Effect of Combined Application of Humic Acid and Urea on the Wheat Growth and Yield

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Abstract This paper aims to research the effects of combined application of humic acid and urea on the wheat yield and yield component, and establish rational fertilizer application scheme of wheat. Split plot experiment was adopted. Two types of phosphorus fertilizer (adding humic acid or not) was assigned to the main plot, and four types of top dressing modes (different amount of urea and humic acid urea) were used in subplots. Effects of combined application of humic acid and urea on the wheat yield and yield component were researched. 375 kg/ha ordinary DAP + 150 kg/ha urea was used as base fertilizer; topdressing of 300 kg/ha urea humate could effectively promote the plant height, leaf area coefficient and aboveground dry matter amount. Adding humic acid in urea in topdressing significantly enhanced the wheat yield and economic coefficient of wheat. Adding humic acid in urea in topdressing has better effects of yield increasing than base fertilizer, and can be used for large scale extension.

Key words Humic acid, Urea, Wheat, Yield, Split plot experiment

1 Introduction

The combined application of organic and inorganic fertilizers is an ideal fertilization model[1], which can effectively improve soil production capacity. Humic acid is natural organic matter, containing hydroxyl, carboxyl, phenolic hydroxyl and other active groups. These active groups determine the strong ion exchange capacity, adsorption capacity, complexation and buffer role of humic acid[2-3]. The studies of He Jing *et al.*[4-5] show that the humic acid can not only improve soil physical and chemical properties, stimulate crop growth, but also enhance the resistance of crops, and improve the quality of agricultural products. Urea is a nitrogen fertilizer with high nitrogen content, huge demand and broad application. After it is applied in soil, the soil urease and nitrification bacteria will make it quickly decompose and drain[6]. By the complexation between humic acid molecules and urea nitrogen, the urea supplemented with humic acid can slow the release rate of urea nitrogen, increase its fertilizer utilization efficiency, and elongate the retention of urea nitrogen in the soil[7-8]. Through different supplementing mode and proportion of humic acid, this paper studies the supplementing mode and amount of humic acid suitable for wheat growth, in order to provide a scientific basis for developing reasonable humic acid fertilization program.

2 Materials and methods

2.1 Experiment overview The experiment was carried out in stock seed farm of cotton in Baizhuang Town, Anyang County, during 2014 – 2015. The terrain was flat and soil was clay loam. Before soil preparation, 750 kg/ha of compound fertilizer (N: P: K = 16: 18: 6) was applied, and the plowing depth was 30 cm. Corn straw was crushed and returned to farmland. Meanwhile, Chunlei brand compound fertilizer and phoxim (controlling soil pests) were applied. Rotary harrowing was conducted three times, and the ground was leveled. Subsequently, the unified planting was arranged, the soil moisture was good, and the seedlings were neat and robust.

2.2 Experimental design The split-plot experiment was used, and the plot area was 9 m × 1.6 m, with 3 replications and a total of 24 plots. The fertilizer type is the main factor, and topdressing type is the subfactor. Main plot (phosphate fertilizer): A_1 (basal application of 25 kg of humic acid DAP, 150 kg/ha humic acid urea); A_2 (basal application of 25 kg of ordinary DAP, 150 kg/ha ordinary urea). Subplot (dressing): B_1 (300 kg/ha ordinary urea); B_2 (180 kg/ha ordinary urea); B_3 (300 kg/ha humic acid urea); B_4 (180 kg/ha humic acid urea). 90 kg/ha K_2O was applied under each treatment. The nitrogen topdressing time was the jointing period. The basal application of phosphate and potash fertilizers was required.

2.3 Field management Throughout the growth period, it was sown on October 11, 2014, and the moisture was good before sowing; it was watered on October 30, to promote the emergence; on March 13, 2015, the reviving water was poured; on May 22, it was watered to facilitate grouting. It was watered three times throughout the growing period. On March 20, the herbicides were sprayed to prevent the weed. On April 29, the pesticides were sprayed to control aphids. During the whole growth period, there were no weeds and pests in the field. It was harvested on June 10, 2015.

2.4 Measurement items and methods In the overwintering, jointing and filling periods of wheat, 10 plants with the consistent growth process were selected in the plot, to measure plant height,

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tiller number, leaf area index and aboveground dry matter weight. After the wheat harvest, the grain was threshed and dried, the grain yield and biological yield were measured, and the economic coefficient was calculated.

2.5 Statistics Excel2003 and SPSS19.0 were used for data analysis, and LSD (Least Significant Difference) was employed for multiple comparison.

