

REGULAR ARTICLE

Effects of physicochemical properties of different substrates on characters and yield of maize

Xuejiao Ren, Jiabin Ci, Liangyu Jiang, Weiguang Yang, Wei Yang*

Faculty of Agronomy, Jilin Agricultural University, Changchun 130118, China

ABSTRACT

A reasonable method was used to analyze the effects of different substrates on the characters and yield of maize, and to improve the quality and yield of maize. The effects of the maize characters and yield of national Fluvo-aquic soil fertility and fertilizer efficiency monitoring base were analyzed from 6 aspects: fertilization and combined application, fertilization and density coupling, controlled release fertilizer (CRF), fertilization level, fertilization depth and proportion, and the amount of organic manure (chicken manure). Data processing is done by using Excel2003 and SPSS17.0 software, and multiple comparisons are made by using Duncan's new multiple range test method. The experiment of the influence factor of fertilization and combined application shows that the combination of NPK + organic fertilizer (constant and high) can increase maize character ratio and NPK + high-amount organic manure can increase maize yield. The experiment of the influence factor of fertilization and density coupling shows that the maize characters reached the optimum under the condition of high fertilizer. The yield of maize is highest when the density is 60000 plants/hm² and the amount of fertilizer is 10.71kg, 3.57kg and 8.93kg per 667m². The experiment of the influence factor of controlled release fertilizer shows that the characters of CRF V and CRF VI are the best. The control time of CRF III, CRF V, CRF VI, and CRF IV compound fertilizer is long, which can increase maize yield. The experiment of the influence factor of fertilizer level shows that the best character of maize is achieved by using the controlled release fertilizer of Agricultural University 450 kg/hm² and two-topdressing 600 kg/hm². In the process of corn production, the use of A-40 treatment (Volfertile controlled release fertilizer 600kg/hm²) and the one-time application of base fertilizer can increase the yield of maize. The experiment of the influence factor of fertilization depth and proportion show that the best combination is that seed fertilizer 20% urea, 40% diammonium phosphate and potassium sulfate were applied under the surface of 8cm and base fertilizer 40% urea, 60% diammonium phosphate and potassium sulfate were applied under the surface of 16cm. It can improve the character and yield of maize at the same time. The experiment of the influence factor of organic manure (chicken manure) shows that the amount of organic fertilizer (chicken manure) 26923kg per hectare with fertilizing 35kg per plot is the best amount of fertilizer, and the yield of maize increases. The proposed method can comprehensively and accurately analyze the effects of different substrates on the character and yield of maize, which can promote rational fertilization in maize and improve the quality and yield of maize steadily.

Keywords: Culture material; Physicochemical property; Maize; Character; Yield; Combined application

INTRODUCTION

The character and yield of maize are directly related to the development of agricultural production and the capacity of grain production. The use of the culture material greatly increased the grain yield. But with the increase of chemical fertilizer input year by year, the low utilization rate of chemical fertilizer and the decrease of grain output appear (Daya and Pant, 2017; Ashik et al., 2018). In the 1989-2002 years, the amount of chemical fertilizer increased by 84%, while the grain output increased by only 12%, which shows that the amount of fertilizer application is not consistent with the grain yield increase (Al-zaqri et al., 2017; Anzlovar et al., 2018; Danby et al., 2018; Liu and Liu, 2010;

Liu, 2017). According to the survey, the way of fertilization for farmers is based on split fertilization and one-off fertilization. In recent years, with the development of compound fertilizer technology and the restriction of rural labor force (Wang et al., 2014), the proportion of farmers with one-off basic fertilizer application has gradually increased (Khan, 2018; Atikuzzamman et al., 2018; Abdur Razzak et al., 2018). At present, there are great differences in fertilizer types, fertilizer levels, and application methods in maize production (Ahamed et al., 2018; Khaleel et al., 2018; McClements, 2018). There are widespread problems such as randomness, unscientific method, low utilization rate of fertilizer, large invest and low income of farmers and so on (Salem et al., 2014). Over the years, some scholars

***Corresponding author:**

Wei Yang, Department of Agronomy, Jilin Agricultural University, Changchun City 130118, China. **E-mail:** davidyoung588@126.com

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have done a lot of research on maize fertilization from the aspects of fertilization mode, fertilizer level, and fertilizer type (Ahamed et al., 2017; Girtler, 2017; Kim et al., 2018; Kylili et al., 2018; Mo et al., 2018; Sanchez Camacho and Martinez Morales, 2017). However, there are few reports on the character and yield of maize in terms of the time, proportion, and level of different fertilizers. In order to promote rational fertilization and improve the quality and yield of maize, the effects of different substrates on the character and yield of maize were studied in this paper.

MATERIALS AND METHODS

The test was carried out in the national Fluvo-aquic soil fertility and fertilizer efficiency monitoring base (Nazli et al., 2016). The base is located in Changping County of Beijing, with the altitude of 20m, an average annual temperature of 11 degrees, annual rainfall of about 600mm, drought in winter and rainy in summer, and two crops per year. Soil is Fluvo-aquic soil. The agrochemical properties of plough soil are: Organic matter 1.23%, pH value 8.82, total nitrogen 0.08%, total phosphorus P_2O_5 0.152%, total potassium K_2O 1.75%, available nitrogen 36.07mg/kg, available phosphorus P_2O_5 11.16mg/kg, available potassium K_2O 78.61mg/kg, and slowly available potassium K_2O 487.3mg/kg. The nutrient content of nitrogen and phosphorus is not high, and the soil is alkaline.

In this paper, the test and analysis were carried out in the national Fluvo-aquic soil fertility and fertilizer efficiency monitoring base (Lu and Sun, 2014). In order to make the test results more accurate, the effects of different substrates on the character and yield of maize were analyzed for different test areas (Oechsner, 2015). Excel2003 and SPSS17.0 software is used for data processing and multiple comparisons are carried out by using Duncan's new multiple range test method.

