Effect of Fertilizer Treatment on the Content of Protein Composition and the Processing Quality of Bread Wheat

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Abstact

The experiment was carried out on the agronomy farm of the Institute of Crop Science, Chinese Academy of Agricultural Science. The variety examined was strong gluten bread wheat, Zhongyou 9701, and the soil was loam. The test was a combination of N.P.K. nitrogen, phosphorus, potassium, levels, on yield and quality. The results showed, under the condition of the same amount of fertilizer, that the treatment of half basic N fertilizer and half top-dressing fertilizer had the highest yield, and significant difference level was achieved between this treatment and the 100% or 70% basic N fertilizer treatments. The yields of all fertilizing treatments were higher than the control (no fertilizer applied). All fertilizing treatments resulted in incrreased protein content and glutenin, and the content of albumin, globulin, gliadin were also improved. Sedimentation, wet gluten, dry gluten, water absorption rate and bread volume of each fertilizer treatment were increased more significantly than the control (no fertilizer applied).Dough development time and stability time were increased, when the ratio of basic N fertilizer was above 50%, the effect of improvement of wheat quality were significant. Wheat quality was improved by increasing nitrogenous fertilizer.

Keywords

Bread wheat, Fertilizer, Protein composition, Processing quality

Introduction

To increase wheat yield and improve wheat quality have been important goals of research. A great deal of studies have been carried out throughout the world. But there has been some contradiction between the wheat yield and quality. The demand for food is quite large in China due to its large population, therefore improving wheat yield has been given the priority for wheat breeding and planting in China for a long time, a lot of researches have been done in the last several decades, The average yield of wheat has increased as many as 5 times from 645kg/hm^2 (1949) to 4095kg/hm^2 (1977). But in China the bread processing qualities of major high yielding wheat was poor. In recent years, some bread wheat with better quality has been bred, but the yields are not satisfactory. Reasonable planting methods could improve the yield and quality effectively; therefore many studies are searching for the cultivating methods which can improve the wheat yield and quality at the same time. In this experiment, some major bread wheat strains were used to research the best cultivating methods on improving the yield and quality of superior bread wheat by applying N.P.K. fertilizer, in order to provide theoretical basis for the cultivating research on superior and productive wheat and its production.

Materials and Methods

Condition of the Field

The field was located in the Renqiu Experimental Farm of Institute of Crop Science, Chinese Academy of Agricultural Science in 2002-2003. The soil was a loam and the preceding crop was corn. The soil nutrient levels in the layers underground from the depth of 0 cm to 20 cm and from 20 cm to 40 cm were: organic materials 1.57%, 0.88%; whole nitrogen 0.083%, 0.054%; whole phosphorus 0.166%, 0.132%; whole potassium 2.49%, 2.50%; nitrogen from alkaline treatment (mg/kg) 59.72, 50.65; rapidly available phosphorus (mg/kg) 23.3, 28.3; rapidly available potassium (mg/kg) 115.0, 82.5.

Materials and Design

The experiment included ten different treatments, as shown in Table1. The wheat variety was Zhongyou9701.It was sown on the 2nd, Oct., in a random arrangement, with 6.66 m^2 in each plot, and repeated three times. During the whole growing period, chemical weedicides were applied, artificial weeding and prevention of aphides once respectively. There were two sample points in each plot, whose growth situation and harvest production were recorded.

Table 1 Design of the first group

Treatment	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10(CK)
N(kg/hm^2) (A:B)	270 (10:0)	270 (7:3)	270 (6:4)	270 (5:5)	270 (4:6)	270 (3:7)	270 (0:10)	270 (5:5)	270 (5:5)	0
P_2O_5(kg/hm^2) (A)	162.5	162.5	162.5	162.5	162.5	162.5	162.5	0	162.5	0
K_2O(kg/ hm^2) (A)	135	135	135	135	135	135	135	135	0	0

A: Basic fertilizing, **B**: Addition fertilizing (11th , Apr.)

Analysis of quality character

Kernel hardness was tested using Single Kernel Character System of Perten Instruments Company, Sweden. Kernel protein and its composition were analyzed with Semi-micrometheel of Kai's Fixed Nitrogen. Albumin, Globulin, glutenin and gliadin were extracted with continuous vibration in turn. Wet gluten content was tested(according to AACC38-2 method) by 2200 gluten content instrument of Perten Instruments Company, Sweden, sedimentation was measured(according to AACC56-63ZELENY method) by sedimentation instrument of Germanic Brabender Company and paste characteristic was analyzed with the Farinograph of Brabender Company Germany (according to AACC56-21method). Finally baking test was performed according to AACC10-01 method.

