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Research Article

Effects of Sheep Manure Combined with Chemical Fertilizers on Maize Yield and Quality and Spatial and Temporal Distribution of Soil Inorganic Nitrogen

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In order to explore the influences of sheep manure mixed with chemical fertilizers upon the yield and quality of maize and the spatial and temporal distribution of soil inorganic nitrogen under the wheat-maize rotation system, achieve increased yield and efficiency with rational fertilization of maize in this area, and at the same time provide a reasonable scientific basis for green production, an experiment was performed at Wanbei Comprehensive Experimental Station of Anhui Agricultural University in 2020 accordingly. The soil for the experiment is sand ginger black soil, and the subject is Zhengdan 958. The experiment adopts a randomized block design with 6 treatments: no fertilizer (T1), single application of the chemical fertilizer (T2), 15% sheep manure mixed with the chemical fertilizer (T3), 30% sheep manure combined with the chemical fertilizer (T4), 45% sheep manure added with the chemical fertilizer (T5), and only sheep manure (T6). The amount of nitrogen, phosphorus, and potassium applied in each treatment remains the same. The result of the experiment shows that T1 treatment has the lowest yield, followed by T6 treatment. The yield of sheep manure combined with the chemical fertilizer is much higher than that of pure sheep manure and no fertilizer. Among them, the yield of T3 is the highest and T4 is the lowest. There is no obvious variation between the combined treatments. Compared with single usage of the chemical fertilizer, the fat content of maize kernels treated with T3 and T4 is 8.9% and 5.6% higher than that of T2 treatment. The protein content of maize kernels treated with T3, T4, and T5 is 2.3%, 2.5%, and 2% higher than that of T2. It shows that the mixture of sheep manure and chemical fertilizer can improve the quality of maize kernels in some degree. The partial productivity of the nitrogen fertilizer in T3 and T5 treatments is 3.7% and 0.8% higher than that of T2 treatment, and the agronomic utilization rate of the nitrogen fertilizer is 10.9% and 1.6% higher than that of T2 treatment. T6 is much lower than that of T2 treatment. It certifies that the combined application of chemical fertilizers with sheep manure can increase the partial productivity and the agronomic utilization rate of the nitrogen fertilizer and increase crop yields and farmers' income. The nitrate nitrogen of 40–60 cm soil layer is increased by 30.4%, 60–80 cm soil layer is increased by 56.5%, and 80–100 cm soil layer is increased by 11.6%. It shows that the mixed usage of organic and inorganic fertilizers can prevent nitrate nitrogen from moving to deep soil and reduce groundwater pollution.

1. Introduction

Chemical fertilizer used to be a booster of China's grain output. But as the amount of application continues to increase, it does not bring higher yields. While the utilization rate of the chemical fertilizer has been at a low level, many environmental problems have been caused. Excessive use of chemical fertilizers makes the nitrogen fertilizer that cannot be absorbed by plants undergo a series of dissociation in the soil to produce nitrate, nitrite, phosphate, and other anions. These anions will be repelled by soil colloids and will be immersed in water bodies through agricultural irrigation or natural rainfall. Entering into surface water will make it eutrophic, and entering into groundwater will cause it nitrate pollution. It is well known that nitrate has greatly harmful effect on the human body. And, using of chemical fertilizers in a long time will also have an impact on soil's physical and chemical characters. Some scholars have proposed that organic and chemical fertilizers should be combined. The ratio and amount of the two may be determined before fertilization, helping to maintaining soil nutrients' balance, reducing the loss of chemical fertilizers, and reducing pollution to the soil environment [1].

Soil is the basis of agricultural production. Applying the chemical fertilizer with organic one can improve soil moisture and other factors, increase organic matter content, maintain nutrient balance, and increase production [2]. In the circumstance of the wheat and maize rotation, the nitrogen in the soil is mainly nitrate nitrogen and ammonium nitrogen. Compared with only using of chemical fertilizers, the mixed application of organic and inorganic ones can prevent the downward migration of nitrate nitrogen and ammonium nitrogen and reduce nitrogen element leakage [3]. Consequently, this article is based on the experiment carried out in the Shajiang black soil area in the southern part of Huanghuaihai Lake, aiming to study the effect of sheep manure combined with chemical fertilizers on the migration of soil inorganic nitrogen and maize yield and quality so as to supply a theoretical basis for reducing groundwater pollution and realizing green production.

2. Related Works

Research by Kaur et al. [4] proved that the mixed application of organic and inorganic fertilizers may keep maize grain yield at a relatively high level. Maintang [5] used the liquid organic fertilizer combined with the organic fertilizer and concluded that 75% of the recommended amount of grain yield is higher than other treatments. A study by Wei et al. [6] observed that the combined application of organic and inorganic fertilizers has a remarkable yield-increasing effect on wheat yield. The application of chemical fertilizers can help crops maintain the normal redox potential of plants, form auxin, increase maize protein content, and improve its quality [7–9].

