



# CHANGE OF YIELD AND BAKING QUALITIES OF WINTER WHEAT GRAIN DEPENDING ON THE YEAR OF GROWING AND PREDECESSOR IN THE CENTRAL FORESTRY OF UKRAINE

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## Abstract

One of the least costly and highly effective ways to increase crop yield and quality of winter wheat is compliance with crop rotation and the selection of best preceding crops. Unfortunately, in modern conditions of intensive agricultural production, it is difficult to do this.

The purpose of our research was to study the formation of the yield and grain quality of soft winter wheat (*Triticum aestivum* L.) Zolotokolosa variety depending on the conditions of the year with different predecessors. We also studied the effect of these factors on the grain quality when cultivating winter wheat under the conditions of the Scientific and Production Center (SPC) of Bila Tserkva National Agrarian University (BTNAU).

The use of predecessors with late harvesting dates, which strongly dry the soil during the sowing period, leads to a significant reduction in yield on 14.3-26.5 dt/ha. This is on 20.0-36.9% less than after peas for grain. The best yields were obtained with such predecessors as peas and rape, that early clear the field: growing winter wheat after them contributed to yield in average 71.4-71.9 dt/ha per four years. The part of the predecessor's effect on the value of yield is 82.36%, and the year of cultivation is 14.83%.

The right choice of predecessors increases yields and improves quality of the grain. Such important for the baking industry indicators as gluten and protein rise.

**Key words:** winter wheat, predecessor, variety, yield, nature of grain, vitreousness, 1000 grains weight, gluten, protein, amino acids.

## Introduction

One of the main conditions of cultivation winter wheat grain in the Forest-Steppe of Ukraine is to increase its quality.

The grain quality is significantly depends on the weather conditions (which in recent years are quite unstable), content of nutrients in the soil and the conditions of mineral and organic nutrition of plants, integrated plant protection and winter wheat varieties.

It is known that a large amount of precipitation in the heading stage contributes to the increase in winter wheat Linlin Wang *et al.*, (2018) yield due to augmentation of starch synthesis and other non-nitrogenous substances. However, the insufficiently high level of nitrogen and other

nutrients in the soil and plants during the formation and filling the grain leads to a decrease in the amount of protein in the grain due to the so-called "growth dilution".

Among all the cereals, winter wheat is most demanding for predecessors (Lykhochvor *et al.* 2008; Tyshchenko). Growing winter wheat after better predecessors provides a significant increase in yield (Sabluk *et al.*, 2007).

In Ukraine, there are several reasons that make selection of the best predecessors and compliance with crop rotation complicated – this is a significant increase of area under the so-called commercial crops (in 2017 sunflower and corn took 38.1% of agricultural lands) (Prokopenko, 2018), which are worse predecessors for almost all crops.

More than 20 years ago, it was considered that the maximum allowable area under sunflower in Ukraine is 1.5 million hectares, and in 2016–2017 the area of their sowing increased more than fourfold and amounted to 6.073–6.033 mln ha (Prokopenko, 2018). Significant decrease in the number of cattle has led to a substantial reduction of areas under such traditional predecessors of winter wheat as peas (410.6 thsd ha), perennial grasses (950.3 thsd ha), sainfoin, corn for green fodder (260.2 thousand thsd ha) (Prokopenko, 2017). Land sharing and transfer of agricultural land from one producer to another lead to the impossibility of creating a crop rotation. Many producers of agricultural products have 100% saturation of crop rotation with cereal crops, which prevents the selection of not only the best but even good predecessor for winter wheat.

All these problems of growing winter wheat are accompanied by more significant climate change. During the last 10 years in the Central Forest Steppe of Ukraine, according to the data of the Bila Tserkva Meteorological Station, favorable conditions for sowing at the end of September were marked only in 2008 and 2013 years, when precipitations exceeded 50 mm per month. In other years during the sowing period it was dry; this delayed germination and led to the liquefaction of crops.

Reforming of agro-industrial production caused significant changes in the structure of the crop area, which resulted in a substantial reduction in peas sowing and crops which previously used for feed purposes (annual and perennial bean and cereal grasses, corn on green fodder) and were good predecessors for winter wheat (Fedorova *et al.*, 1985).

