

Research Article

Effect of Long-term Fertilization on the Quality of Wheat

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Abstract: Aim of the study was to investigate the effect of long-term fertilization on the quality of wheat grain including protein, starch, fat content and the amino acid was analyzed by cluster analysis. The effect of fertilization on the quality of wheat seed was investigated based on continues application of fertilizer for 26 and 36 years in Gleyic Cambisols. The results showed that the amounts of protein were 14.12% and 14.1% for N₂ and N₂PK treatments which was higher than others. In addition, the total amounts of amino acid decreased by fertilization. However, the amounts of starch decreased and the less decreased treatment was N₂PK treatment for 0.07%. The highest fat was 0.17% for N₂PK treatment.

Keywords: Amino acid, fat, long term fertilization, proten, quality of wheat, starch

INTRODUCTION

The needs of food produced by wheat are imperative with the improving of our daily life. We pay more attention to the study of wheat quality. Not only the inheritance but also the ecological environment and cultivation technology can influence the wheat quality, while, the fertilizer is also one of the effect factors (Liu *et al.*, 2005; Jan *et al.*, 2002). Therefore, the wheat quality can be improved by suitable management and fertilization. There were a lot of studies on the effect of Nitrogen (N) fertilizer on the wheat quality (Ravindra *et al.*, 2002; Zhang *et al.*, 2012; Xu *et al.*, 2012; Feng *et al.*, 2009), but a few of them were about the application of balance fertilization (Sun *et al.*, 2006; Vuscan, 2010; Jiang *et al.*, 2004). In this study, the effect of inorganic fertilizer on wheat quality was studied and the results could be provided more materials for fertilization.

MATERIALS AND METHODS

Experiment design: The experiment was built up in Laiyang (36.9°N, 120.7°E) since 1978. It is warm temperature in the region. The mean annual rainfall and temperature are 779.1 mm and 11.2°C, separately. It is Gleyic Cambisols and the basic properties are as follows: 6.8 pH; 4.10 g/kg Soil Organic Matter (SOC); 0.50 g/kg Total Nitrogen (TN); 0.46 g/kg total phosphorus (total P); 15 mg/kg Olsen P; 38 mg/kg Available Potassium (AK) and 11.8 cmol/kg Cation Exchange Capacity (CEC). The rotation of wheat and corn were in the autumn and summer every year. The types of wheat was Fu 63, Lainong 9214 and Yanyou 361 in 1978-1992, 1993-2002 and 2003-2013,

separately. In addition, the types of corn were Luyu 4 and Luyu 16 in 1978-1996 and 1997-2013, separately. The urea was used for N fertilizer were 138 kg/ha and 276 kg/ha per year. The application of P₂O₅ and K₂O for the P and K fertilizer were 90 kg/ha and 135 kg/ha per year. There were six treatments in this study (Table 1). The pig manure was used as basic fertilizer and N fertilizer applied in different growth season of corn.

Experiment method: The wheat samples were protected by paper bags in the field and samples in 2003 and 2013 were used in this study. In each plot, 30 samples were random collected and kept 25% samples on average. All the samples were sieved to 0.25 mm. The contents of protein of the wheat was investigated by Kjeldahl determination (Wang *et al.*, 2006). The starch was determined by anthranone-H₂SO₄ and fat was tested by residue method, but the amino acid was analyzed by automatic amino-acid analyzer. All the data were analyzed by SPSS 19.0.

RESULTS

Effect of long term fertilization on the protein of wheat seed: The amounts of protein of wheat seed increased under long term fertilization for the 26 and 36 years samples. Compared to CK treatment, it increased by 13.42% and 16.07% for N₁ and N₂ treatments in the 26 years of fertilization, separately. Moreover, it increased by 22.15% and 21.97% for N₂ and N₂PK treatments in 36 years of fertilization, separately (Fig. 1). However, it increased by 19.98% and 19.72% for N₂P and N₂K treatments. Compared to 26 years of fertilization, the protein increased by fertilizer except CK and N₂PK treatments.

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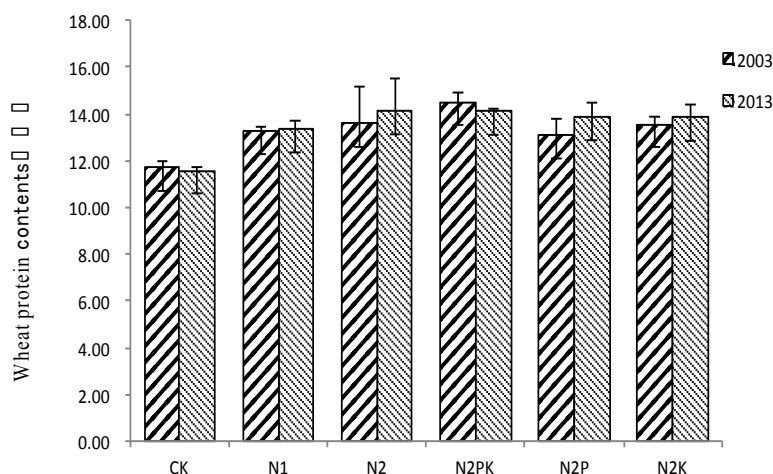