In terms of soil physical and chemical properties, research by Dermiyati [10] showed that the combination of organic and inorganic fertilizers could significantly increase soil pH, control soil acidity, and increase the possible phosphorus content in the soil, but the effect on soil total nitrogen and organic carbon content is not obvious. Through a two-year experiment, Hammad et al. [11] drew a conclusion that the mixed application of organic and inorganic fertilizers is necessary because it has a significant positive effect on improving soil fertility. Through a 10-year location experiment, Nisar and Benbi [12] found that the mixed application of organic and inorganic fertilizers can significantly reduce soil bulk density. The combined application of organic and inorganic fertilizers can improve the internal environment of the soil, increase the content of accessible nutrients in the soil, improve fertility, and supply sufficient nutrients for the increase of crop yields [13–15]. Research by Singh et al. [16] in the alluvial plains of India showed that the combined using of organic fertilizers and inorganic fertilizer amendments could not only remarkably increase the content of available nitrogen in the soil but also have a positive effect on increasing the content of calcium, potassium, phosphorus, and magnesium and improving fertility. Wang's research [17] also has the similar results.

One year after the application of nitrogen to wheat, 30% organic fertilizer instead of the chemical fertilizer is more conducive to improving the utilization of the nitrogen fertilizer, thereby increasing wheat yield. Some scholars [18, 19] have concluded that the mixed application of organic fertilizers and chemical ones in an intensive planting system can significantly reduce phosphorus and potassium runoff losses, maintain the balance of phosphorus and potassium, and increase the utilization of phosphorus and potassium fertilizers. Compared with conventional nitrogen fertilizers, the yield of maize and using efficiency of nitrogen could be increased by slow/controlled release of fertilizers [20, 21]. But since the excessive use of inorganic fertilizers, especially nitrogen fertilizers, the leaching effect of nitrate nitrogen in the soil has become more obvious, and serious groundwater pollution has occurred in many countries around the world [22–27]. Although the utilization of the organic fertilizer can also cause the growth of nitrate nitrogen, the application of organic matter can dynamically manage the soil and increase soil activity [28]. The substitution of organic fertilizers for chemical fertilizers can reduce environmental pollution and provide an important way to achieve the goal of zero growth in chemical fertilizer consumption [29, 30].

3. Materials and Methods

3.1. Test Site. The test was performed at the North Anhui Experimental Station (33°41′N, 117°04′E) of Anhui Agricultural University, Fuhu New Village, Yongqiao District, Suzhou City, Anhui Province. The test site is located in the Huaibei Plain, with a warm temperate semihumid climate having four clear seasons. The average annual sunshine time is about 2500 h, the annual average temperature is 15.7°C, and the rainfall is sufficient. The annual average rainfall is about 858 mm, and the frost-free period is about 210 days. The kind of the soil at the test site is Shajiang black soil, which is alkalescent, and the soil texture is sticky and heavy.

3.2. Experimental Design. The trial adopts a random block design with 6 treatments: no fertilizer (T1), single application of the chemical fertilizer (T2), 15% sheep manure mixed with the chemical fertilizer (T3), 30% sheep manure combined with the chemical fertilizer (T4), 45% sheep manure combined with the chemical fertilizer (T5), and single application of sheep manure (T6). The overall quantity of N, P, and K nutrients in the combined treatment is the same as the total amount of the single application of the chemical fertilizer, which is the nitrogen fertilizer: 240 kg/hm^2, phosphate fertilizer (P_2O_5): 120 kg/hm^2, and potassium fertilizer (K_2O): 240 kg/hm^2. Set 3 repetitions, the plot is 10 m long and 6 m wide, and the area is 60 m^2. The moisture content, total nitrogen, whole phosphorus and potassium of the maize season sheep manure were 55.21%, 1.756, 1.628, and 1.332 g/kg and 61.24%, 1.675, 1.324, and 1.178 g/kg, respectively. Table 1 shows the basic physical and chemical status of the soil before planting maize.

The maize variety tested is Zhengdan 958, which has uniform ears, thin shafts, deep grains, not bald, no hollow stalks, good resistance, and yield stability and is suitable for planting in summer maize areas in China. The organic fertilizer selected in the experiment is fermented sheep manure, and the inorganic fertilizer selected is diamine phosphoric acid, urea, and potassium oxide. Before planting maize, we use a rotary tiller to spin organic and inorganic fertilizers into the soil in a certain proportion. The remaining nitrogen fertilizer is topdressed with urea in the maize's bell mouth period (basic fertilizer: topdressing = 5 : 5). The planting density of maize is 55,500 plants/hm^2. The sowing date is June 22, 2020, and the harvest date is October 4, 2020.

3.3. Experimental Determination

3.3.1. Determination of Maize Yield and Quality. When maize is harvested, 10 maize plants are randomly selected from each of the 6 plots, and the number of grains per ear is counted. Then, they are placed in a prepared mesh bag, and after sun-dried and threshed, the grain weight and thousand-grain weight are weighed. And, the effective number of ears of maize in the plot is investigated, and finally, the theoretical yield of maize is obtained. For maize, 0.5 kg of grain samples were weighed for quality determination, and each sample was tested in three replicates to ensure the accuracy of the test. In order to determine the protein, fat, and starch content of maize kernels, this article uses PerkinElmer's product Perten DA 7200 for determination.