The best predecessors of winter wheat create more favorable conditions for moisturizing and provide nutrients in an easily accessible form at the beginning of autumn vegetation, and this is the main condition for increasing its winter resistance and yield (Kutsenko and Liashenko, 2008).

When wheat is placed after wheat and other stubble predecessors, it is significantly affected by pests and diseases, which leads to considerable liquefaction of crops even in the fall (Buhai, 1969).

When cultivating early-maturing and medium-early maturing varieties of soybean in the case of timely and qualitative soil preparation after harvesting before winter cereals sowing, there are all the necessary conditions to obtain valuable seedlings (Babych and Poberezhna, 2000).

### **The purpose and tasks of the research**

In our work, we investigated the effect of predecessors on the yield and baking quality of the soft winter wheat (*Triticum aestivum* L.) Zolotokolosa variety

cultivated at the SPC of BTNAU in 2013-2016.

Currently, six main crops (winter wheat, corn for grain, soybeans, sunflower, barley and winter rape) occupy about 90% of the arable land in the Forest-Steppe of Ukraine, and they are not the best predecessors, some of them were considered 15-20 years ago inadmissible. So for producers it is getting more and more difficult to choose predecessors, and we decided to explore all the mentioned above crops, as well as white mustard and peas for grain.

### **Materials and Methods**

At the SPC of Bila Tserkva National Agrarian University, the soil cover is quite diverse, due to the heterogeneity of natural conditions that have considerably affected the processes of soil formation. Different subtypes of chernozem, gray forest and dark-gray soils predominate in the soil structure.

The soil of crop rotation, where the research was conducted, is a typical low-humus, coarse-dust medium-loamy granulometric composition.

According to the conducted agrochemical analysis, the soil was characterized by the following indexes in arable (0-30 cm) layer: humus content-3.23%; easily hydrolyzed nitrogen-7.6 mg; available phosphorus-13.9 mg; mobile form of potassium-15.1 mg/100 g soil; the amount of absorbed bases is 25.3 mg-eq; the hydrolytic acidity is 2.15 mg-eq/100g soil.

The given data indicate that the soils of BTNAU are relatively fertile and low-humus. Reaction of soil solution is weak acid.

The winter wheat Zolotokolosa variety was sown after all predecessors at the same time in optimal terms with the seed rate 5.5 mln/ha. Main soil tillage is plowing 20-22 cm depth with phosphorus and potassium fertilizers – 60 kg/ha active substance. Nitrogen fertilizers were added to the fertilizing on permafrost soil-30 kg/ha active substance, and in the beginning of boot stage-60 kg/ha active substance. Harvesting was made with combine SAMPO-500.

The total area of the plots is 5000m<sup>2</sup>; accounting area is 50m<sup>2</sup>, the repetition of the experiment is three-fold.

The quality of winter wheat grain by the main parameters (weight of 1000 grains, nature, vitreousness, gluten) was determined according to Ukrainian national standardization system 4138-2002 and corresponding methods, protein-according to Barnshtein. Mathematical data processing was carried out by the dispersion method using a PC.

### Results and Discussion

We have found that predecessors had a significant effect on the yield of winter wheat grain (Table 1).

The best predecessors were peas for grain and winter

**Table 1:** Yield of winter wheat Zolotokolosa variety after different predecessors, t/ha

Predecessors	2013	2014	2015	2016	Mean	+/- control
Peas for grain (control)	6,81	6,84	7,28	7,81	7,19	-
Winter rape	6,82	6,79	7,30	7,65	7,14	0,05
White mustard	6,41	6,52	6,72	7,15	6,70	0,49
Winter barley	5,28	5,45	5,67	5,99	5,60	1,59
Winter wheat	5,52	5,36	6,04	6,35	5,82	1,37
Soybean	6,00	6,27	6,44	6,81	6,38	0,81
Corn for grain (FAO 220)	5,39	5,45	5,99	6,22	5,76	1,43
Sunflower	4,02	4,13	4,65	5,34	4,54	2,65
LSD <sub>05</sub> , t/ha	0,229	0,207	0,259	0,337	-	-
	LSD <sub>AB</sub> -0,241, LSD <sub>A</sub> -0,085, LSD <sub>B</sub> -0,121					