Results

Effect on the yield

As shown on the Table 2, When the amount of fertilizer being equal, the treatment with higher percentage of nitrogenous additional fertilizer had the higher yield. However, when the fertilizer was all applied as base fertilizer, its yield became much lower than the treatment as topdressing. The treatment without any fertilizer had a significantly lower yield than the one fertilized. Both A8 and A9 treatments were applied the equal amountof nitrogenous fertilizer and the same application method, the yield results were similar to A4 treatment. This experiment showed non-phosphate and non-potassium treatment had no obvious effect on the yield. The reason maybe the high content of nitration originally maintained in the soil. Further discussion is needed.

Table 2 Effect of fertilizer level on yield

Treatment	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Yield	4215	4575	4523	5108	4980	4988	4980	4763	4860	2933

(kg/ hm^2)	e	d	d	a	ab	ab	ab	c	bc	f
	G	EF	F	A	AB	ABC	ABC	DE	BCD	H

Note: The small letter figured that the number was significant difference in 0.05 level and the capital figured that in 0.01 level. The below is the same.

Effect on the protein composition content

Different fertilizer treatments had certain effect on the content of the components of protein, but the effect was not the same. As to albumin, the percentage of nitrogenous fertilizer would be positive to the increase of albumin content, but the discrepancy was not significant. All the fertilizing treatments increased the content of albumin more than the control. And the variation between most fertilizing treatments and the control was significant. As to globulin, although all the treatments had effects on the content of globulin, the treatment A6 had the highest content. As to gliadin, its content is higher in all the fertilizing treatments than the control, and the highest was the A7 treatment. As to glutenin, the variation among the fertilizing treatments was insignificant, but the content of glutenin higher than control significantly. This indicated different fertilizing percentage had different effect on each protein composition, but raise the percentage of topdressing of nitrogenous fertilizer would be favorable to the increase of each protein component. The highest content of total protein was the A7 treatment in which all the nitrogenous was top-dressed. And the result was significantly higher than the A1 treatment. The results in all the fertilizer treatments were much higher than the control. There was a positive correlation existed between the content of each protein component and the total content of seed protein. The correlation coefficient of albumin, globin, gliadin and glutenin was 0.81**,0.89**,0.98**,0.96** respectively, all reaching the level of significance. This indicated that the factors increasing the content of the total protein had some effect on each component of protein. The results didn't agree with the ones obtained in other experiments, which need further discussion.

Table 3 Effect on grain protein composition content (%)

Treatment	Albumin	Globulin	Gliadin	Glutenin	Total protein
A1	2.95 ab	1.79 cd	2.82 c	5.30 A	14.32 b B
A2	2.97 ab	1.77 d	2.90 bc	5.68 A	14.90 ab AB
A3	3.12 a	1.87 abcd	2.97 abc	5.58 A	15.03 ab AB
A4	2.92 ab	1.93 ab	3.04 ab	5.70 A	15.17 a AB
A5	3.01 a	1.93 ab	3.16 ab	5.62 A	15.21 a AB
A6	3.04 a	1.99 a	3.19 ab	5.62 A	15.24 a AB
A7	3.14 a	1.92 ab	3.22 a	5.62 A	15.50 a A
A8	2.92 ab	1.84 bcd	3.14 ab	5.58 A	15.22 a AB
A9	2.99 a	1.91 abc	3.08 abc	5.34 A	15.21 a AB
A10	2.72 b	1.59 e	2.16 d	4.13 B	11.92 c C

Effect on grain hardness and paste quality

Although the seed hardness varied among the treatments, the discrepancy was not significant. The sedimentation was the lowest in the control, which had an extremely significant discrepancy to all the treatments. However, there was no significant difference among the treatments. Although the content of wet gluten had significantly increased the control, the discrepancy among different fertilizing treatments was small. The content of dry gluten showed the similar result with the wet gluten and there was an extremely significant correlation between the two (0.98**), showing that the sedimentation value, wet gluten content and dry gluten content could be significantly increased by appropriately applying more fertilizer.