Analysis of effects of different substrates on the character and yield of maize

The test was carried out in the experimental plot of the base. The area is surrounded by concrete, with the depth of 1 meter and the area of $3m^2$ ($2 \times 1.5m$). 7 treatments are set up in the experiment. From the angle of the formation of maize character and yield, the effects of different substrates on maize character and yield were analyzed.

Test treatment

1. CK: No fertilizer.
2. NPK: Each area was applied urea 105g + potassium chloride 30g (urea $350kg/hm^2$ + calcium superphosphate $500kg/hm^2$ + potassium chloride $100kg/hm^2$) per quarter, and the amount of fertilizer determined according to the local fertilization standard.

3. NPK + common-amount organic manure: NPK chemical fertilizer + manure $4.5kg(15000kg/hm^2)$.
4. NPK + high-amount organic manure: NPK chemical fertilizer + manure $9kg(30000kg/hm^2)$.
5. NPK + common-amount wheat straw retention: NPK chemical fertilizer + crushed wheat straw $0.67kg(2333kg/hm^2)$.
6. NPK + high-amount wheat straw retention: NPK chemical fertilizer + crushed wheat straw $1kg(3333kg/hm^2)$.
7. NPK + maize straw retention: NPK chemical fertilizer + crushed maize straw $1kg(3333kg/hm^2)$.

Notes: In addition to applying chemical fertilizer and control treatment, several treatments of organic fertilizer were applied in the above fertilization treatments. The amount of common-amount organic material is based on local fertilization standard. Except control treatment, 6 fertilization treatments were designed and implemented according to the principle of equal nitrogen and phosphorus (Lidia and et al., 2014). Except for the content of nitrogen, phosphorus, and potassium in the organic materials, the insufficient part is replenished with NPK fertilizer, so that the total amount of nitrogen, phosphorus, and potassium is equal to the total amount of fertilizer. The test was repeated 4 times.

Analysis of effects of coupling of fertilization and density on character and yield of maize

For the phenomenon that the planting density is too thin or too dense and the amount of fertilizer is not reasonable, the effect of the coupling of fertilizer and density on the character and yield of maize is researched in this test (Brienzo et al., 2015), in order to provide reference for high yield and high efficiency cultivation of maize.

The experiment uses two-factor split-plot design, the main area is fertilizer factor with 4 levels, and the secondary area is planting density with 6 levels.

1. High fertilizer. Fertilization of pure $N21.42kg, P_2O_57.14kg, K_2O17.86kg$ per $667m^2$.
2. Medium fertilizer. Fertilization of pure $N15.0kg, P_2O_55.0kg, K_2O12.5kg$ per $667m^2$.
3. Low fertilizer. Fertilization of pure $N10.7kg, P_2O_53.57kg, K_2O8.93kg$ per $667m^2$.
4. No fertilizer.

Test treatment

Assume the density factor of the secondary area is B, includes 6 levels. B1~B6 are 37500, 45000, 52500, 60000, 67500, and 75000 plants/ hm^2 . The total number of treatments is 24 and repeated 3 times. Potash fertilizer and phosphate fertilizer as taken as base fertilizer. The amount of nitrogen fertilizer 20% is base fertilizer, the case of 20%

is seedling fertilizer and the case of 60% is bract fertilizer. The plant spacing is depended on density. Above 4 rows are set up for protection. After maturity, the middle 2 rows are harvested in each area, and the yield is measured and converted to the yield of the 14% standard water content. It is repeated 3 times to harvest all. 10 representative ears are taken for test in door. The herbicide measures in different areas are consistent with field management.

Analysis of effects of controlled release fertilizer on character and yield of maize

The effects of different controlled release fertilizers on the character and yield of maize were researched in this experiment, in order to screen out the best controlled release fertilizer that can increase yield, improve quality, and facilitate application.

Type of fertilizers for test

1. CRF I and CRF II are coated urea fertilizer produced in Beijing, containing 43% nitrogen.
2. CRF III is coated compound fertilizer produced in Zhengzhou. The ratio of N, P, and K is 19.4:8.69:9.49.
3. CRF IV is coated compound fertilizer produced by Shandong Agricultural University. The ratio of N, P, and K is 18:9:9.
4. CRF V and CRF VI are produced in Beijing. The ratio of N, P, and K is 13:5:10. The former is not coated, and the latter is coated compound fertilizer.
5. The ratio of N, P and K of the compound fertilizer is 16:16:16, and urea contains pure nitrogen 46%.

Test treatment: 9 treatments are set in the test: The 6 controlled release fertilizers of CRF I, CRF II, CRF III, CRF IV, CRF V, CRF VI and the 3 control groups of CK1, CK 2, and CK 3 .

The controlled-release fertilizer is used as a base fertilizer and applied with seeds at the same depth (Nguyen and et al., 2015). In order to avoid burning seeds, seed and fertilizer are separated 5~10cm. CK1, CK 2, and are the double controls of CRF I and CRF II, and CK 3, is the control of the CRF III, CRF IV, CRF V, and CRF VI. Specific amount of fertilizer application is shown in Table 1. Repeat 3 times. The planting density is 60 thousand plants/hm².

Analysis of effects of fertilization level on the character and yield of maize

In this test, the effects of fertilizer levels of different culture materials with similar cultivation conditions on the character and yield of maize were studied (Urrea-López et al., 2014), in order to promote scientific and rational fertilization of maize, improve the utilization efficiency of fertilizer, and provide theoretical guidance for improving maize yield of unit area. The test field has well irrigation

Table 1: Treatment of fertilizer application

Handle	Application amount
Control I	900
Control II	900
CK1	900 urea (base fertilizer)
CK2	450 urea (base fertilizer) +450 urea (big chasing)
Control III	1500
Control IV	1500
Control V	2070
Control VI	2070
CK3	750 compound fertilizer (base fertilizer) +330 urea (big chasing)