Fig. 1: Contents of protein wheat in different fertilization treatments

Table 1: Experimental selected 6 fertilization treatments (kg/hm²)

Treatments	Fertilizer type and amounts (kg/hm ²)	Treatments	Fertilizer type and amounts (kg/hm ²)
CK	0	N ₂ P	N:276; P ₂ O ₅ :90
N ₁	N:138	N ₂ K	N:276; K ₂ O:135
N ₂	N:276	N ₂ PK	N:276; P ₂ O ₅ :90; K ₂ O:135

Footnotes 1 and 2, respectively represent the low and high volume fertilization

Table 2: Starch contents of winter wheat in different fertilization treatments

Treatments (%)	26 years (2003) Starch content (%)	36 years (2013) Starch content (%)	Amplitude (%)
CK	52.63±0.01 a	49.97±0.89 a	-5.05
N ₁	49.39±0.79 b	43.87±1.22 c	-11.18
N ₂	48.67±0.47 b	36.21±2.79 b	-25.6
N ₂ PK	48.52±2.22 b	46.47±1.71 b	-4.23
N ₂ P	46.45±1.77 c	43.75±2.17 c	-5.81
N ₂ K	46.64±1.59 c	37.12±1.46 d	-20.41

Different small letter indicate significantly different at 5% levels

Table 3: Crude fat contents of winter wheat in different fertilization treatments

Treatments (%)	26 years (2003) Starch content (%)	36 years (2013) Starch content (%)	Amplitude (%)
CK	3.23±0.89 ab	2.62±0.24 bc	-18.86
N ₁	2.55±0.13 c	2.33±0.07 bc	-8.64
N ₂	1.86±0.10 d	2.26±0.07 c	21.33
N ₂ PK	3.31±0.16 a	3.08±0.14 a	-7.08
N ₂ P	2.32±0.09 c	2.66±0.19 b	14.69
N ₂ K	2.96±0.12 b	2.73±0.09 ab	-7.77

Different small letter indicate significantly different at 5% levels

Effect of long term fertilization on the starch of wheat seed: The contents of starch of wheat seed decreased for 26 and 36 years of fertilizer treatments (Table 2). It was 52.63% for CK treatment, but decreased by more than 11% for N₂P and N₂K treatments. However, it was 36.21% for N₂ treatment which was the lowest. Compared to the samples of 26 years of fertilizer treatment, it decreased by -25.6% for N₂ treatment, but -5.81% for N₂PK treatment in 36 years of fertilizer treatment. It indicated that balance fertilization could increase the content of protein of wheat seed, but decrease the starch.

Effect of long term fertilization on the fat of wheat seed: Compared to CK treatment, the content of fat of wheat seed were lower for fertilizer treatment of 26 years except N₂PK treatment, while, it decreased more slowly for fertilizer treatment of 36 years. It decreased by -7.08% for N₂PK treatment of 36 years, but -18.86% for CK treatment, compared to 26 years of fertilizer treatment. It showed that balance fertilization could be better for fat concentration of wheat seed (Table 3).

Effect of long term fertilization on the amino acid of wheat seed: The amounts of amino acid was shown in

Table 4: 26Years (2003) effect of different fertilizing on the content of amino acid (%)

Amino acid	Treatments					
	CK	N ₁	N ₂	N ₂ PK	N ₂ P	N ₂ K
THR*	0.33	0.37	0.43	0.42	0.41	0.41
VAL*	0.43	0.51	0.56	0.55	0.54	0.54
MET*	0.16	0.17	0.19	0.18	0.18	0.18
ILE*	0.34	0.42	0.51	0.49	0.45	0.48
LEU*	0.76	0.92	1.1	1.08	0.97	1.02
PHE*	0.52	0.72	0.71	0.74	0.65	0.73
LYS*	0.4	0.37	0.46	0.41	0.46	0.48
ASP	0.54	0.56	0.66	0.69	0.67	0.71
SER	0.52	0.62	0.7	0.71	0.68	0.71
GLU	3.36	4.28	5.05	4.33	4.69	4.48
GLY	0.45	0.54	0.57	0.61	0.57	0.58
ALA	0.39	0.44	0.47	0.49	0.48	0.5
CYS	0.18	0.19	0.21	0.2	0.2	0.21
TYR	0.09	0.46	0.13	0.42	0.1	0.11
HIS	0.25	0.3	0.33	0.35	0.32	0.33
ARG	0.51	0.61	0.65	0.69	0.66	0.67
PRO	0.12	1.43	1.55	1.68	1.83	1.86
Essential amino acid*	2.94	3.48	3.96	3.87	3.66	3.84
Total amino acids	9.35	12.91	14.28	14.04	13.86	14