rape (Christian *et al.*, 2018), after which the average grain yield of wheat for four years was 7.14-7.19 t/ha. In our opinion, this is primarily due to the accumulation of moisture in the soil, because almost three months (July, August and September) before winter wheat sowing (September 30) that was fallow land, similar data were obtained at the Bila Tserkva Selection and Research Station (Buzynnyi, 2015).

A noticeable decrease in wheat yield is observed in sowing after late harvesting crops-corn on grains and sunflower, compared with the predecessors such as peas and white mustard. These variants had yield lower on 1.43-2.65 t/ha compared to control. Polish scientist I. Konopka and others (2006) investigated that winter wheat, sown after the winter rape, had a significantly higher yield of biomass and grain, than after corn (Konopka *et al.*, 2006).

In our studies, significant (-36.9%) decrease in grain yield was observed when sowing wheat after sunflower, due to essentially less moisture in the arable layer and the negative reaction of winter wheat to late tillage after harvesting the predecessor (Buhai, 1969).

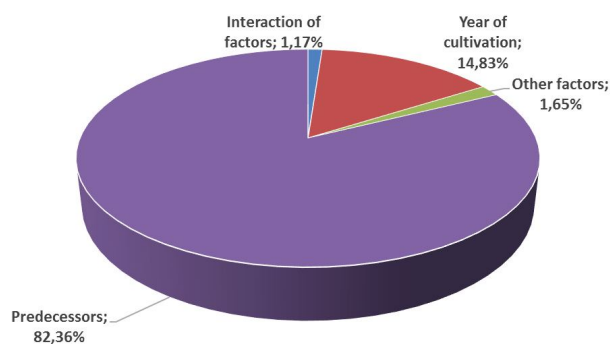
Lower yields are also obtained when using winter wheat and barley as predecessors. In these variants, the yield compared to control is lower on 1.91-2.21% and 1.37-1.59 t/ha.

K. Sieling (2005) asserts that wheat, cultivating after wheat, reduces yield primarily due to a decrease in productive tillering and a reduction in 1000 grains weight (K. Sieling *et al.*, 2005).

Analysis of meteorological conditions shows that the

most optimal weather was in 2016. In this year, the increase in yield was in average 11.5-32.8%, compared to the least favorable 2013. The largest increase in grain yield, depending on the conditions of the year, was observed in the cultivation wheat after sunflower-1.32 t/ha.

Dispersion analysis shows that the selection of predecessor has the most effect on winter wheat yield, the part of this effect is 82.36%, and the conditions of the year has significantly less effect-14.83%, although the years varied considerably on the amount of precipitation during the vegetation period and temperature conditions. Effect of other factors -1.65% and interaction of factors 1.17% is rather insignificant and is within the limits of error.



**Fig. 1:** Effect of investigated factors on the yield of winter wheat Zolotokolosa variety

The predecessors and weather conditions had an effect not only on the yield, but also on the quality of winter wheat grain.