Table 2: Experimental treatment

Processing number	Type of fertilization	Amount of fertilizer(kg/hm ²)
A-30	FertilizerA	450
A-40	FertilizerA	600
A-50	FertilizerA	750
B-30	FertilizerB	450
B-40	FertilizerB	600
B-50	FertilizerB	750
C-30	FertilizerC	450
C-40	FertilizerC	600
C-50	FertilizerC	750
CK1-30	Primary fertilization	450
CK1-35	Primary fertilization	525
CK1-40	Primary fertilization	600
CK2-30	Two manuring	450
CK2-35	Two manuring	525
CK2-40	Two manuring	600

Fertilizer A is the controlled release fertilizer of wolf, N and P₂O₅ were 26%, 10% and 12%, respectively; Fertilizer B is Liaozhongjing compound fertilizer, N, P₂O₅ and K₂O were 26%, 10% and 12%, respectively; Fertilizer C is the controlled release fertilizer of Agricultural University, N, P₂O₅, K₂O and were 26%, 6% and 8%, respectively; Two amine phosphoric acid containing N 18%, P₂O₅ containing 46%; Urea containing 46%. A, B and C were treated with bottom fertilizer once; CK1 phosphoric acid two amine 225kg/hm² is used as base fertilizer once and urea as top dressing at a large bell stage; CK2 phosphoric acid two amine 225kg/hm² was used as base fertilizer once, urea as top dressing at jointing stage 1/2 and 1/2 at big bell stage

condition, and 15 treatments are set up, which is shown in Table 2.

The planting density of the tested maize was 67.5 thousand plants/hm². The length of the row of the test plot is 5m. The area has 6 rows. The test repeats 3 times and has randomized block arrangement. 4 rows of protection rows are set in the surrounding area of the test area. 10 ears were selected by using the average ear method for each treatment. The ear length, ear diameter, bald tip length, row number, row grain number, 100 grain quality and yield were determined. The steps of taking ear by average ear method are: The average fresh weight (FW) is obtained by of the ear weight of each plot divided by the number of ears. The fresh weight of each typical ear is selected close

to or equal to FW. 10 representative ears are marked for seed test.

Analysis of effects of depth and proportion of fertilization on character and yield of maize

The test treatment was divided into two parts: fertilization depth A and fertilization proportion B. The fertilization depth A sets 3 levels. A1 fertilization depth is 0, 8, and 16cm, A2 fertilization depth is 0, 10, and 16cm, and A3 fertilization depth is 0, 12, and 16cm.

The fertilization proportion B sets 3 levels.

1. B1: Fertilizer with sowing is 10% urea, 30% diammonium phosphate, and potassium sulfate. Base fertilizer is 50% urea, 30% diammonium phosphate, and potassium sulfate.
2. B2: Fertilizer with sowing is 20% urea, 30% diammonium phosphate, and potassium sulfate. Base fertilizer is 50% urea, 60% diammonium phosphate, and potassium sulfate.
3. B3: Fertilizer with sowing is 30% urea, 50% diammonium phosphate, and potassium sulfate. Base fertilizer is 30% urea, 50% diammonium phosphate, and potassium sulfate.

Each factor sets 3 levels, and 9 treatments are formed through orthogonal combination. The treatments from 1 to 9 are A1B1, A1B2, A1B3, A2B1, A2B2, A2B3, A3B1, A3B2, and A3B3. In addition, fertilizer is divided into three layers of seed fertilizer, fertilizer with sowing, and base fertilizer. 4 treatments are selected to test.

1. Treatment 10: Fertilization depth is 3, 8, and 16cm. Seed fertilizer is 10% diammonium phosphate, and potassium sulfate, fertilizer with sowing is 10% urea, 20% diammonium phosphate, and potassium sulfate, and base fertilizer is 50% urea, 70% diammonium phosphate, and potassium sulfate.
2. Treatment 11: Fertilization depth is 3, 10, and 16cm. Seed fertilizer is 10% diammonium phosphate and potassium sulfate, fertilizer with sowing is 10% urea, 20% diammonium phosphate, and potassium sulfate, and base fertilizer is 50% urea, 70% diammonium phosphate, and potassium sulfate.
3. Treatment 12: Fertilization depth is 3, 12, and 16cm. Seed fertilizer is 10% diammonium phosphate and potassium sulfate, fertilizer with sowing is 10% urea, 20% diammonium phosphate, and potassium sulfate, and base fertilizer is 50% urea, 70% diammonium phosphate, and potassium sulfate.
4. Treatment 13: Fertilization depth is 3 and 12cm. Seed fertilizer is 10% diammonium phosphate and potassium sulfate, and base fertilizer is 60% urea, 90% diammonium phosphate, and potassium sulfate.
5. Treatment 14 is a control group. Fertilization depth

is 0 and 12cm. Base fertilizer is 60% urea, 100% diammonium phosphate, and potassium sulfate. The control is applied to the whole fertilizer as the base fertilizer (Zhang et al., 2014). There is a total of 14 treatments, and 6 ridges per treatment. Ridge spacing is 1.1m, the length of the row is 10m, the area of each plot is 66m², and the test area is 924m².

In each treatment, 40% nitrogen fertilizer is retained for manuring before jointing (Pavlović et al., 2015). Before seeding, the fertilizer is packaged quantitatively with mechanical fertilizer and artificial seeding. When the maize has 2~3 leaves, deep loosening is carried out. The ploughing is carried out before jointing and 40% urea is applied. Artificial weeding is carried out during the growth period. The pure amount of fertilizer per hectare is N 67.5kg, P₂O₅ 45.0kg, and K₂O 26.2kg.

Analysis of effects of different amounts of organic manure (chicken manure) on character and yield of maize

The effects of organic fertilizer (chicken manure) on the character and yield of maize are analyzed. Organic manure is denoted as T. 7 treatments are carried out. T1: No fertilizer; T2: 15kg; T3: 20kg; T4: 25kg; T5: 30kg; T6: 35kg; T7: 40kg.

The area of the test area is 13m². Repeat 3 times. There are 4 rows, the length of the row is 5cm, the row spacing is 65cm, and the plat spacing is 30cm. Field investigation is carried out according to the experimental scheme in the whole process of maize growth (Shin and Jeong, 2014). Each plot is measured individually during harvest. All treatments adopt uniform cultivation management and control measures from grass damage.