3.3.2. Determination of Soil Inorganic Nitrogen. The content of inorganic nitrogen in the soil (nitrate and ammonium nitrogen) was measured by taking a constant flow analyzer (Germany, AA3). Using the 5-point sampling method, which is to collect 0–20 cm, 20–40 cm, 40–60 cm, 60–80 cm, and 80–100 cm by using soil drills, the soil samples of 5 soil layers are milled and sieved after mixing to remove rocks, roots, and other impurities and kept in a refrigerator at −80°C. Put 10 g of each soil sample into a beaker, and add 50 mL of KCL extract during the experiment. Put it on a magnetic stirrer, and stir for about 30 minutes; then, after standing for 15 minutes, take 10 mL of the supernatant and immediately put it in the continuous flow analyzer detection. If it cannot be detected in time, it needs to be stored in a refrigerator at −80°C immediately. The storage time should not be too long; otherwise, it will affect the accuracy of the measurement results.

3.4. Statistical Analysis. Microsoft Excel 2010 and R4.0 software are used for the arrangement and charting of the test data. DPS7.05 software is used to analyze the variance used, and Duncan's new multiple range method is applied to check the significance of differences.

The agronomic effects of nitrogen are mainly decided by the partial productivity and the agronomic utilization rate of nitrogen fertilizers [31], and the calculation formulas are as follows:

Nitrogen partial productivity = grain yield in nitrogen application area/fertilizer nitrogen application amount.

Agronomic utilization rate of nitrogen fertilizer = (grain yield in the area where nitrogen is applied-grain yield in the area where nitrogen is not applied)/the amount of fertilizer nitrogen applied [32].

4. Results and Analysis

4.1. The Effect of Sheep Manure Combined with Chemical Fertilizers on Maize Yield and Quality. The using of the nitrogen fertilizer is crucial to maize ears' increase [33, 34]. It can be seen from Figure 1 that, in terms of maize ear number, T2 and T3 treatments are significantly higher than T1, T4, T5, and T6 treatments. It shows that the mixed application of 15% sheep manure with chemical fertilizers is the most beneficial for maximizing maize ears. With the increased proportion of sheep manure combined application, the number of ears per ear has a significant reduction process, and the T4, T5, and T6 treatments have no significant difference.

It can be seen from Figure 2 that, in terms of maize thousand-grain weight, T2, T3, T4, and T5 have unobvious difference, and from T2 to T6 treatments are all significantly higher than T1 treatments. It shows that compared to no fertilization, fertilization itself, regardless of whether organic fertilizer is added, helps to increase the thousand-grain weight of maize significantly [35, 36]. Among them, 15% sheep manure is the most effective. If the proportion of the organic fertilizer is increased, the 1000-kernel weight of maize will slightly decrease.

It could be concluded from Figure 3 that T1 treatment has the lowest yield, followed by T6 treatment. The yield of sheep manure combined with the chemical fertilizer is remarkably higher than that of nonfertilizer and pure sheep manure, but there is no significant variation with single using of the chemical fertilizer. Among the three combined treatments, T3 treatment has the highest yield and T4 treatment has the lowest. The yield difference among all the treatments is not significant. It can be seen that the combination of sheep manure and chemical fertilizers can help to achieve high crop yields to a certain extent.

Figure 4 shows that there is no significant variation in the protein, fat, and fatty acid between T3, T4, and T5 treatments and T2 treatment, and the starch content of T3 and T4 treatments is much lower than that of T2 treatment. The protein content of T6 treatment was significantly lower than that of T2, the fat and starch content of T6 treatment was not significantly different from that of T2 treatment, and the fatty acid content of T6 treatment was much higher than that of T2 treatment. The fatty acid contained in maize kernels treated with T3, T4, and T5 was 4.1%, 10.8%, and 11.1% lower than that of T2 treatment, the fat content of T3 and T4 treatment is 8.9% and 5.6% higher than that of T2 treatment, and the protein content of maize grains treated with T3, T4, and T5 was 2.3%, 2.5%, and 2% higher than that of T2.

Table 1: Basic physical and chemical status of the tested soil.

Treatment	pH	Organic matter (g/kg)	Available *P* (mg/kg)	Available *K* (mg/kg)	Total *N* (g/kg)	Total *P* (g/kg)	Total *K* (g/kg)	Bulk density (g/cm^3)
T1	8.33 ± 0.03c	16.83 ± 0.75d	4.71 ± 0.4e	152.47 ± 4.11c	1.27 ± 0.02c	0.57 ± 0.06c	13.73 ± 1c	1.46 ± 0.05a
T2	8.32 ± 0.06c	20.3 ± 0.46c	5.6 ± 0.25d	190.7 ± 4.35b	1.33 ± 0.03c	0.71 ± 0.01b	15.9 ± 0.47b	1.48 ± 0.01a
T3	8.35 ± 0.09c	20.7 ± 0.44bc	5.67 ± 0.1d	194.77 ± 2.09b	1.49 ± 0.06ab	0.79 ± 0.04ab	16.18 ± 0.18b	1.46 ± 0.02a
T4	8.39 ± 0.08bc	20.87 ± 0.25bc	7.68 ± 0.44c	195.6 ± 6.29b	1.43 ± 0.04b	0.8 ± 0.09ab	15.76 ± 0.66b	1.38 ± 0.01b
T5	8.47 ± 0.06ab	21.77 ± 0.85b	9.01 ± 0.39b	208.8 ± 5.99a	1.46 ± 0.04b	0.85 ± 0.06a	17.64 ± 0.59a	1.39 ± 0.03b
T6	8.52 ± 0.06a	27.3 ± 0.7a	12.1 ± 0.83a	217.97 ± 2.04a	1.53 ± 0.03a	0.88 ± 0.08a	18.62 ± 0.63a	1.35 ± 0.03b

