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The Fertilization Effect on Grain Protein Content in Wheat

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Abstract: The influence of fertilization on wheat grain protein content in long-term stationary experiment were studied. The aim of this investigation is looking of resolution for getting maximum of yield and optimum grain protein content. Except of nutrition influence, the influence of environment condition of year on grain protein content were studied. The changes of grain protein content and grain yield under the effect of fertilization and year conditions were analyzed. The obtained results showed that wheat grain protein content were determined with genotype capacity of nitrogen accumulation and utilization.

Key words: wheat, protein content, grain yield, fertilizer, mineral nutrition.

Introduction

The grain protein content in wheat represents important indicators of its nutritive value and technological quality. In spite of that, the increasing protein content in wheat grain under influence of scientific farming measures were not investigated enough so now. Also, for this problem in wheat selection are enough paid attention. One of the reason is likely, because quality of grain had not adequate price at the market. The consequence of that is spreading and

production wheat with high yield and low protein content and which can not use for making bread with good quality.

Among scientific farming measures which can influence on protein content in grain of wheat, the important role, play, mineral nutrition, especially nitrogen nutrition. The main attention is directed on study of influence of mineral nutrition on yield and substantially less its influence on grain protein content (Kostic et al., 1990; Jelenic, 1966; Popovic et al., 1967; Karandasev, 1966; Kodanev, 1976; Mineev and Efremova, 1976; Pavlov, 1984).

Recently, in the purpose of improving of technological quality of grain and flour, the nitrogen nutrition of wheat (through root and above organs) at the late phases of development, during the heading stage and later were used (Finney et al., 1957; Djokic and Stojanovic, 1981; Hucklesby et al., 1971; Hunter and Stanford, 1973; Karandasov, 1966; Kodanev, 1976; Pavlov, 1984). This nutrition have influence on increasing of grain protein content.

The investigation showed that protein content was in negative correlation with yield. So, at the genotypes with high yield are characterized with low protein content and vice versa (Terman et al., 1969; Pavlov, 1979; Djokic, 1974).

In this work influence of fertilization on wheat protein content and ratio of protein content and yield were studied.

Material and methods

The investigation of wheat fertilization was carried out on experimental field of Institute for Small Grains on smonitza soil type (vertisol) deficient in available nitrogen, phosphorous and supplied in available potassium. For this study the long-term stationary experiment was designed. The winter wheat KG-56 cultivars was used for experiment. The experiment comprised two field on which were rotated crops of corn and wheat. In 1970 year on the one field and in 1977 year on the other field experiments were established. During 1971-1990 year investigation were carried out. The experiment consisted several variation of fertilization:

1. Control variant - non fertilized; 2. Nitrogen fertilization; 3. $NP_1^+K^+$; 4. $NP_2^+K^+$; 5. NP_1K; 6. NP_2K; 7. NP_1^+; 8. NP_1; 9. NK.

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periodical application (in 1980 and in 1985) of certain fertilizers rates:

P_1^+= 400 kg P_2O_5/ha,	P_2^+= 800 kg P_2O_5 /ha,	K^+= 400 kg K_2O/ha
P_1 = 80 kg P_2O_5/ha,	P_2 = 60 kg P_2O_5 /ha,	K= 100 kg K_2O/ha
N_1 = 120 kg N/ha,	N_2 = 150 kg N /ha	

The phosphorus and potassium and half rate of nitrogen before sowing remain rate of nitrogen on the end of winter season before continuing vegetation were added.

The nitrogen content in grain was determined by the kjeldalh method and protein content obtained in multiplication of nitrogen concentration with 5.7 coefficient.

Results

Effect of mineral nutrition

The grain protein content in wheat under fertilization was increased (Tab. 1). The average value of grain protein content obtained on control variant during all period of investigation was 8.9% and variate from 7.9 to 9.9%.