EFFECTS OF PHYSICOCHEMICAL PROPERTIES OF DIFFERENT SUBSTRATES ON CHARACTER AND YIELD OF MAIZE

Effects of combined application of different substrates on character and yield of maize

The test results of effects of nitrogen, phosphorus and potassium fertilizer combined with different organic materials on the character and yield of maize are shown in Table 3 and Table 4.

$$LSD_{0.06} = 2887.4596, LSD_{0.01} = 3955.3100$$

Effects of fertilization and density coupling of different substrates on characters and yield of maize

The test results of effects of fertilization and density coupling of different substrates on characters and yield of maize are shown in Table 2 and Table 5. Table 6 shows the difference significance analysis of component factor of maize yield.

Table 3: Effects of different substrates on maize growth and development

Handle	1	2	3	4	5	6	7
Ear length(cm)	10.9	15.1	15.6	15.6	14.6	14.7	15
More than control%	-	38.5	43.1	43.1	33.9	34.9	37.6
Difference saliency							
0.05	b	a	a	a	a	a	a
0.01	B	A	A	A	A	A	A
Panicle girth(cm)	12.1	13.9	14.4	14.6	14.1	14.1	14.1
More than control%	-	14.9	19	20.7	16.5	16.5	16.5
Difference saliency							
0.05	b	a	a	a	a	a	a
0.01	B	A	A	A	A	A	A
Number of spikes	247	413	435	450	398	420	416
More than control%	-	67.2	76.1	82.2	61.1	70	68.4
Difference saliency							
0.05	b	a	a	a	a	a	a
0.01	B	A	A	A	A	A	A
100 grain weight(g)	19.8	23.9	25.9	26.6	25	24.9	24.5
More than control%	-	20.7	30.8	34.3	26.3	25.8	23.7
Difference saliency							
0.05	c	b	ab	a	ab	ab	b
0.01	C	B	AB	A	AB	AB	B

The LSD method was used to determine the difference significance.

Table 4: Effects of different substrates on Maize Yield (kg/hm²)

Handle	2012	2013	2014	X	Increase production than control(%)	Difference saliency	
						0.05	0.01
NPK+ high quantity organic fertilizer	16105.00	15570.84	17704.17	16460.00	147.6	a	A
NPK+ constant organic manure	15802.50	13920.83	16508.34	15410.56	131.8	ab	A
NPK+ high wheat straw	15888.33	12245.83	13471.67	13868.55	108.6	ab	A
NPK+ constant wheat straw	15200.00	11345.83	13945.84	13497.22	103.0	b	A
NPK	13579.17	10966.67	13812.5	12786.11	92.3	b	A
NPK+ corn stalk	11678.63	11408.34	14933.34	12673.44	90.6	c	B
CK	8909.50	4979.17	6058.33	6648.89	-		

Effects of controlled release of different substrates on characters and yield of maize

The test results of effects of the controlled release of different substrates on characters and yield of maize are shown in Table 7 and Table 8.

Effects of fertilization level of different substrates on characters and yield of maize

The test results of effects of fertilization level of different substrates on characters and yield of maize are shown in Table 9 and Table 10.

Effects of fertilization depth and proportion of different substrates on characters and yield of maize

The test results of effects of fertilization depth and proportion of different substrates on characters and yield of maize are shown in Table 11.

Effects of different amounts of organic manure (chicken manure) on character and yield of maize

The test results of effects of different amounts of organic manure (chicken manure) on character and yield of maize are shown in Table 12 and Table 13.

DISCUSSIONS

Discussions of effects of combined application of different substrates on character and yield of maize

NPK fertilizer combined with different organic materials has great effects on ear length, ear circumference, and grain number per ear (Robson et al, 2015). The difference of comparison of the 6 treatments of NPK, NPK+ organic fertilizer (common-amount, high-amount), NPK+ wheat straw retention (common-amount, high-amount), and NPK+ corn straw retention and the control group reach a very significant level. The effects of the treatments of

NPK+ organic fertilizer (common-amount, high-amount) are best. But there is no significant difference between 6 fertilization treatments.

6 fertilization treatments had obvious effects on increasing grain number of maizes. The grain number of the NPK+ high organic fertilizer treatment is highest, followed by NPK+ constant organic fertilizer treatment. The other treatments are close to NPK.

The 100-grain weight ratio of the 6 treatments increases significantly compared with the control group and the difference reaches a very significant level. The treatment of NPK+ high organic fertilizer has the best effect, and the difference reaches a very significant level compared with that of NPK treatment and NPK+ maize straw retention.

From Table 4, it can be seen that, NPK fertilizer combined with organic materials can play a positive role in improving

maize yield (Huang et al., 2014). Compared with the control, the difference reaches a very significant level. The productions of 4 treatments of NPK + organic fertilizer (common-amount, high-amount) and NPK + wheat straw retention (common-amount, high-amount) are more than double of the control.

Discussions of effects of fertilization and density coupling of different substrates on characters and yield of maize

From Table 14, it can be seen that, the effect of fertilizer factors on the plant character and ear character of maize has no significant difference on 1000-grain weight, and the influence on the other character reaches a very significant level. In the treatment of 4 fertilizers, the high fertilizer treatment is the highest in other indexes except that the height of the plant and grain number per row is second and the 1000-grain weight is the third. The effects of density on plant character and ear character are significant (Khila et al., 2016). With the increase of density, stem diameter, ear length, ear diameter, row number per row, row grain number, and 1000-grain weight are decreased. For B1 (37500 plants/hm²), these indexes are the highest. With the increase of density, plant height, ear position and barren tip are increasing. For B6 (75000 plants/hm²), these indexes are the highest.

From Table 6 and Table 5, it can be seen that, the coupling effect of fertilizer and density has significant difference in the interaction effect of barren tip, 1000-grain weight, and yield. There is a significant difference in yield between different levels of fertilizer.