*: The essential amino acid

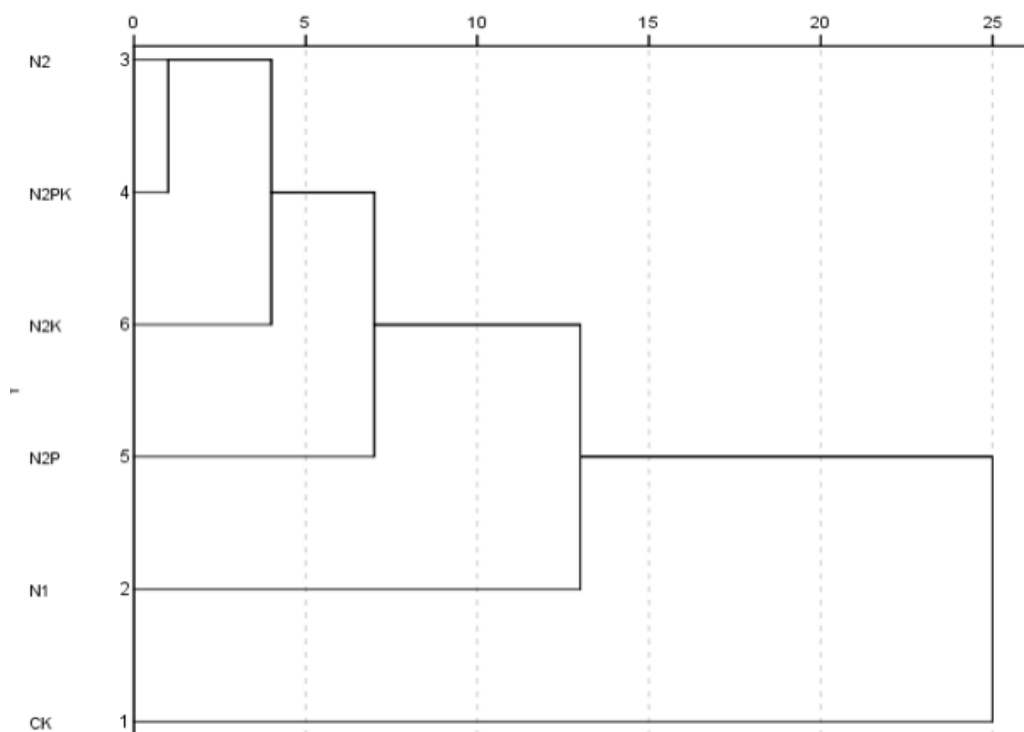


Fig. 2: Long-term fertilization experiment of winter wheat grain amino acid composition of hierarchical cluster analysis results (26 years)

Table 4. The amounts of total amino acid increased for fertilizer treatment of 26 years, compared to CK treatment. It was higher for N₂ and N₂PK treatments rather than others, which increased by 52.73 and 50.16%. The necessary amino acid for human body was also higher for N₂ and N₂PK treatments than others. The cluster analysis also showed that amino acid accumulated similar in wheat seed for N₂ and N₂PK treatments (Fig. 2). Compared to CK treatment, the

amounts of total amino acid increased for fertilizer treatment of 36 years. It was higher for N₂ and N₂PK treatments rather than others, which increased by 30.03 and 27.13%. The necessary amino acid for human body was also higher for N₂ and N₂PK treatments than others too. The cluster analysis indicated that amino acid contents were similar in wheat seed for N₂ and N₂PK treatments (Fig. 3 and Table 5).