Table 1. Grain protein content wheat

Treatment	1981	1982	1933	1984	1985	1986	1987	1988	1989	1990	Average
	Control										
1	9.3	9.5	8.7	8.2	9.2	8.1	9.9	8.0	8.6	7.9	8.9
	120 kg N/ha										
2	11.7	12.5	11.8	10.0	12.4	10.5	13.2	10.2	12.6	10.8	11.6
3	11.4	12.4	10.5	9.9	11.8	11.0	12.1	10.9	12.8	10.4	11.3
4	10.9	12.1	10.6	9.6	11.6	10.8	12.1	10.0	12.6	9.9	11.1
5	10.9	12.1	10.5	9.8	11.4	10.9	12.0	10.1	12.6	10.5	11.1
6	10.9	11.8	10.7	10.2	11.2	10.4	12.2	10.8	12.4	10.3	11.1
7	10.7	12.1	10.7	9.7	11.3	10.3	12.3	10.4	12.6	11.0	11.1
8	10.9	12.1	10.7	9.9	11.1	10.8	12.2	11.6	12.6	10.1	11.2
9	11.3	12.4	11.7	10.0	11.9	11.0	12.9	10.9	12.6	10.8	11.6
Lsd 5%	0.7	0.4	0.5	0.6	0.3	0.8	0.5	1.1	0.4	1.0	0.6
1%	1.0	0.5	0.7	0.8	0.5	1.1	0.7	1.5	0.6	1.4	0.9
	150 kg N/ha										
2	11.5	12.9	12.9	11.3	12.9	11.7	13.6	11.4	12.8	12.1	12.3
3	11.8	12.8	11.7	11.2	12.1	11.7	12.9	12.4	13.1	12.4	12.2
4	11.8	12.5	12.9	10.8	12.0	11.3	12.8	11.8	12.6	11.6	12.0
5	11.6	12.9	13.0	10.6	11.9	11.7	12.5	11.8	12.7	11.7	12.1
6	11.7	12.7	13.1	11.2	12.0	11.6	12.7	12.0	12.6	11.7	12.1
7	11.7	12.7	12.0	10.8	11.2	11.0	12.8	11.4	12.8	12.3	12.0
8	11.7	12.5	11.9	12.3	11.7	11.4	12.6	11.6	12.5	11.6	11.9
9	12.1	13.0	13.2	10.9	12.6	11.6	13.6	11.9	12.5	12.4	12.4
Lsd 5%	0.5	0.4	1.4	0.5	0.3	0.4	0.5	0.7	0.7	0.4	0.6
1%	0.7	0.6	1.8	0.7	0.5	0.6	0.6	1.0	0.1	0.6	0.9

Under the fertilization the protein content in average for all variant and all time of investigation was increased and it was 11.3% at the low and 12.4% at the higher rate of nitrogen. In relation to control the increasing was 2.4 and 3.5 of absolute and 28 at the low and 47 of relative percent at the high nitrogen rate. The relative increasing of nitrogen content under fertilization are lagging behind yield increasing and nitrogen accumulation in plant and protein in grain (Table 2.). The increasing of grain protein content depends of variant of fertilization. The highest increasing were obtained in N and K variants. The grain protein content in these variants were similar and varied from 10.0 to 13.2% at the low and from 10.9 to 13.6% at the high nitrogen rate. In average for all period of investigation, protein content was 11.6 at the low and 12.3% at the high rate of nitrogen application. In variants of application combinations phosphorus with nitrogen and nitrogen with potassium, the protein content decreased in relation to variant only of nitrogen fertilization or together nitrogen and potassium. In this group belong variants with high and low rate of phosphorus and variants with application of phosphorus supply and every year application. Among those variants there were no significant differences in grain protein content. In

dependence of variants, which were applicated, the protein content varied between 11.1 and 11.3% at the low and 12.0 and 12.3 at the high nitrogen rate. Tightly higher values of protein content in variant with low rate of phosphorus supply were found.

Influence of year

The grain protein content in all variants have indicate significant variation among years (Table 1. and 2). This differences in average for all variants of nutrition varied from 9.6% in 1984 year to 12.2% in 1989 year at the low rate of nitrogen application and from 11% in 1984 to 13% in 1987 year with high rate of nitrogen application.

Table 2. The average values of all experimental treatments for content and yield of grain proteins, grain yield and amount of nitrogen in plant top (grain + straw)

Year	Grain proteins		Grain yield (kg/ha)	N in yield (kg/ha)
	%	kg/ha		
1981	11.1	620	5.51	143
1982	12.2	667	5.48	149
1983	10.9	456	4.16	107
1984	9.9	553	5.62	123
1985	11.6	559	4.83	117
1986	10.7	496	5.20	118
1987	12.4	455	3.61	103
1988	10.8	587	5.47	132
1989	12.6	479	4.07	117
1990	10.5	547	5.23	123
Average	11.3	451	4.92	123
1981	11.7	701	5.83	166
1982	12.8	718	5.56	166
1983	12.7	541	4.26	127
1984	11.0	644	5.86	151
1985	12.2	576	4.80	132
1986	11.5	553	4.82	132
1987	13.0	484	3.76	119
1988	11.8	650	5.53	147
1989	12.7	416	3.79	107
1990	12.0	693	4.98	135
Average	12.1	587	4.92	138

The lowest value of protein content was 9.5% in 1984 in variant seven (NP_1^+) at the low rate and 10.6% in 1984 year in fifth variant (NP_1K) with high nitrogen rate were applicated.