1. Under high fertilizer condition, the yield of 67500 plants/hm² is the highest and the one of 60000 plants/hm² is the second, and there is no significant difference between 2 densities.
2. Under medium fertilizer condition, the yield of 60000 plants/hm² is the highest and the one of 52500 plants/hm² is the second, and there is no significant difference between 2 densities.
3. Under low fertilizer condition, the yield of 60000 plants/hm² is the highest and the one of 52500 plants/hm² is the second, and there is no significant difference between 2 densities.
4. Under no fertilizer condition, the yield of 45000 plants/hm² is the highest and the ones of 52500 and 37500 plants/hm² is followed, and there is no significant difference between 3 densities.

Table 5: Effects of fertilization and density coupling on yield of maize with different substrates

Fertilizer level	Density (plant /hm ²)	yield	Production and investment ratio
High fertilizer	67500	661.3aA	4.42
	60000	610.8abAB	4.08
	52500	580.4bcAB	3.88
	75000	566.4bcAB	3.79
	45000	565.4bcAB	3.78
	37500	524.1cB	3.50
Medium fertilizer	60000	589.2aA	5.63
	52500	569.9aAB	5.44
	67500	514.0bBC	4.91
	45000	506.4bBC	4.84
	75000	497.8bcC	4.76
	37500	455.6cC	4.35
Low fertilizer	60000	571.4aA	7.65
	52500	531.4abAB	7.11
	45000	494.0bcABC	6.61
	37500	465.8bcdBC	6.23
	67500	457.5cdBC	6.12
	75000	404.5cdBC	5.41
No fertilize	45000	465.6aA	
	52500	433.5abAB	
	37500	412.9abcAB	
	60000	382.4bcAB	
	67500	345.9cB	
	75000	335.4cB	

Corn price is calculated at 2.2 yuan /kg, and fertilizer cost is only included in the cost

Table 6: Difference significance analysis of maize yield components

Source of variation	Ear length	Spike width	Ear row number	Grain number	Alopecia apex	1000 grain weight	Yield
A	**	*			**	*	**
B	**	**	*	**	**	**	**
A×B					**	*	**

*** Indicates a significant difference. ** ** indicates a very significant difference.

Table 7: Effects of controlled release of different substrates on maize characters

Handle	Ear length(cm)	Increase or decrease(%)			spike width(cm)	Increase or decrease(%)			Seed yield(%)	Increase or decrease(%)			1000 grain weight(g)	Increase or decrease(%)		
		CK ₁	CK ₂	CK ₃		4.86	CK ₁	CK ₂		CK ₃	CK ₁	CK ₂		CK ₃	CK ₁	CK ₂
Control I	18.5	1.1	-2.1		4.86	-4.5	-5.3		86.8	-0.9	-0.6		262.1	-6.0	-15.4	
Control II	18.7	2.2	-1.1		4.94	-2.9	-3.7		86.9	-0.8	-0.5		280.4	0.6	-9.5	
CK ₁	18.3	0.0			5.09	0.0			87.6	0.0			278.8	0.0		
CK ₂	18.9		0.0		5.13		0.0		87.3		0.0		309.7		0.0	
Control III	19.7			1.0	5.10			-0.2	86.9			-0.1	309.7			
Control IV	19.3			-1.0	5.18			1.4	85.8			-1.4	312.5		3.5	
Control V	21.2			8.7	5.19			1.6	87.0			0.0	329.7		9.2	
Control VI	17.6			0.5	5.17			1.2	87.7			0.8	322.3		6.8	
CK ₃	19.5			0.0	5.11			0.0	87.0			0.0	301.9		0.0	

Table 8: Effects of controlled release of different substrates on maize yield

Handle	Average yield(kg/hm ²)	And CK ₁ ±(%)	And CK ₂ ±(%)	And CK ₃ ±(%)
Control I	7683.15	-9.2	-15.8	
Control II	8211.75	-2.9	-10.0	
CK ₁	8457.15	0.0		
CK ₂	9121.05		0.0	
Control III	9942.15			0.5
Control IV	9923.85			0.3
Control V	10696.20			8.1
Control VI	9930.90			0.4
CK ₃	9893.10			0.0

Table 9: Effect of fertilization level of different substrates on maize characters

Handle	Ear length (cm)	Spike width (cm)	Alopecia apex (cm)	100 grain weight(g)	Ear row number	Grain number
A-30	18.5Aab	5.17Aa	0.3Aab	34.2Aa	15.6Aab	38.7Bc
A-40	19.1Aa	5.20Aa	1.0Aa	34.4Aa	16.4Aab	40.7ABab
A-50	19.2Aa	5.20Aa	0.7Aa	34.2Aa	15.2Aa	41.7ABab
B-30	18.7Aab	5.18Aa	1.3Aa	35.4Aa	15.5Aab	41.0ABab
B-40	18.8Aab	5.33Aa	0.7Aab	34.4Aa	15.8Aab	42.0Aab
B-50	18.8Aab	5.16Aa	1.3Aa	34.6Aa	15.3Aab	41.0ABab
C-30	19.2Aa	5.22Aa	0.0Ab	34.7Aa	15.7Aab	41.3ABab
C-40	18.9Aab	5.24Aa	1.0Aa	34.8Aa	15.7Aab	40.3ABab
C-50	18.5Aab	5.15Aa	1.0Aa	34.3Aa	15.2Ab	40.1ABab
CK ₁ -30	18.8Aab	5.17Aa	1.3Aa	35.3Aa	15.1Ab	41.8ABab
CK ₁ -35	18.8Aab	5.21Aa	1.0Aa	35.3Aa	16.6Aa	40.9ABab
CK ₁ -40	18.2Aab	5.17Aa	1.3Aa	35.0Aa	16.2Aa	40.9ABab
CK ₂ -30	18.2Aab	5.17Aa	0.7Aab	34.2Aa	15.5Aab	40.5ABab
CK ₂ -35	17.9Ab	5.08Aa	1.0Aa	34.9Aa	14.9Ab	40.0ABab
CK ₂ -40	19.0Aa	5.25Aa	0.0Ab	35.3Aa	16.5Aa	43.0ABab

5. From the production to investment ratio, the production to investment ratio decreases with the increase of fertilizer amount. The amount of fertilizer with the best economic benefit is low fertilizer, the investment per 667m² fertilizer is 164.4 yuan, and the average production to investment ratio of 6 densities is 6.52. The next is the medium fertilizer, the investment per 667m² fertilizer is 230.3 yuan, and the average production to investment ratio of the 6 densities is 4.99. The worst is high fertilizer, the investment per

667m² fertilizer is 329 yuan, and the average production to investment ratio of 6 densities is 3.91.