3 Results and analysis

3.1 Effect of combined application of humic acid and urea on wheat yield components As can be seen from Table 1, it is found that almost there were no significant differences in spike length, total number of spikelets, number of sterile spikelets, grain number per ear, volume weight and yield, and economic coefficient between treatments. Overall, all the elements under basal application of ordinary DAP + urea were better than under basal application of humic acid DAP + humic acid urea, but there were no significant differences. For the topdressing treatment, in terms of the yield and economic coefficient, the treatments were in the order of $B_3 > B_1 > B_4 > B_2$; in terms of spike length, total number of spikelets, number of sterile spikelets and grain number per ear, all topdressing treatments showed inconsistent performance, and overall, B_3 was better than other treatments. The yield and economic coefficient were highest under A_2 and B_3, reaching 5413.65 kg/ha and 0.28, respectively. It indicated that the basal application of phosphate fertilizer had smaller effect on yield, yield components and economic coefficient than topdressing treatment; the yield and economic coefficient under humic acid-urea topdressing were better than urea topdressing, and with the increasing usage, both yield and economic coefficient were increased.

Table 1 Comparison of yield components, yield and economic coefficient of wheat in different treatments

Treatment	Spike length//cm	Total number of spikelets	Number of sterile spikelets	Grain number per ear	Volume weight g/L	Yield kg/ha	Economic coefficient
A_1B_1	9.10 a	21.00 a	4.33 a	38.67 ab	809.00 a	4448.10 a	0.24 a
A_1B_2	9.70 a	23.00 a	4.67 a	38.00 ab	808.00 a	4362.15 a	0.22 a
A_1B_3	9.57 a	22.67 a	5.33 a	36.00 ab	805.33 a	4439.55 a	0.24 a
A_1B_4	9.37 a	22.00 a	5.00 a	35.33 ab	806.67 a	4692.60 a	0.25 a
A_2B_1	9.80 a	23.33 a	4.33 a	43.33 a	803.67 a	5071.20 a	0.27 a
A_2B_2	9.53 a	22.67 a	5.33 a	34.67 ab	803.33 a	4651.50 a	0.22 a
A_2B_3	10.20 a	22.67 a	6.00 a	38.00 ab	805.67 a	5413.65 a	0.28 a
A_2B_4	9.40 a	21.67 a	6.00 a	32.00 b	803.67 a	4356.75 a	0.23 a

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

3.2 Effect of combined application of humic acid and urea on the wheat plant height at different growth stages As shown in Table 2, there were no significant differences in wheat plant height at overwintering, jointing and filling stages between treatments. Overall, the height of wheat plant under basal application of humic acid DAP + humic acid urea was smaller than under basal application of ordinary DAP + urea, but there were no significant differences; four kinds of topdressing treatments showed different performance at different growth stages. The plant height under application of humic acid urea was greater than under application of ordinary urea, and the plant height under B_3 was smaller than under B_4. On the whole, the wheat plant height under A_2B_3 treatment was greater than under other treatments at the overwintering and filling stages, but it was smaller than under other treatments at the jointing stage.

Table 2 Comparison of wheat plant height under different treatments at different growth stages

Treatment	Plant height//cm		
	Overwintering stage	Jointing stage	Filling stage
A_1B_1	21.21 a	56.47 a	77.87 a
A_1B_2	22.04 a	58.67 a	78.82 a
A_1B_3	22.03 a	56.10 a	78.20 a
A_1B_4	22.48 a	58.80 a	79.70 a
A_2B_1	22.73 a	59.10 a	78.73 a
A_2B_2	22.17 a	57.00 a	78.47 a
A_2B_3	23.88 a	57.37 a	80.70 a
A_2B_4	24.13 a	56.60 a	80.17 a

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

3.3 Effect of combined application of humic acid and urea on the wheat tiller number per plant at different growth stages As shown in Table 3, there were significant differences in the wheat tiller number per plant at the overwintering stage between treatments, and the number under A_1B_2, A_2B_3 and A_2B_4 was significantly larger than under other treatments, while the number under A_1B_1 was significantly smaller than under other treatments. At the jointing and filling stages, there were no significant differences in the wheat tiller number per plant. Overall, at the overwintering stage, the wheat tiller number per plant under basal application of ordinary DAP + urea was larger than under basal application of humic acid DAP + humic acid urea, but it was opposite for the jointing and filling stages. Four topdressing treatments showed different performance at different growth stages. The tiller number under humic acid urea topdressing treatment was larger than under ordinary urea topdressing treatment, and at the overwintering stage, the tiller number under B_3 was smaller than under B_4, but it was opposite for the jointing and filling stages. On the whole, at the overwintering stage, the wheat tiller number per plant under A_2B_3 was larger than under other treatments, but at the jointing and filling stages, it was smaller than under other treatments.