The highest values of protein content 13.2% in 1987 year in second variant (N) at the low rate and 13.6% in 1987 year in variant nine (NK) at the high rate of nitrogen application. In average for all variants, the lowest grain protein content 9.9% in 1984 at the low and 11% at the high nitrogen rate were

obtained. The highest protein content 12.6% in 1989 at the low and 13.0% in 1987 year at the high rate of nitrogen application were obtained (Table 2.).

Effect of precipitation

The wheat grain protein content showed certain dependence from precipitation and distribution of rainfall during the months May and June. The lowest protein content in year with average rate of precipitation in those two months was obtained. The lowest protein content in 1984, 1986, 1988 year with average precipitation during the May and June 149 mm, 174 mm and 130 mm, were found. The exception was 1990 year in which low value of protein content which characterized with low precipitation during months May and June (74 mm). However this year are characterized meddle quality of rainfall in 3rd decade of Maj 1st and 2nd decade of June month (64 mm). The highest wheat grain protein wheat grain protein content in year with above of average quantity of precipitation in months May and June (1987, 1989 - 203 mm and 251 mm) was obtained. The exception was 1982 year in which above meaddle grain protein content and which characterized under meaddle quantity in May and June and with drought in 1st decade. The drought was decreased in 2nd decade of June month.

Grain protein and yield

In the year (1987, 1989) with lower yield than average yield, the highest protein content were found. However in 1982 the above average protein content was followed with above average yield. In the year with above average yield (1984, 1986, 1988, 1990) the below average protein content were obtained. However, the average protein content in the year (1981) with above average yield and in year 1983 with below average grain yield were found.

The variation of protein content under influence of nutrition within a year are showed negative correlation with grain yield. The low grain yield at the N and NK treatments were connected with high protein content, while high yield in remain treatments were followed with low protein content.

The variation of grain protein content and grain yield under the nitrogen nutrition are showed different their interdependence. The low rate of nitrogen caused increasing of grain protein content and grain yield in relation to control while high rate of nitrogen, in relation to low nitrogen rate, are caused increasing of protein content and there was, no influence on grain yield.

Among average values of protein content variation and grain yield at the all variants of fertilization in years, the high significantly negative correlation (r= -55) were found. The variation of these traits, among a few variants of fertilization in average for all period of investigation indicated tightly expression negative correlation (r= -28) which was not significant. However, in the variants with high and low rate of nitrogen, the average correlation was significant.

In the year with low grain protein content the accumulation of nitrogen in plants and yield of grain protein was high (Table 2.). The exception was first and second year of investigation in which maximal nitrogen accumulation in

plant and yield of grain protein were not followed with low protein content. The average in first and above average in second year was found.

Discussion

The results indicating different influence of some nutrition on grain protein content in wheat. For yield and protein content increasing, main role play nitrogen. Rather good nitrogen nutrition have positive influence on plant activity on more quantity synthesis of assimilate for grain filling. Increasing rate of nitrogen caused parallel increasing grain yield and grain protein content. The relative increasing of nitrogen accumulation in grain is faster than accumulation of dry matter. From there parallel with increasing of yield and grain protein content are increasing. Solely is possible that with lowest rate of nitrogen are appear increasing of yield and decreasing of grain protein content. At the highest rate of nitrogen and with grain protein content above 16% the yield are increased (Pavlov and Mineev, 1984; Pavlov, 1984). Parallel increasing of yield and grain protein content were obtained. The value in this investigation is about 2% of nitrogen (11.4% of protein) which is in agreement with our earlier investigation (Djokic and Lomovic, 1990) and with results of other investigation (Goos et al. 1982). However, there were and lower values than these (Glen et al., 1985).

Grain protein content in wheat can use as indicator for estimation of adequate nitrogen supply during vegetation of wheat (Goss et al., 1982; Glen et al., 1985) what means whether nitrogen deficiency limitied wheat protein content. On the base of this criteria we can determine optimal rate nitrogen for wheat. The optimal rate appropriated to nitrogen rate which are supply maximal yield with lowest concentration of nitrogen (protein) in grain.

In this study analysis per year showed that optimal rate of nitrogen varied between 120 and 150 kg N/ha. In average for all period of investigation 120 kg N/ha was optimal rate because equal yield (4.9 t/ha) in case of application high and low rate of nitrogen was obtained. The protein content of low rate of nitrogen application was 11.4% and in the case of high rate of nitrogen application 12.1%.

