0.60	0.46	0.72	0.40
13	12.60	3.35	0.60	0.40	0.55	0.40
14	13.30	3.04	0.70	0.46	0.30	0.58
15	15.40	3.58	0.57	0.63	0.73	0.35
16	11.40	3.10	0.57	0.30	0.35	0.35
17	15.70	3.77	0.50	0.66	0.88	0.23
18	11.50	3.39	0.77	0.30	0.58	0.70
19	12.90	3.67	0.57	0.42	0.80	0.35
20	12.10	2.81	0.70	0.35	0.13	0.58
21	7.91	2.91	0.37	0.00	0.20	0.00
22	12.30	2.65	0.63	0.37	0	0.46
23	10.46	2.70	0.47	0.22	0.04	0.18
24	13.27	2.79	0.53	0.45	0.11	0.28
25	19.74	3.93	0.94	1.00	1.00	1.00
26	9.39	2.93	0.52	0.13	0.22	0.26

$$S_e^2 = \frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2} = \frac{(15-1)\times 1.6641+(15-1)\times 2.4964}{15+15-2}$$
$$= 2.08$$

$$t = \frac{\overline{x}_1-\overline{x}_2}{\sqrt{S_e^2(\frac{1}{n_1}+\frac{1}{n_2})}} = \frac{18.16_1-16.06}{\sqrt{2.08\times(\frac{1}{15}+\frac{1}{15})}} = 3.99$$

From t distribution, $t_{0.05}(15+15-2)=t_{0.05}(28)=1.70$

$$t = 3.99 > -t_{0.05}(28) = -1.70$$

Therefore, H_0 is accepted and H_1 is refused, that is $\mu_1 \geq \mu_2$. This result indicates that the height of maize seedling in the soil mixture is higher than that in pure farmland soil.

Where, H_0, H_1 are the Hypothesis 0 and Hypothesis 1, respectively;

$\sigma_1^2 = \sigma_2^2$ are the variance of plant height of maize seedlings in the soil mixture and in the pure farmland soil, respectively;

n_1, n_2 are the number of maize seedlings in the soil mixture and in the pure farmland soil, respectively;

$\overline{x}_1$, $\overline{x}_2$ are the mean value of plant height of maize seedlings in the soil mixture and the pure farmland soil, respectively;

S_1, S_2 are the standard deviation of plant height of maize seedlings in the soil mixture and the pure farmland soil, respectively, and S_1^2 and S_2^2 are their variances, respectively;

μ_1, μ_2 are the mathematical expectation of plant height of maize seedling in the soil mixture and the pure farmland soil, respectively.

The hypothesis testing result indicates that the plant height of maize seedlings in the soil mixture is much better than that in the pure farmland soil at 95% confidence. Furthermore, the stem diameter and dry weight of maize seedlings are the same with the plant height. All the hypothesis tests show that the agronomic traits of the maize seedlings in the soil mixture are remarkably better than those in the pure farmland soil at 95% confidence. Maize possesses different nutritional and mineral element requirements at various growth periods and requires additional phosphorus and zinc (Zhang et al. 2010, Liu et al. 2014). Thus, the additive containing phosphorus and zinc is helpful for maize seed-

Table 8: Agronomic traits of maize seedlings in the verification test.

No. of group	Plant height (cm)	Stem diameter (mm)	Dry weight (g)
G1	17.73	3.20	0.27
G2	17.87	3.70	0.26
G3	20.23	3.50	0.22
G4	18.67	3.90	0.26
G5	17.51	3.50	0.24
G6	20.81	4.10	0.29
G7	19.46	3.80	0.30
G8	17.40	2.90	0.28
G9	17.92	3.50	0.24
G10	18.86	3.60	0.24
G11	15.94	2.80	0.22
G12	16.92	2.70	0.25
G13	18.50	3.40	0.26
G14	17.06	2.90	0.28
G15	17.45	3.00	0.28
CK1	17.96	3.00	0.26
CK2	17.61	3.20	0.24
CK3	13.78	2.40	0.21
CK4	14.80	2.70	0.22
CK5	15.69	2.30	0.20
CK6	16.90	3.10	0.22
CK7	17.48	3.50	0.24
CK8	13.79	2.50	0.21
CK9	16.40	2.80	0.23
CK10	14.05	2.40	0.21
CK11	17.37	3.30	0.26
CK12	16.76	3.10	0.25
CK13	15.59	2.70	0.24
CK14	14.47	2.60	0.22
CK15	18.26	3.60	0.27

Table 9: Mean value of agronomic traits of maize seedlings in verification test.

Group	Plant height (cm)	Stem diameter (mm)	Dry weight (g)
G	18.16	3.37	0.26
CK	16.06	2.88	0.23

Table 10: Standard deviation of agronomic traits of maize seedlings in verification test.

Group	Plant height (cm)	Stem diameter (mm)	Dry weight (g)
G	1.29	0.43	0.024
CK	1.58	0.41	0.021

ling growth. According to Table 2 and the test results, Group 25 in the quadratic general rotary combination test contain the most proper element that maize seedlings require for growth.

CONCLUSION

Cultivating maize seedlings is suitable in cold areas in the North of China. However, a large amount of farmland soil is consumed in this method. To reduce consumption of farmland soil in cultivating maize seedlings and explore a new method of recycling maize stalks, three tests on soil mixture with maize stalk were designed and conducted, namely, the single-factor, the quadratic general rotary combination and verification tests. The agronomic traits of maize seedlings such as plant height, stem diameter and dry weight were analysed. The following conclusions could be drawn:

1. According to the single factor test of additive mixed with the farmland soil, the farmland soil to the additive ratio of 3:1 is the best ratio. Maize stalk powder, phosphogypsum and ground charcoal are helpful for maize seedling growth.
2. Based on the single-factor test, the quadratic general rotary combination test was designed with four factors and five levels for the soil mixture for maize seedlings. The agronomic traits of maize seedlings in the soil mixture are better than those in the pure farmland soil. In the best group, the dosage is 63.2 g of farmland soil, 7.8 g of maize stalk powder, 44.7 g of phosphogypsum powder and 22.5 g of ground charcoal. Therefore, the best ratio of soil mixture with maize stalk is farmland soil, maize stalk powder, phosphogypsum powder, and ground charcoal at 1: 0.12: 0.71: 0.36.
3. Using the best ratio of soil mixture with maize stalk obtained from the quadratic general rotary combination test, the verification test shows that the agronomic traits of maize seedlings are better than those in the pure farmland soil.

In this study, a method for the preparation of soil mixture with maize stalk was designed and tested. The method reduces farmland soil consumption in cultivating maize seedlings, and allows the recycling of maize stalks. It is environmentally friendly, low in carbon and sustainable to the environment. However, some problems still exist in this study. For example, the maize seedlings were tested, but their growing circumstances after being transplanted into the farmland field and the nutrition of the maize fruit are not tested. The farmland soil is black soil obtained in the Northeast of China, and the maize variety is Demeiya Number 1. Furthermore, the difference in various soil and different varieties are not considered. No organic fertilizer in the soil mixture is used in this research, but a certain amount of organic fertilizer commonly used in the soil mixture is utilized. The influence of organic fertilizer working together with the soil mixture on maize seedlings needs to be investigated. Therefore, further investigation on soil mixture with maize stalk is necessary to solve these problems.

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