Discussions of effects of controlled release of different substrates on characters and yield of maize

From Table 7, it can be seen that, CRF V and CRF VI have the best characters and CRF III and CRF IV are followed. The yield increasing effect of these two fertilizers is mainly on 1000-grain weight. The character of CRF IV is in general and close to the control (Barakat et al, 2014).

From Table 8, it can be seen that, different controlled release fertilizers have different effects on maize yield. The yield of CRF I is 5.5% and 2.4% higher than that of CK_1 and CK_2 , respectively. The yield of CRF II is 7.2% and 10.4% lower than that of and CK_1 , CK_2 respectively. The results show that the CRF II could not increase the yield of maize. The yields of CRF III, CRF IV, CRF V and CRF VI are 9.9%, 5.1%, 13.5%, and 7.2% higher than that of CK_3 , respectively. It shows that these 4 controlled release compound fertilizers have significant effect on the increase of maize yield. The yields of CRF I and CRF II are not better than those of CK_1 and CK_2 . The yield of CRF I is 9.2% and 15.8% lower than that of CK_1 and CK_2 , respectively. The yield of CRF II is 2.9% and 10.0% lower than that of CK_1 and CK_2 , respectively. It can be clearly seen that these two controlled release fertilizers can not only increase the yield of maize, but also greatly reduce the yield. The yields of CRF III, CRF IV, CRF V and CRF VI are 0.5%, 0.3%, 8.1%, and 0.4% higher than that of CK_3 , respectively. The increase

production effect of CRF I is the best. In general, the ratio of nitrogen, phosphorus and potassium of the 4 controlled release fertilizers of CRF III, CRF IV, CRF V, and CRF VI, is reasonable and the control time is long. As a one-off application of base fertilizer, it can meet the demand of fertilizer nutrition for maize growth and development (Shen et al., 2014). Therefore, compared with the traditional fertilization method, it saves time and effort, and can effectively increase the yield of maize.

Discussions of effects of fertilization level of different substrates on characters and yield of maize

From Table 9, it can be seen that, the ear length obtained with the treatments of the Volfertile controlled release fertilizer 600 and 750kg/hm², and controlled release fertilizer of Agricultural University 450kg/hm², and two-topdressing 600kg/hm² are higher than the treatment of two-topdressing 525kg/hm². The largest of the barren tip is the Liaozhongjing compound fertilizer 450 and 750kg/hm² and one topdressing 450 and 600kg/hm². The controlled release fertilizer of Agricultural University 450kg/hm² and two-topdressing 600kg/hm² show the best performance, without barren tip. The ear row number obtained with the treatments of Volfertile controlled release fertilizer 600kg/hm², one topdressing 525 and 600kg/hm², and two-topdressing 600kg/hm² is larger than the treatments of controlled release fertilizer of Agricultural University 750kg/hm², one topdressing 450 kg/hm², and two-topdressing 525 kg/hm². There is no significant difference between the other treatments. For grain number per row, the two-topdressing 600kg/hm² treatment is the largest, with 43 grains, and 4.3 grains per row more than the Volfertile controlled release fertilizer 450kg/hm² with the minimum number. The treatments of two-topdressing 600kg/hm², Liaozhongjing compound fertilizer 600kg/hm² and one topdressing 450kg/hm² are significantly

Table 10: Effect of fertilization level on yield of maize with different substrates

Handle	Yield(kg/hm ²)
A-30	11864.3cdBC
A-40	13546.0abA
A-50	12212.3cB
B-30	11657.5cdBC
B-40	12010.5cdBC
B-50	11342.4dC
C-30	11760.3cdBC
C-40	12370.5cB
C-50	11816.6cdBC
CK ₁ -30	11313.2dC
CK ₁ -35	12328.5cB
CK ₁ -40	11821.9csBC
CK ₂ -30	11423.7dC
CK ₂ -35	11998.0cdBC
CK ₂ -40	13925.1aA

Table 11: Effect of fertilization depth and proportion on yield and quality of Maize

Handle	Plant height(cm)	Ear position(cm)	Ear length (cm)	Spike width (cm)	Alopecia apex(cm)	Ear row number	Grain number	100 grain weight(g)	Number of plants (individual /m ²)	Yield (kg/hm ²)
1	263	90	16.9	4.8	0.9	16	27	31.8	8.4	11856
2	273	95	15.4	4.4	1.0	16	25	32.5	8.8	12081
3	262	88	17.3	4.7	0.7	16	31	33.1	8.5	13057
4	247	90	17.1	4.7	0.7	16	27	33.1	8.6	12156
5	246	90	16.8	4.8	0.7	16	29	33.1	8.5	13132
6	255	85	15.8	4.5	0.4	14	26	31.8	8.6	11406
7	253	86	14.7	4.5	1.0	14	25	31.2	8.5	11331
8	257	85	15.9	4.5	1.0	16	25	31.0	8.5	11256
9	261	82	15.9	4.5	1.1	14	25	30.5	8.5	10655
10	268	91	16.8	4.6	0.9	14	28	32.5	8.5	12006
11	253	92	16.7	4.8	0.5	14	26	33.5	8.5	11856
12	256	85	14.8	4.6	0.7	14	25	31.6	8.7	10355
13	247	90	15.9	4.6	0.6	14	27	32.2	8.5	11706
14	265	95	16.6	4.6	0.9	16	28	32.3	8.5	11406

Table 12: Effects of different amounts of organic manure (chicken manure) on maize characters