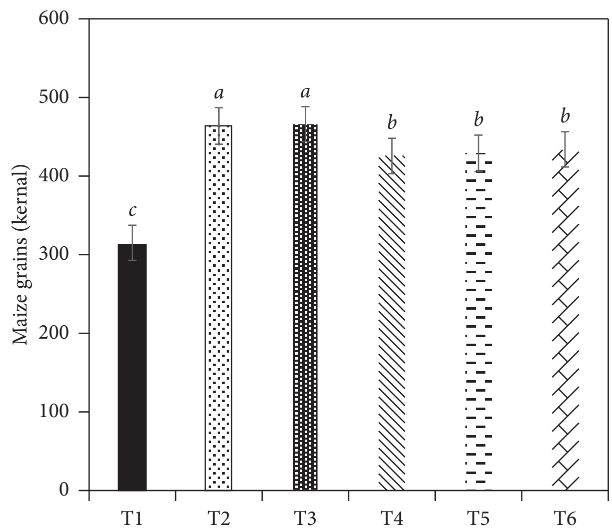

Figure 1: Effect of sheep manure combined with chemical fertilizers on the number of maize ears.

It could be concluded from Figure 5 that there is a reciprocity between maize yield and its quality variables protein, fat, starch, and fatty acid among which yield and protein content are highly positively correlated and starch and fatty acids are obviously positively correlated. There is a weak, but not significant, positive correlation between yield and fat content and protein and fat content. There is a significant negative correlation between fatty acid and yield and fatty acid and protein content, and there is a significant negative correlation between starch and fatty acid content, starch and yield, and starch and protein content.

4.2. The Influence of Sheep Manure Mixed with Chemical Fertilizers on the Agronomic Effects of Nitrogen. It can be seen from Figure 6 that the partial productivity and the agronomic utilization rate of the nitrogen fertilizer have similar regularities. In terms of nitrogen fertilizer partial productivity, T3 > T5 > T2 > T4 > T6. T3 treatment was 3.7% higher than T2 treatment. T5 treatment was 0.8% higher than T2 treatment, and T6 treatment was obviously lower than other treatments. There was no significant variation between sheep manure combined with the chemical fertilizer and single chemical fertilizer.

In terms of nitrogen fertilizer agronomic utilization, T3 > T5 > T2 > T4 > T6. There was no much variation between the treatment of sheep manure mixed with the chemical fertilizer and single chemical fertilizer. However, T3 treatment was 10.9% higher than T2, and T5 treatment was 1.6% higher than T2. T6 treatment was lower than other treatments, and the difference is significant.

The mixed application of sheep manure and chemical fertilizers can improve soil quality and promote the reproduction of soil microorganisms, especially nitrogen-fixing bacteria, ammoniating bacteria, cellulose-decomposing bacteria, and many other beneficial microorganisms. These beneficial microorganisms can decompose organic matter in the soil, increase soil particle structure, improve the ecological environment of crop roots, promote root growth, enhance root vitality, and improve crop tolerance to waterlogging. When applying the sheep manure organic fertilizer, the beneficial biological activity improves the soil structure, improves the soil's quality to hold water and fertilizer, and reduces the loss of nutrients. Moreover, the beneficial microorganisms dissolve phosphorus and potassium. It may increase the competent utilization rate of fertilizers to more than 50%. All the above are beneficial to the further improvement of nitrogen fertilizer utilization efficiency.

4.3. Spatiotemporal Evolution of Soil Inorganic Nitrogen Content under the Combined Application of Sheep Manure and Chemical Fertilizers. As shown in Figure 7, during the period of maize seedling, the ammonium nitrogen content of 0–80 cm soil layer decreased in T1, T2, and T6 treatments.

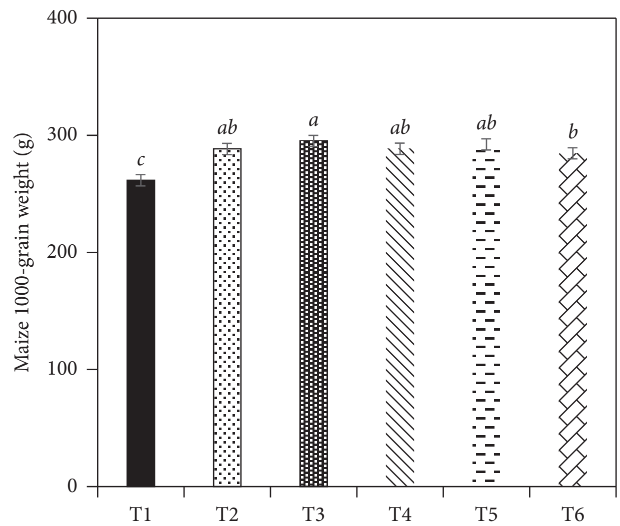

Figure 2: Effect of sheep manure combined with chemical fertilizers on thousand-grain weight of maize.