It is necessary emphasize that maximal yield is obtaining with protein content which are not supply best technological quality of grain and flour. For the 13% protein content in grain, which is enough for optimal quality, its need about 30 kg N/ha higher than nitrogen rate for obtaining optimal yield. Application of this add rate of nitrogen today are not use in spread production. Since grain quality in wheat is not add paid and there is economics reason, its need consider measures for payment of protein percent in grain with obtaining maximal yield. Increasing of nitrogen rate to optimal rate parallel increase yield and grain protein content.

Decreasing of grain protein content under the phosphorus is result of yield increasing which were not followed with adequate increasing of nitrogen accumulation in grain. That implicated dilution of nitrogen content in grain. This phenomenon can explain on two way. The first is that under the phosphorus assimilation and utilization of nitrogen completely and wheat positive have influence on plant activity (Djokic and Kostic, 1974; Backer and Tucher, 1971;

Mosolova, 1979; Kostic et al., 1990). The second explanation is that phosphorus have direct influence on increasing of assimilate synthesis for grain filling. The negative influence of phosphorus on grain protein content were obtained earlier (Kostic et al., 1990; Kodanev, 1976; Mosolova, 1979; Mineev and Pavlov, 1979; Pavlov, 1984).

The investigation showed that potassium did not have main influence on grain protein content in wheat. However, the study of Kodanev (1976) showed that potassium can influence on increasing grain protein content. The potassium have positive influence on yield and utilization and accumulation of nitrogen in plants and grain. Oftenly the nitrogen accumulation in grain relatively higher increase than accumulation of dry matter in grain what have influence on increasing of nitrogen concentration and protein content. Our result showed that nitrogen concentration in relative similar ratio were increased as well as accumulation of dry matter and nitrogen in grain. So, yield increasing with no changeable grain protein content were obtained.

At the same cultivar, the grain protein content variate in dependence of year, and within year protein content depends from technology and region of growing. Usually that variation are in negative correlation with variation of yield. During favorable year for wheat growing the nitrogen accumulation in grain is lagging behind dry matter accumulation. So, increasing grain yield with decreasing protein content were obtained. During unfavorable conditions decreasing of dry matter accumulation was higher than nitrogen accumulation in grain. The grain nitrogen concentration was increased and yield was decreased.

The negative correlation of protein content and yield were caused by different changes of impact of some source for some matter for grain filling (Kotlyar and Kumakov, 1983; Zenela and Sklyar, 1986; Igoshin and Igoshina, 1987; Djokic, 1985; Pavlov, 1984; Djokic and Lomovic, 1990). Namely, dry matter accumulation in grain mostly depends from photosynthesis, that is photosynthesis during reproductive stage as long as nitrogen accumulation in grain depends in higher part mainly about 2/3 from reutilization of earlier nitrogen accumulate in vegetative organs and with low part 1/3 from current nitrogen absorption. Because of that changes of environmental conditions during reproductive stage which have influence on photosynthesis and nitrogen absorption will have influence on the all changes of yield and protein content. The changes of accumulation of dry matter in grain and nitrogen in grain and above part will have some direction but different intensity. The yield will increase relative higher in favorable conditions and relative higher will decrease in unfavorable conditions than grain nitrogen accumulation. Because of that nitrogen concentration in grain will decrease in favorable and will increase in unfavorable conditions. The negative correlation between yield and grain protein content will a consequence because of that.

In the first respect we are finding illogical conclusion that high protein content in grain are not results of increasing of nitrogen absorption and accumulation in plant, but on the contrary because of decreasing. Only in the case of nitrogen nutrition are controlled is possible cause increasing of nitrogen accumulation in grain, equally or proportionally higher than dry matter accumulation in grain. That will cause increasing of yield and grain protein

content. The increasing of grain protein content will result of increasing nitrogen accumulation in plant.

So, correlation between this two trait can translate from negative into positive what was confirmed results of this investigation.

The results showed that variation of yield and grain protein content under the year and mineral nutrition (excluding nitrogen nutrition) are expressed in negative correlation what is similar as well as variation under the influence genotypes. This is indicating negative correlation between yield and grain protein content which are obtained after modified and genotypes variation of yield and grain protein content with the same nature that is same physiological causes. In both cases, cause of negative correlation is low accumulation and utilization which are not high enough to supply increasing of nitrogen accumulation in grain which followed or exceed yield. Only in case of nitrogen nutrition this regularity is disturb. At the low nitrogen rate in relation to control, the grain nitrogen accumulation relatively higher was increased than dry matter accumulation. This influenced parallel on yield increasing and grain protein content and on expression of positive correlation between these two traits. At the high nitrogen rate in relation to low rate, the grain nitrogen accumulation is increase and yield are not significantly changed, what indicating absence of correlation of two traits. The nitrogen utilization in plant in both cases were reduced. The physiological efficiency and nitrogen harvest index were decreased.