Handle	Plant height(cm)	Alopecia apex(cm)	Ear row number	Ear length(cm)	Number of spikes	100 grain weight(g)
1	291	1.9	16.4	17.1	619.7	38.1
2	307.8	1.2	17.1	17.3	630.9	39.9
3	307.4	1.3	17.2	17.6	623.6	38.6
4	301	0.9	17.3	16.8	621.3	39.5
5	310.0	1.0	16.9	17.5	633.0	40.3
6	313.4	0.5	17.4	19.8	653.5	41.2
7	303.0	0.8	16.8	17.4	595.1	38.9

Table 13: Effects of different amounts of organic manure (chicken manure) on maize yield

Material code	Plot yield			Average yield of district	Hectare yield
	I	II	III		
T ₁	12.4	11.95	13.31	12.67	9744.3
T ₂	12.73	15.3	14.82	14.28	10985.7
T ₃	15.91	13.85	14.38	14.71	11317.1
T ₄	15.35	13.93	14.52	14.60	11231.9
T ₅	14.44	15.63	15.13	15.07	11590.3
T ₆	17.63	14.15	14.15	15.53	11945.4
T ₇	13.95	14.55	13.78	14.09	10839.5

higher than those of Volfertile controlled release fertilizer 450kg/hm². The ear diameter of Liaozhongjing compound fertilizer 600kg/hm² is the largest, which is 5.33cm. The two-topdressing 525kg/hm² treatment is the smallest, with 5.08cm. The worst is 0.25cm. The largest of 100-grain weight is obtained with the treatment of Liaozhongjing compound fertilizer 450kg/hm², which is 35.4g. The minimum is obtained with the treatments of Volfertile controlled release fertilizer 450 and 750kg kg/hm² and two-topdressing 450kg/hm², which is 34.2g. The worst is 1.2g.

From Table 10, it can be seen that, the corn yield of CK₁₋₄₀ (two-topdressing 600kg/hm²) and A-40 treatment (Volfertile controlled release fertilizer 600kg/hm²) is significantly higher than that of other treatments. The corn yield of CK₁₋₄₀ is the largest, which is 13925.1 kg/hm². The corn yield of CK₁₋₃₀ (one topdressing 450kg/hm²) is the smallest, which is 11313.2 kg/hm². The two-topdressing is applied at the 2 stages of jointing and flare opening. It provides sufficient nitrogen fertilizer for the later stage of corn production, avoiding the phenomenon of removing fertilizer, and increasing the yield of maize. The yield of maize with A, B, C3 controlled release fertilizer and CK₁ (once topdressing) increased first and then decreased with the increase of fertilizer amount (Chen et al., 2015). The corn yield of CK₂ (two-topdressing) increased with the increase of the amount of fertilizer, thus increasing the yield of maize.

Discussions of effects of fertilization depth and proportion of different substrates on characters and yield of maize

From Table 11, it can be seen that, the yield of 1 and 2 levels of different fertilization depths are better. The yield

of three layers of fertilizer treatments is relatively high, and the 3 level of different fertilization depths shows poor performance. Different treatment designs have great influence on maize yield. The treatment combination with balanced design increased by 12% compared with the conventional fertilization method, and the treatment combination with unbalanced design reduced 9.2% yield compared with the conventional fertilization method. The different levels of fertilizer application rate varied with the depth of layer fertilization (Decaluwé et al., 2014).

According to the test results, different depth of fertilizer application is the main effect on yield. The interaction of the two factors is the secondary effect. The 1 and 2 levels (0, 8, 16cm and 0, 10, 16cm) of different depth of fertilizer application are conducive to yield increase. The 2 level (seed fertilizer: 20% urea, ammonium 40% phosphate, potassium sulfate, base fertilizer: 40% urea, 60% ammonium phosphate, potassium sulfate) of the factor of fertilization proportion is beneficial to the increase of yield of corn.

The effects of the 3 stages of the test were summarized (Wang, 2016). In the 3 levels of different levels of fertilization depth, the 1 level (0, 8, 16cm) and 2 level (0, 10, 16cm) are stable, and the 3 level (0, 12, 16cm) has lower treatment effect. In the 3 levels of different levels of fertilization proportion, the treatment effect of the 2 level (seed fertilizer: 20% urea, 40% phosphoric acid two amine, potassium sulfate, base fertilizer: 40% urea, 60% ammonium phosphate, potassium sulfate) and 1 level (seed fertilizer: 10% urea, 30% phosphoric acid two amine, potassium sulfate, base fertilizer: 50% urea, 70% phosphate two amine, potassium sulfate) is more stable. The stability of the 3 level (seed fertilizer: 30% urea, 50% diammonium phosphate, potassium sulfate, base fertilizer: 30% urea, 50% diammonium phosphate, potassium sulfate) is poor.

Discussions of effects of different amounts of organic manure (chicken manure) on characters and yield of maize

From Table 12, it can be seen that, from 6 indexes of plant height, barren tip length, ear row number, ear length, grain number per ear, and 100-grain weight, the treatment 6 is

Table 14: Effects of fertilization and density coupling on maize characters in different substrates

Factor level	Plant height(cm)	Ear position(cm)	Stem diameter(mm)	Ear length (cm)	Spike width(cm)	Ear row number	Grain number	Alopecia apex(cm)	1000 grain weight(g)
A1	299.9bB	134.8aA	22.75aA	17.0aA	4.58aA	13.8aA	35.5aAB	0.60bB	360.0aA
A2	309.8aA	132.1aAB	22.23aA	16.8aA	4.48bAB	13.1bB	35.4aAB	0.60bB	371.9aA
A3	298.1bB	127.5bB	20.47bB	15.9bB	4.44bBC	12.9bB	35.7aA	1.00aA	362.4aA
A4	293.6bB	119.0cC	19.12cC	15.3cB	4.34cC	13.1bB	34.0bB	1.08aA	358.4aA
B1	290.0bB	118.0dD	23.08aA	17.4aA	4.71aA	14.0aA	38.2aA	0.38dD	396.7aA
B2	291.8cBC	123.8cCD	22.60aAB	17.2aA	4.60bAB	13.9aA	37.1aA	0.43dCD	389.2aAB
B3	295.7bcBC	126.9bcBC	21.53bBC	16.4bAB	4.49cBC	13.6aA	35.2bB	0.67cdBCD	367.6bBC
B4	299.5bB	131.0bAB	20.85bcBC	15.9bcBC	4.41cdC	13.6aA	34.2bcB	0.85bcBC	360.0bcC
B5	307.6aA	132.5abAB	20.03cC	15.4cBC	4.33dCD	12.4bB	33.4cdBC	1.09bB	342.4cCD
B6	311.5aA	137.7aA	18.78dD	15.1cC	4.22eD	11.9bB	32.2dC	1.52aA	323.3dD