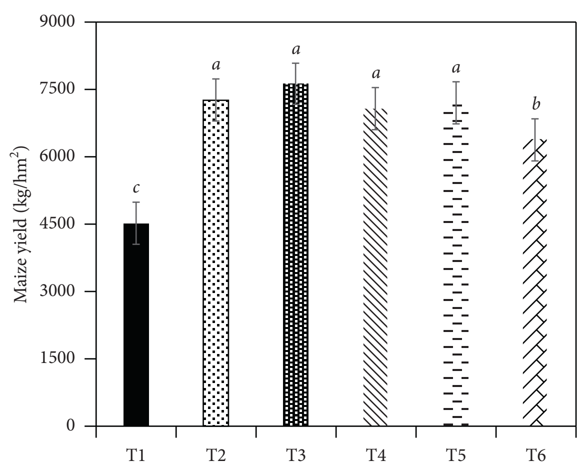

Figure 3: Effect of sheep manure combined with chemical fertilizers on maize yield.

T3 treatment 0–20 cm soil layer content decreased, while 20–80 cm soil layer ammonium nitrogen content increased. T5 treatment rises in the 0–40 cm soil layer and descends in the 40–100 cm soil layer. In T5 treatment, during the growth period, the 0–40 cm soil layer rises, the 40–80 cm soil layer decreases, and the 80–100 cm soil layer rises. From the seedling state to the jointing state, each treatment has a different range of increase in the 0–100 cm soil. From jointing to tasseling stage, it may be that, with the increase of temperature and precipitation, the ammonia volatilization rate was increased, and the ammonium nitrogen content of each treatment decreased, and the range of decreasing for T2–T6 treatments was 22.4%, 22.1%, 30.1%, 2.3%, and 25.3%, respectively.

From the tasseling stage to the powder-spreading stage, the T2 treatment changed most drastically. The decreasing amplitudes of the soil layers in the 0–100 cm soil were 43.9%, 52.5%, 42.3%, 13.1%, and 41.9%, respectively. From the loose powder stage to the grouting stage, the ammonium nitrogen contained in the 0–20 cm soil layer acted by each treatment all decreased. The possible reason is that the evaporation of water vapor caused volatilization of ammonia, and then, the ammonium nitrogen content decreased [37]. At the same time, during this period, the reproductive growth of maize replaced vegetative growth, and its ability to absorb nitrogen was stronger, which also led to a further decline in ammonium nitrogen content. From the filling state to the maturity stage, ammonium nitrogen content of each treatment group still had a downward trend. In the 0–20 cm soil interval, the decrease rate of T2 treatment was 40.7%, T3 treatment was 33.9%, and T6 treatment was 26.2%. From the filling state to the maturity stage, the ammonium nitrogen content of each treatment group still had a downward trend. In the 0–20 cm soil interval, the decrease rate of T2 treatment was 40.7%, T3 treatment was 33.9%, and T6 treatment was 26.2%. At the seedling stage, maize has a weak ability to absorb nitrogen. From the jointing stage, the accumulation of nitrogen in the soil gradually decreases, which is mainly

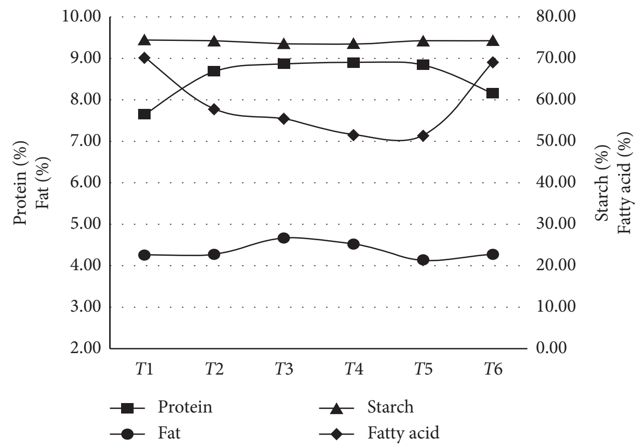

Figure 4: Effect of sheep manure combined with chemical fertilizers on maize grain quality indicators.