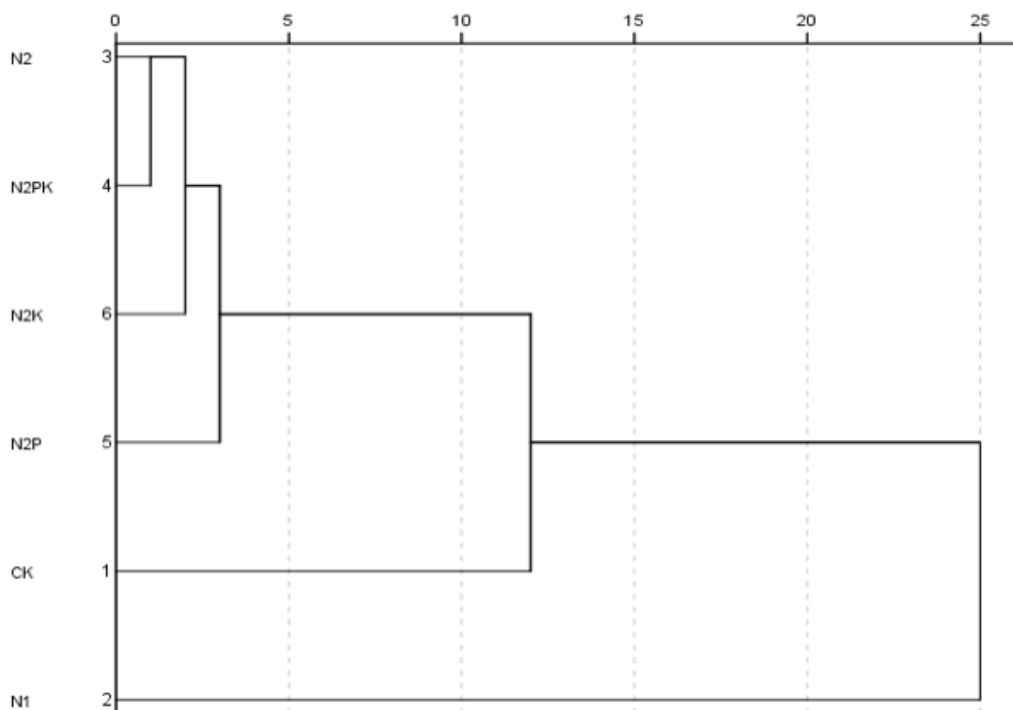


Fig. 3: Long-term fertilization experiment of winter wheat grain amino acid composition of hierarchical cluster analysis results (36years)

Table 5: 36 Years (2013) effect of different fertilizing on the content of amino acid (%)

Amino acid	Treatments					
	CK	N ₁	N ₂	N ₂ PK	N ₂ P	N ₂ K
THR*	0.34	0.38	0.42	0.39	0.38	0.38
VAL*	0.46	0.5	0.56	0.52	0.49	0.5
MET*	0.15	0.15	0.18	0.16	0.17	0.17
ILE*	0.37	0.42	0.46	0.42	0.4	0.42
LEU*	0.79	0.88	0.97	0.9	0.86	0.89
PHE*	0.37	0.55	0.46	0.42	0.58	0.6
LYS*	0.79	0.42	0.97	0.9	0.42	0.45
ASP	0.72	0.58	0.67	0.63	0.63	0.65
SER	0.67	0.54	0.62	0.62	0.6	0.61
GLU	1.46	3.52	4.14	4.26	4.03	4.12
GLY	0.58	0.46	0.51	0.51	0.51	0.52
ALA	0.51	0.41	0.46	0.44	0.45	0.45
CYS	0.19	0.16	0.18	0.17	0.18	0.18
TYR	0.12	0.1	0.1	0.1	0.1	0.1
HIS	0.33	0.27	0.31	0.29	0.29	0.3
ARG	0.68	0.54	0.62	0.58	0.6	0.621
PRO	1.46	1.17	1.36	1.39	1.33	1.35
Essential amino acid*	3.27	3.3	4.02	3.71	3.3	3.41
Total amino acids	9.99	11.05	12.99	12.7	12.02	12.311

*: The essential amino acid

DISCUSSION

Nitrogen fertilizer can significantly improve the winter wheat grain protein content. The protein content within a certain scope increased with more nitrogen application rate (Chi *et al.*, 2006). Carlone (1987) and Sauberlich and Salmon (1953) research showed that the grain protein content increased with more nitrogen application rate. The grain protein content were very significant positive correlation with nitrogen

application. Consistent with the experimental results, the nitrogen fertilizer on winter wheat grain protein content in the enhancing effect is relatively stable. Abbas *et al.* (2011), Wang *et al.* (2000) research suggests that potassium can promote grain protein synthesis and can improve the winter wheat grain protein content and amino acid content, consistent with the test results. Experiment indicated that phosphate on spring wheat grain protein, amino acid content of influence is not obvious, with Xudong Wang (Wang

et al., 2006) the results of the study, by contrast, with Zhang *et al.* (2004) research, may be associated with different fertilizer rate and varieties tested. Long-term fertilization of N fertilizer wheat grain starch content decreased and with the increase of N fertilizer starch content decreased. The N₂P, N₂K and N₂PK treatments with wheat grain starch content were significantly lower than the contrast CK treatment. The highest N₂PK processing crude fat content, crude fat content between different fertilizer treatments all have significant difference. The grain crude fat content increased with the increase of nitrogen supply level.

CONCLUSION

Compared with no fertilizer or single nitrogen, nitrogenous add phosphorus add potassium fertilizer to improve wheat grain protein, fat and amino acids, with an increase in N fertilizer application, protein and amino acid content significantly increased, fat and starch content decreased.

The quality of wheat seed could be improved by balance fertilization. Especially, the contents of protein and amino acid could be increased by more N fertilizer application.

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