The difference between the lowercase letter and the English alphabet after the same column data is significant. The difference between the capital letters and the English letters indicates that the difference is very significant. Table 6 is the same.

better than other treatments. The plant height: $T_6 > T_5 > T_2 > T_3 > T_7 > T_1$, the barren tip length: $T_6 > T_7 > T_4 > T_5 > T_2 > T_3 > T_1$, the ear row number: $T_6 > T_4 > T_3 > T_2 > T_5 > T_7 > T_1$, the ear length: $T_6 > T_3 > T_5 > T_7 > T_2 > T_1 > T_4$, the grain number per ear: $T_6 > T_5 > T_2 > T_3 > T_4 > T_1 > T_7$, the 100-grain weight: $T_6 > T_5 > T_2 > T_4 > T_7 > T_3 > T_1$. The results show that treatment 6 is the best application rate of organic fertilizer, which can promote plant growth and development, enhance comprehensive resistance, and increase seed setting rate and grain capacity.

From Table 13, it can be seen that, the treatment 6 is more effective than other treatments in increasing production. The yield of corn increased by 12.74%~22.59% compared with that of no organic manure. The result shows that organic fertilizer plays an important role in improving soil fertility and satisfying the nutrient requirements of maize during the whole growth period.

CONCLUSIONS

In this paper, from the 6 aspects of fertilization and application, fertilization and density coupling, fertilization and controlled release, fertilization level, fertilization depth and proportion, and the amount of organic manure (chicken manure), the character and yield of maize in the national Fluvo-aquic soil fertility and fertilizer efficiency monitoring base are tested and analyzed. Excel2003 and SPSS17.0 software is used for data processing and multiple comparisons are carried out by using Duncan's new multiple range test method. The conclusions are obtained as follows: (1) Effects of combined application of different substrates on character and yield of maize. From 7 treatments and 4 repeated tests, it can be known that, the application of NPK+ organic fertilizer (common amount and high amount) can optimize the characters of maize. The application of NPK+ high organic fertilizer can increase the yield of maize. There is no significant

difference between other treatments; (2) Effects of fertilization and density coupling of different substrates on characters and yield of maize. From using two-factor split-plot design, 24 treatments and 3 repeated tests, it can be known that, under the condition of high fertilizer, the character of maize reached the best. The yield of maize is the highest for the density 60000 plants/hm² and the amount of fertilizer applied N10.71kg, P₂O₅3.57kg, K₂O and 8.93kg per 667m²; (3) Effects of controlled release of different substrates on characters and yield of maize. From application of 6 controlled release fertilizer and setting 9 treatments, 3 controls, and 3 repeated tests, it can be known that, the characters of CRF V and CRFVI are the best. The proportion of N, P and K of 4 kinds of controlled release fertilizers of CRF III, CRF IV, CRFV, and CRFVI is reasonable, and the control time is long. The one-off application of base fertilizer can meet the needs of maize growth and development for fertilizer nutrition. Therefore, compared with the traditional fertilization method, it saves time and effort, and can effectively increase the yield of maize; (4) Effects of fertilization level of different substrates on characters and yield of maize. By setting 15 treatments and 3 repeated tests, with 10 ears selected with the average ear method, it can be known that, the main reason for increasing grain yield is to choose a good fertilizer type, formulate reasonable fertilization level and fertilization method. It is suggested that A-40 treatment (Volfertile controlled release fertilizer 600kg/hm²) should be used in maize production process, and can be used as a base fertilizer to increase maize yield. The character of maize is the best by the treatment of the controlled release fertilizer of Agricultural University 450 kg/hm² and two-topdressing 600 kg/hm²; (5) Effects of fertilization depth and proportion of different substrates on characters and yield of maize. Orthogonal test was carried out on two factors of maize depth and proportion of fertilizer application. The test results show that, under the same amount of fertilizer application, different levels of fertilizer depth and proportion combination will form

different character types and yield results. The best combination method is seed fertilizer 20% urea, 40% ammonium phosphate and potassium sulfate applied to the subsurface 8cm, base fertilizer 40% urea, 60% phosphate, and potassium sulfate applied to the surface of 16cm. In addition, the 2 level of fertilization depth and the 1 level of fertilization proportion are better in the treatment, but the former can simultaneously improve the characters and yield of maize; (6) Effects of different amounts of organic manure (chicken manure) on character and yield of maize. Within certain fertilization level, maize yield increases with the increase of the amount of fertilization. Compared with no fertilization, the yield of maize is increased by 12.74%~22.59%. With the gradual increase of the amount of fertilizer, maize yield declined in the case of more than a certain level of fertilization. From the point of view of economic fertilization, the treatment 6 should be selected, that is, 35kg fertilizer per plot. Treatment 6 is the best amount of organic fertilizer, which can promote plant growth and development, optimize maize character ratio and enhance comprehensive resistance. The amount of organic manure (chicken manure) 26923kg per hectare is the best amount of fertilizer, which can increase the yield of maize. The relationship between maize yield and fertilizer amount is preliminarily understood through experimental research, which provides reference for rational fertilization in maize production. Comprehensive analysis of these conclusions can be concluded that the proposed method can comprehensively and accurately analyze the effects of different substrates on the characters and yield of maize, which can promote rational fertilization and improve the quality and yield of maize.

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