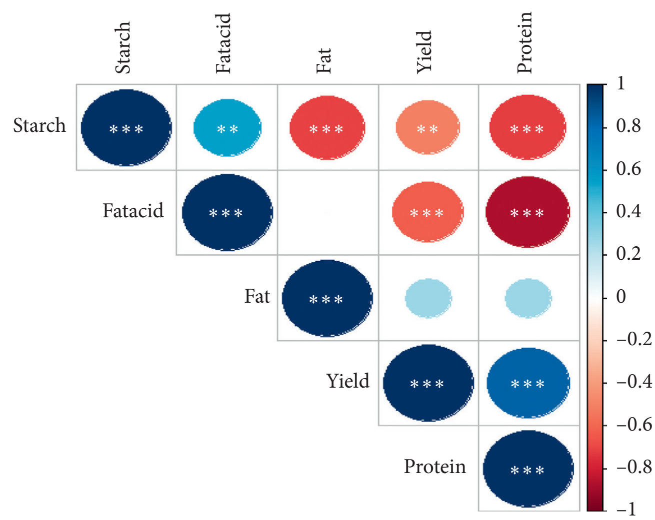

Figure 5: Heat map of the correlation between maize yield and quality variables.

because the absorption of nitrogen by maize begins to increase, which is consistent with the conclusions of related studies [38–40].

As shown in Figure 8, different fertilization treatments will significantly affect the accumulation of soil nitrate nitrogen at different levels [37]. From the maize seedling stage to the jointing stage, the nitrate nitrogen contained in the 0–20 cm soil layer of each treatment increased, and the nitrate nitrogen contained in the 20–40 cm soil layer T2 and T4 decreased, but the decline was smaller. The soil layers of 40–60 cm and 60–80 cm from the seedling state to the jointing state showed an upward trend. The soil layers of 40–60 cm and 60–80 cm from the seedling state to the jointing state showed an upward trend.

From the jointing period to the tasseling period, the nitrate nitrogen content of 0–20 cm soil layer increased significantly with the application of urea, combined application treatment, and pure using of the chemical fertilizer in the jointing state. In the 80–100 cm soil layer, except for T1, the nitrate nitrogen content of other treatments has a small change. However, in the 60–80 cm soil layer, the nitrate nitrogen contained in T4 and T5 treatments increases, and the nitrate nitrogen contained in T3 treatment decreases. The nitrate nitrogen contained in the 80–100 cm soil layer during the tasseling stage of T2 treatment was higher than that of the 60–80 cm soil layer, which may be because the downward leakage of precipitation leached the nitrate nitrogen from the upper soil to the lower soil and increased the nitrate nitrogen content.

The nitrate-nitrogen contained in 0–20 cm in each treatment decreased from the loosening of the maize flour stage to the filling stage. It may be that the growth rate of maize increased and the absorption rate of nitrogen began to increase, which caused the nitrate-nitrogen content of the surface soil to decrease. The content of nitrate nitrogen in the deep soil of maize increased. The possible reason is that more precipitation caused the infiltration of nitrate nitrogen. From the grain filling stage to the maturity stage, the nitrate nitrogen content in the 0–20 cm soil layer continued to decrease, which may be due to the change from vegetative growth of maize to reproductive growth, and the demand for nitrogen in maize grains increased. The nitrate nitrogen

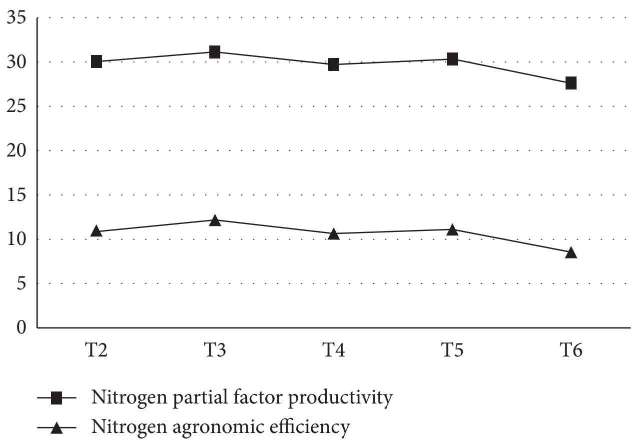

Figure 6: Influence of sheep manure mixed with chemical fertilizers on the agronomic effects of nitrogen.