So, we can conclude that main cause of difficulties for the next increasing of yield and protein content in wheat grain there is in limited ability of wheat plant for further increasing and utilization of nitrogen in plant. Nowadays results in wheat selection showed that increasing of grain protein content was on the count of yield decreasing, and yield increasing on the count of dilution of protein content. Nitrogen accumulation of plant and crops were not significant changed. The nitrogen utilization were improved in plant and decreased in crops. Recently, new program with the aim of new genotype creation with more efficiency and accumulation and utilization of nitrogen in plant as well as base for increasing of yield or grain protein content or both of them.

Conclusion

During the full time assayed the protein contents at the variant which are not fertilized in average was 8.9% and varied from 7.5 to 10.5%. Under the influence of fertilizer protein content is increase for 2.4% after low and 3.5% after high nitrogen rate. The highest protein content in N 10% and NK variant 13.2% was obtained and varied from 10.9% after low rate to 13.6% after high rate of nitrogen. In variants of phosphorus combination with nitrogen and phosphorus with nitrogen and potassium the protein content are increased.

Differences among year in protein content values were found. In average for all variant of nutrition protein content varied from 9.5% to 13.5% at the low rate and from 11.0% to 13.6% at the high nitrogen rate. In the year with high precipitation in month May and June and drought during this period, the

highest grain protein content were obtained. In the years with average precipitation during months May and June lowest protein content were obtained.

The variation of protein content in grain wheat was in negative correlation to yield, depends from mineral nutrition and environmental condition in the year. The favorable years for wheat are characterized with low, and unfavorable with high grain protein content.

The results showed that negative correlation between yield and grain protein content, represent limiting factor for the further increasing yield and protein content by using agrotechnical and selection methods. This snags can resolve by new genotypes creation which are more efficient in accumulation and utilization of nitrogen.

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UTICAJ DJUBRENJA NA SADRŽAJ PROTEINA KOD PŠENICE

-originalni naučni rad-

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Rezime

U ovom radu je izučavan uticaj djubrenja na sadržaj proteina u zrnu pšenice i odnos sadržaja proteina i prinosa zrna. Izučavanjem je obuhvaćena sorta pšenice KG-56 u višegodišnjem stacionarnom ogledu na oglednom polju Instituta za strna žita na zemljištu tipa smonica, koje je siromašno pristupačnim azotom, fosforom i kalijumom. Korišćeno je 8 različitih varijanti djubrenja i kontrola (bez djubrenja). Sadržaj azota je analiziran korišćenjem Kjeldalh metode pri čemu su dobijene koncentracije azota umnožene sa koeficijentom 5,7 i dobijene vrednosti sadraja proteina u zrnu. Rezultati istraživanja su pokazali variranje sadržaja proteina u zrnu u zavisnosti od varijante djubrenja, načina prihranjivanja i klimatskih uslova u toku godine. U kontrolnoj varijanti u toku desetogodišnjih analiza prosečna vrednost sadržaja proteina bila je 8,9%. Sadržaj proteina u zrnu bio je veći posle djubrenja i to za 2,5% pri dodavanju niske doze azota a za 3,5% posle visoke doze azota. Najveći sadržaj azota (10%) je dobijen kod N varijante i 13,2% NK varijante a varirao je izmedju 10,9% (pri niskoj dozi azota) i 13,6% pri visokoj dozi azota. Sadržaj proteina se povećava u varijantama fosfora u kombinaciji sa azotom kao i fosfora u kombinaciji sa azotom i kalijumom. Ustanovljeno je da klimatski faktori utiču na vrednost sadržaja azota. Tako je sadržaj proteina u zrnu bio veći u godinama sa većom količinom padavima i periodima suše u toku maja i juna. Ovo ukazuje na važnost zemljišne vlage u povećanju mogućnosti usvajanja mineralnih elemenata u fazi cvetanja i nalivanja zrna kao smenjivanje sa sužnim periodom. Ustanovljena je negativna korelacija izmedju sadržaja proteina i prinosa zrna što predstavlja ograničavajući faktor za istovremeno povećanje prinosa i sadržaja proteina zrna kod pšenice.