Table 3 Comparison of wheat tiller number per plant under different treatments at different growth stages

Treatment	Tiller number		
	Overwintering stage	Jointing stage	Filling stage
A_1B_1	6.97 c	9.60 a	4.60 a
A_1B_2	7.80 ab	8.80 a	4.50 a
A_1B_3	7.50 bc	9.50 a	4.53 a
A_1B_4	7.43 bc	9.27 a	4.87 a
A_2B_1	7.47 bc	9.53 a	4.33 a
A_2B_2	7.33 bc	9.33 a	4.47 a
A_2B_3	7.73 ab	8.83 a	4.02 a
A_2B_4	8.23 a	8.73 a	4.53 a

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

3.4 Effect of combined application of humic acid and urea on the wheat leaf area index at different growth stages As shown in Table 4, at the overwintering and jointing stages, the wheat leaf area index under the basal application of ordinary DAP + urea was higher under the basal application of humic acid DAP + humic acid urea, but it was opposite for the filling stage. Four topdressing treatments showed different performance at different growth stages. At the overwintering and filling stages, the wheat leaf area index under humic acid topdressing treatment was higher than under ordinary urea topdressing treatment, but it was opposite for the jointing stage. At the overwintering and filling stages, the leaf area index under B_3 was lower than under B_4, but it was opposite for the jointing stage. On the whole, at the jointing stage, the wheat leaf area index under A_2B_3 was higher than under other treatments, but at the overwintering and filling stages, it was lower than under other treatments.

Table 4 Comparison of wheat leaf area index under different treatments at different growth stages

Treatment	Leaf area index		
	Overwintering stage	Jointing stage	Filling stage
A_1B_1	0.92 c	5.34 d	5.20 d
A_1B_2	1.09 bc	6.21 abc	5.39 cd
A_1B_3	1.06 bc	6.46 abc	6.05 abc
A_1B_4	1.22 ab	6.43 abc	6.67 a
A_2B_1	1.16 ab	6.54 ab	6.42 ab
A_2B_2	1.17 ab	6.74 a	5.98 abc
A_2B_3	1.25 ab	5.96 bc	4.43 e
A_2B_4	1.32 a	5.83 cd	5.93 bc

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

3.5 Effect of combined application of humic acid and urea on the aboveground dry matter weight at different growth stages As shown in Table 5, at the overwintering stage, the wheat aboveground dry matter weight under basal application of ordinary DAP + urea was greater than under basal application of humic acid DAP + humic acid urea, but it was opposite for the jointing and filling stages. Four topdressing treatments showed different performance at different growth stages. At the overwintering and filling stages, the aboveground dry matter weight under humic acid urea topdressing treatment was greater than under ordinary urea topdressing treatment, but it was opposite for the jointing stage. This indicated that the basal application of phosphate fertilizer had greater impact on yield, yield components and economic coefficient than topdressing treatment. On the whole, at the overwintering stage, the aboveground dry matter weight under A_2B_3 was smaller than under other treatments, but it was higher than under other treatments at the jointing and filling stages.

4 Conclusions

The experimental results showed that compared with ordinary DAP + ordinary urea, the basal application of the same amount of humic acid DAP + humic acid urea did not significantly improve wheat yield and economic coefficient, but decreased them by 9% and 6%, respectively. Compared with ordinary urea topdressing, the humic acid urea topdressing increased the yield and economic coefficient by 2% and 5.2%, respectively. Obviously, the topdressing of urea supplemented with humic acid played a more prominent role in increasing yield than base fertilizer, and 300 kg of topdressing was better than 180 kg of topdressing. In 8 experimental treatments, the yield and economic coefficient were highest under the basal application of 375 kg/ha ordinary DAP + 150 kg/ha ordinary urea, and 300 kg/ ha humic acid urea topdressing.

Table 5 Comparison of wheat aboveground dry matter weight under different treatments at different growth stages

Treatment	Aboveground dry matter weight		
	Overwintering stage	Jointing stage	Filling stage
A_1B_1	9.85 c	83.65 b	123.01 f
A_1B_2	11.76 b	89.74 a	133.35 e
A_1B_3	10.92 bc	55.04 e	180.13 b
A_1B_4	10.80 bc	65.94 c	186.38 a
A_2B_1	11.93 b	58.57 d	114.51 g
A_2B_2	9.81 c	83.14 b	166.87 c
A_2B_3	11.43 b	56.68 de	139.96 d
A_2B_4	13.83 a	55.45 e	134.51 de

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

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and crispness for the dried puffed products, but the moisture content was high, and 2.5% citric acid treatment was appropriate; NaCl solution soaking treatment could effectively promote material dehydration, and high concentration NaCl penetrating fluid played a significant role in maintaining material color, but it would increase product hardness and reduce product quality, and 2% NaCl treatment had the best effect.

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