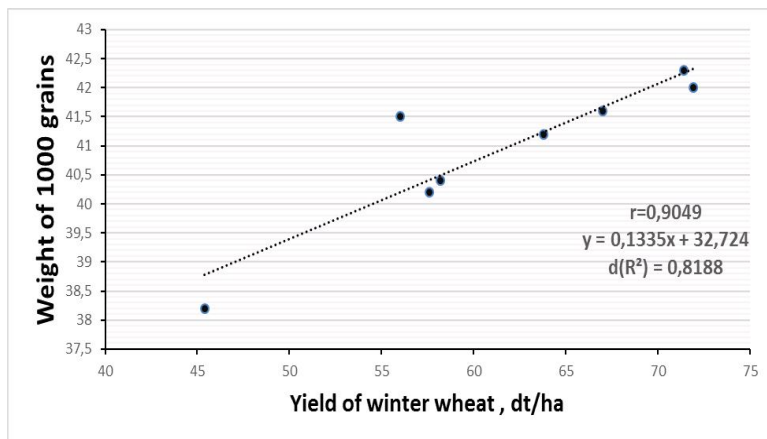
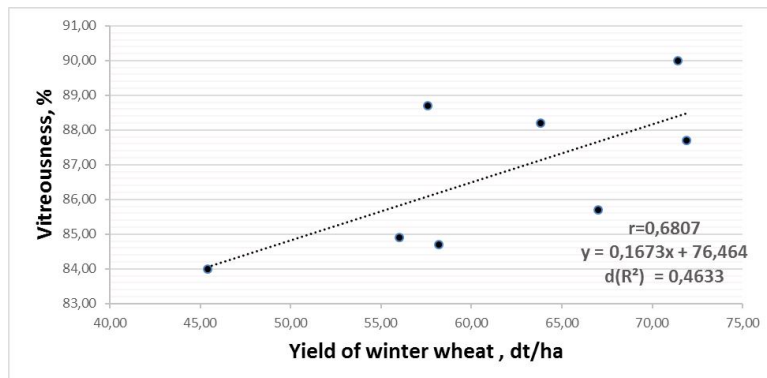
The grain size slightly depended on predecessors, but varied greatly over the years. The largest and high-nature grain was formed in 2016, when its filling occurred with good moisture providing of plants. If during the period of grain filling there was a drought with high daily temperatures (2013), the grain after some predecessors was small, dull and weak.

The nature of winter wheat grain was higher in control after peas, as well as soybeans and winter rape-760.7-765.8 g/l. The nature of grain less than 760 g/l was after sowing white mustard, barley, winter wheat and corn for grain. The lowest nature was after sunflower-749.3 g/l.

Weight of 1000 grains was the best after predecessors of *Fabaceae* and *Brassicaceae* families-41.2-42.3 g. Less than 40 g of 1000 grains weight in winter wheat

**Table 2:** Physical indexes of winter wheat grain quality for 2013-2016 years

Predecessors	The nature of winter wheat grain, Г/П	Weight of 1000 grains	Vitreousness
Peas for grain (control)	765,8	42,0	87,7
Winter rape	764,0	42,3	90,0
White mustard	755,9	41,6	85,7
Winter barley	750,9	41,5	84,9
Winter wheat	752,3	40,4	84,7
Soybean	760,7	41,2	88,2
Corn for grain (Fao 220)	752,6	40,2	88,7
Sunflower	749,3	38,2	84,0
LSD <sub>05</sub>	1,65	1,12	1,51

**Fig. 2:** Correlation between the yield of winter wheat and the weight of 1000 grains**Fig. 3:** Correlation between the yield of winter wheat and the vitreousness

was only after sunflower-38,2 g.

The vitreousness after all predecessors was higher in dry conditions (2013 and 2015 yrs)-about 90%, in more humid 2016 it was slightly lower-78.1-82.2%.

When sowing wheat after winter rape, for four years, vitreousness was 90.0%. High vitreousness was also formed when sowing after soybeans and corn-88.2-88.7%. In Zolotokolosa variety, the average vitreousness for the years of research varies from 1.3 to 6.0% depending on the predecessor, which is, in our opinion, a

rather low difference.

Correlation between the yield and the weight of 1000 grains in Zolotokolosa variety (Fig. 2) is quite high  $r = 0.9049$ ; and the coefficient of determination  $R^2 = 0.8188$  points on the strong dependence between yield and 1000 grains weight.

The correlation between yield and vitreousness is  $r = 0.6807$  (Fig. 3), and there is a direct dependence between these indices; the determination coefficient is  $r^2 (d) = 0.4633$ .