Table 4 Effect on grain hardness and paste quality

Treatment	Hardness	Sedimentation	Wet gluten (%)	Dry gluten (%)
A1	65 a	62.0 A	33.5 A	11.5 b B
A2	60 a	63.6 A	34.2 A	11.6 bc B
A3	58 a	63.6 A	34.2 A	11.7 bc AB
A4	63 a	62.7 A	33.8 A	11.4 c B
A5	60 a	62.4 A	34.2 A	11.7 bc AB
A6	64 a	63.9 A	33.7 A	11.6 bc B
A7	61 a	64.6 A	35.2 A	12.1 a A
A8	60 a	63.2 A	34.2 A	11.6 bc B
A9	60 a	62.6 A	34.5 A	11.8 ab AB
A10	55 a	38.6 B	24.9 B	9.90 e C

Effect on the farinograph parameter and bread quality

We can see from table 5 that water absorption rate of all treatments was increased more obviously than the control, but under the condition of the same application methods of N fertilizer, there was no prominent effect of the rate of basic fertilizer to top-dressing fertilizer and different application of P.K on absorption.

Table 5 Effect on the farinograph parameter and bread quality

Treatment	Absorption (%)	Development time (m)	Stability (m)	Bread volume (ml)	Bread score
A1	59.4 A	6.1 a A	15.4 ab	701 b B	70.7 ab
A2	59.9 A	5.2 a AB	15.8 ab	710 b AB	70.8 ab
A3	59.6 A	5.5 a A	15.0 abc	718 ab AB	74.2 ab

A4	59.4 A	5.0 a AB	15.1 ab	718 ab AB	74.8 a
A5	59.2 A	5.3 a AB	15.9 ab	742 a A	76.2 a
A6	59.7 A	5.7 a A	16.1 ab	702 b B	73.5 ab
A7	59.8 A	6.5 a A	17.4 a	729 ab AB	75.5 a
A8	59.1 A	5.5 a A	14.2 bc	730 b AB	75.5 a
A9	59.3 A	5.5 a A	14.3 bc	712 b AB	72.7 ab
A10	55.3 B	2.8 b B	12.7 c	663 c C	68.5 b

There was a similar trend between development time and stability time, which were increased more significantly than the control and the longest was A7. It indicated fertilizer had some important effect on improving paste quality, moreover, increasing the proportion of top-dressing N fertilizer could positively improve absorption and prolong stability, there was obvious difference of bread volume among treatments and the control and the extreme value was up to 79 ml, The volume of treatment A5 was the biggest. The bread score was based on several values which included the bread volume, color, elasticity, and so on. The correlation of bread score and volume was positive. r =0.91**.

Conclusion and Discussion

The yield of wheat was sensitive to fertilizer treatment under the condition of general soil. Compared to the control, the yield increased significantly in all the treatments. The highest yield was A4 treatment, in which all the phosphate fertilizer, potassium fertilizer and half nitrogen were applied as base fertilizer, another half nitrogenous fertilizer was top-dressed. The A5 treatment was the second, in which base fertilizer and topdressing were of the ratio of 4:6.When the total amount of fertilizer being equal, the treatment of A1 had a remarkable decrease in yield, showing an enormous effect imposed by different fertilizer treatments. In areas which irrigation system is available, a ratio of 5:5 or 4:6 between base fertilizer and topdressing is advisable in the wheat production. This could not only guarantee the healthy growth of seedling in the earlier stage, but also satisfy middle and late stage of growth. Thus a relatively higher yield is more likely.

Within certain range, the application of fertilizer can be effective in increasing the yield. No organic fertilizer was applied in the current study, So in our experiment, the amount of nitrogenous fertilizer applied were larger than that showed by Ravindra et al (2002). They concluded that 20 t farmyard manure +120 kg N/hm^2 enhanced grain yield, improved grain quality. The huge discrepancy was due to the different production conditions.

Under the same irrigation condition, fertilizing treatments showed remarkable effect on the total protein of the seeds, but they don't always agree with the influence on yield, the highest content of seed protein appeared in the treatments which increased the topdressing rate of nitrogen during the period of the elongation stage, showing a better effect on improving the quality of seeds. The contents of protein in all the treatments were significantly higher than the control (no fertilizer applied), showing the importance of fertilizing on seed quality. The yield of protein is determined by the yield of grain and its protein content. In this experiment, the A4 treatment had the highest protein yield. One of our research objectives in wheat production is make sure that the yield and quality can be improved at the same time. In this experiment, the A4 treatment can be used as reference in the production, for its higher yield and better quality.

In this experiment, the sedimentation value, wet gluten and absorption were much higher than those in control. When the amount of nitrogenous fertilizer were the same, a different ratio of base fertilizer to topdressing had no significant influence on the parameters mentioned above. The highest content of dry gluten, development time and stability time all appeared in the treatment of A7, The bread volume and bread score, where highest in the A4 treatment, which nitrogenous fertilizer half base fertilized and half top-dressed.

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