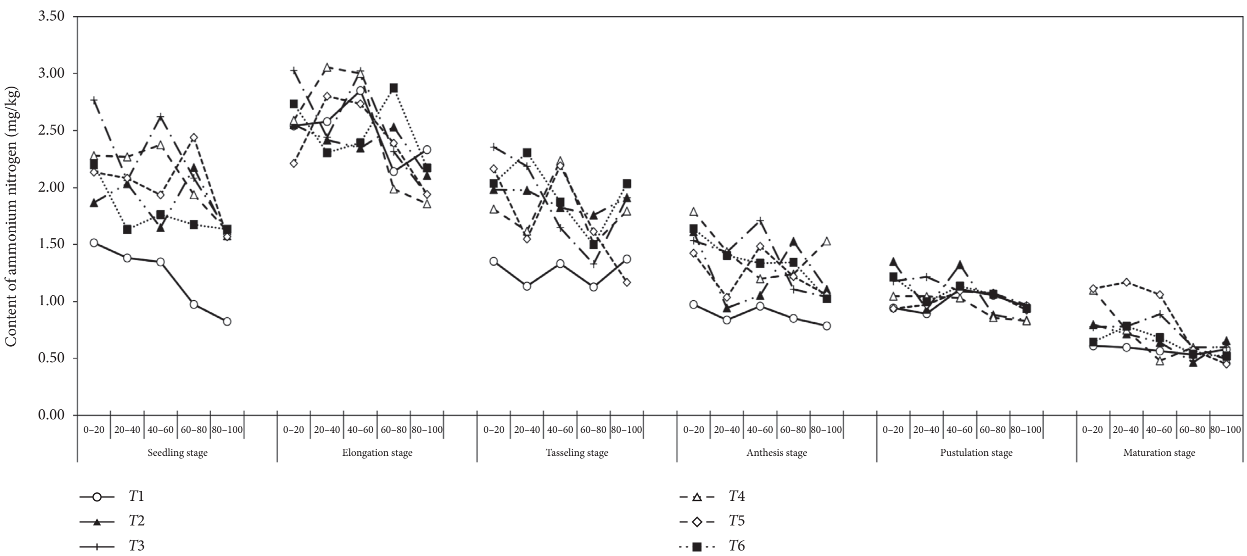

Figure 7: Temporal and spatial evolution trend of ammonium nitrogen in soil profile at different growth stages of maize under the combination of sheep manure and chemical fertilizer.

contained in the 80–100 cm soil layer of the combined application treatment decreased significantly, with the decreasing amplitudes being 10.1%, 58.3%, and 33.8%, respectively. In T4 and T5 treatments, the content of nitrate nitrogen in the soil layer of 40–60 cm and 60–80 cm decreased in different ranges.

5. Discussion

5.1. The Effect of Sheep Manure Combined with Chemical Fertilizers on Maize Yield and Quality. The maize thousand-grain weight of the combined treatments was higher than that of T2. The number of grains per ear of T2 and T3 was significantly higher than that of other treatments, and T3 was higher than T2. Sheep manure combined with chemical fertilizers might increase yield through increasing the number of ears and grains per ear. At the same time, the proportion of combined application is also very important. In this experiment, 15% sheep manure mixed with the chemical fertilizer and 45% sheep manure mixed with chemical fertilizer treatment were superior in yield performance. The protein contained in T3 treatment was higher than that of T2 treatment, but the difference was indistinct. It may be due to the fact that sheep manure combined with chemical fertilizers prolonged the growth period of crops and increased the protein content.

5.2. The Influence of Sheep Manure Mixed with Chemical Fertilizers on the Agronomic Effects of Nitrogen. In this experiment, the partial productivity of the nitrogen fertilizer in T3 and T5 treatments was 3.7% and 0.8% higher than that of T2 treatment, and the agronomic utilization of nitrogen was 10.9% and 1.6% higher than that of T2 treatment. T6 treatment was significantly lower than that of pure using of the chemical fertilizer and combined application. Studies have shown that agronomic nitrogen utilization can be increased by applying both organic and inorganic fertilizers,

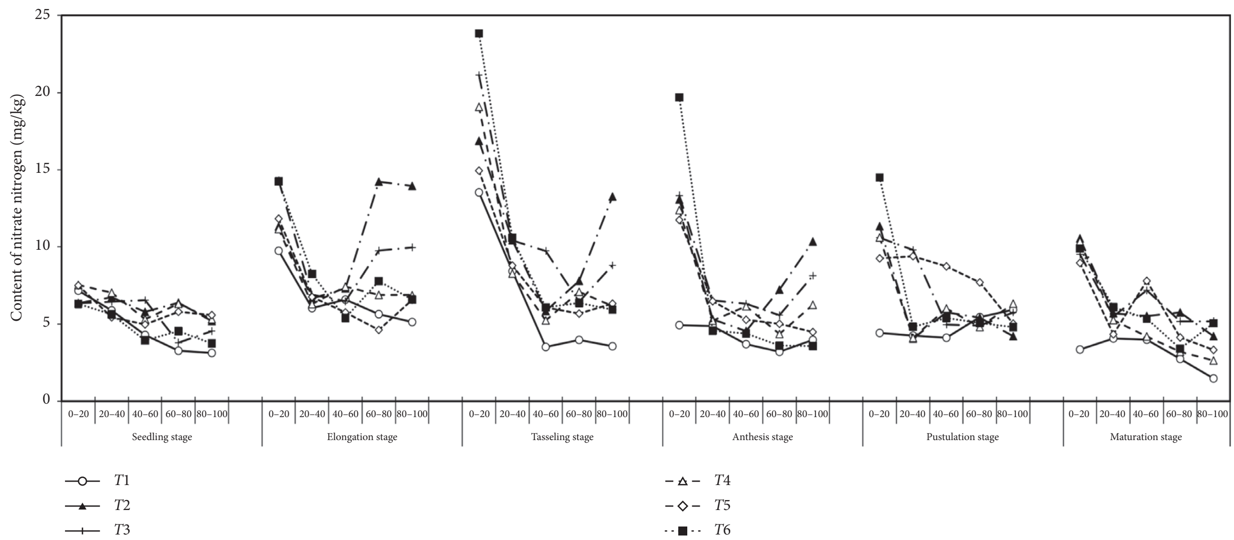

Figure 8: Temporal and spatial evolution trend of soil nitrate nitrogen in different growth stages of maize under the combination of sheep manure and chemical fertilizers.

but if the amount of the organic fertilizer is too high, the agronomic utilization of nitrogen will decrease, which is consistent with this experiment. Sheep manure mixed with chemical fertilizers can improve nitrogen utilization. The possible reason is that nitrogen will be transferred from the vegetative organs such as the stems and leaves of the crop to the grain when the reproductive growth of the crop replaces the vegetative growth. It increases the accumulation of nitrogen in the reproductive organs and improves the utilization of the nitrogen fertilizer. Some scholars have found that the mixed using of 15% organic fertilizers with chemical fertilizers may increase nitrogen utilization, while others have found that mixed using of 30% and 45% organic fertilizers with chemical fertilizers can increase the agronomic utilization of nitrogen. Based on numerous studies, it is found that organic fertilizers between 15% and 45% have a significant effect on the agronomic efficiency of nitrogen fertilizers [18]. In this experiment, T3 treatment (15% sheep manure mixed with chemical fertilizers) had higher nitrogen partial productivity and nitrogen fertilizer agronomic utilization than T2 treatment and was greater than T5. The result of the combined application range between 15% and 45% is consistent with the above research results.

5.3. The Effect of Sheep Manure Mixed with Chemical Fertilizers on Soil Inorganic Nitrogen. In this experiment, in the surface soil of the maize seedling stage, T4 treatment had the highest nitrate nitrogen content and T3 treatment had the highest ammonium nitrogen content. Most urea will be hydrolyzed into ammonium nitrogen after application and then converted into nitrate nitrogen through nitrification. This can explain the increase in nitrate nitrogen content of 0–20 cm in the maize tasseling stage (after urea topdressing during the jointing period) and the decrease of the ammonium nitrogen content in each fertilization treatment. The maturity stage of maize is 5.53 mg/kg, an increase of 30.4%. The 60–80 cm soil layer has increased by 56.5%, and the 80–100 cm soil layer has increased by 11.6%. It shows that single application of chemical fertilizers has the risk of causing nitrate nitrogen to move into the depths of the soil. If some measures are not taken, it is very likely that nitrate nitrogen will move out of the root absorption zone, causing groundwater pollution. In the treatment of sheep manure mixed with chemical fertilizers, the nitrate nitrogen content of 80–100 cm soil layer of T4 treatment decreased by 22.4%, indicating that the mixed using of organic and inorganic fertilizers can hold soil nitrogen and prevent nitrate nitrogen from moving to deep soil. It is likely that, after the organic fertilizer being applied to the soil, the probiotic fermentation and enzymes in the organic fertilizer promote the crop's absorption of soil nitrogen and decreasing of the accumulation of nitrate nitrogen in the soil. The nitrate nitrogen contained in 80–100 cm soil treated with sheep manure was increased compared with the initial period of the experiment, which indicates the full application of the organic fertilizer may increase nitrate nitrogen leaching risk. If the organic fertilizer is still applied alone, it may also cause groundwater pollution [41].

6. Conclusion

The combined application of different fertilizers has different degrees of influence on maize yield, grain quality, nitrogen agronomic effects, and soil inorganic nitrogen content in 0–100 cm under the wheat-maize system. This paper mainly draws the following conclusions:

(1) The yield of sheep manure combined with the chemical fertilizer is remarkably higher than that of single application of sheep manure and no fertilizer, but there is no significant variation with single using of the chemical fertilizer. Among them, T3 treatment had the highest yield and T4 treatment had the lowest. The difference between the treatments was not significant, indicating that sheep manure combined with chemical fertilizers can achieve high crop yields to a certain extent.

(2) Compared with the single using of the chemical fertilizer, the fat contained in T3 and T4 treatments is 8.9% and 5.6% higher than that of T2 treatment, and the protein content of maize grains of T3, T4, and T5 treatments is 2.3%, 2.5%, and 2% higher than T2. It shows that the mixture of sheep manure and chemical fertilizer could improve the quality of maize kernels to a certain extent.

(3) In this experiment, the partial productivity of the nitrogen fertilizer in T3 and T5 treatments was 3.7% and 0.8% higher than that of T2 treatment, and the agronomic utilization rate of the nitrogen fertilizer was 10.9% and 1.6% higher than that of T2 treatment. It shows that the combined using of sheep manure with chemical fertilizers can increase the partial productivity and the agronomic utilization rate of the nitrogen fertilizer, increasing crop yields and farmers' income.

(4) Compared with the maize before planting, the nitrate-nitrogen contained in the 80–100 cm soil layer of T4 treatment decreased by 22.4%, and the nitrate-nitrogen contained in the 40–60 cm soil layer of the single application of chemical fertilizer increased by 30.4%. The 60–80 cm soil layer increased by 56.5%, and the 80–100 cm soil layer increased by 11.6%. It shows that the mixed application of sheep manure with chemical fertilizers can prevent nitrate nitrogen from moving into deep soil and reduce groundwater pollution.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

All the authors contributed equally to this work.

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