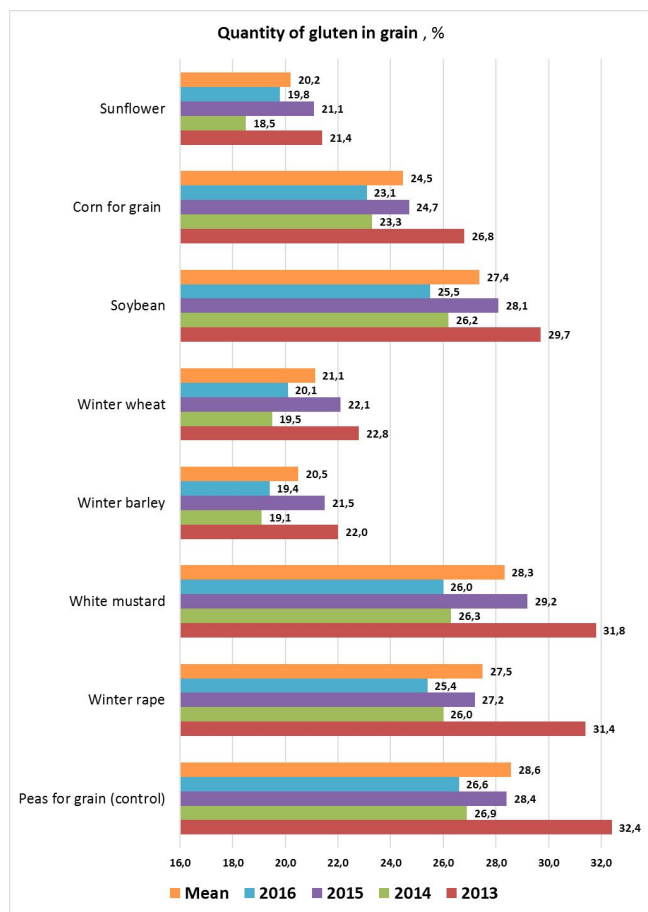
The most important technological indexes of wheat grain quality are the content of gluten and protein. More protein and gluten were in the grain of wheat grown after legume crops, and less content-after non-fallow crops, especially cereal predecessors and sunflower.

The content of gluten in wheat grains was higher in dry conditions during 2013 and 2015 years. If the last two months before harvesting were sufficiently moist, the amount of gluten in the grain decreased. The best predecessors that had a significant effect on the gluten content of winter wheat were peas and white mustard (Fig. 4).

A significant fluctuation in the amount of gluten in the grain, depending on the predecessor and the year of cultivation, has been established. So in 2013, the variability of this index was 0.6-11.0%, and in 2016-0.4-6.2%.

The best predecessor, which contributed to the growth of gluten in wheat grain, is peas for grain. In average for four years after peas, the amount of gluten was 28.6%. A high amount of gluten was observed after white mustard-28.3%, winter rape-27.5%, and soybeans for grain-27.4%. The low amount of gluten in the grain was when sowing winter wheat after stubble predecessors-winter wheat 21.1% and winter barley 20.5%. The worst predecessor for forming gluten in wheat grain was sunflower with a variation depending on the year 18.5-21.4% and in average over four years 20.2%; that is, grain with this amount of gluten did not even match the third grade and it could be used only for fodder.

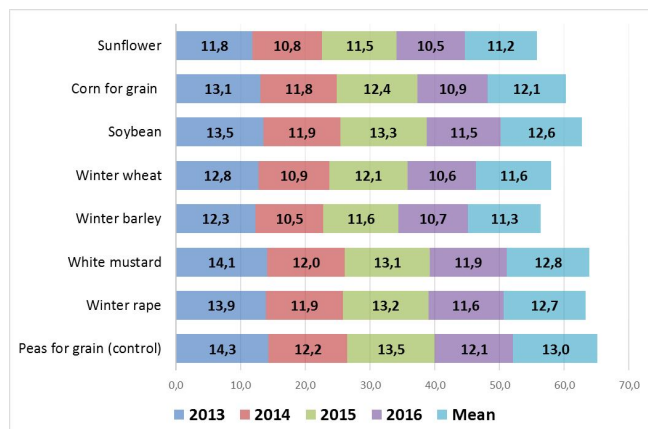
The best conditions for obtaining a high yield of high-protein grain are due to the good supply of plants with nitrogen, some deficiency of accessible moisture and elevated temperatures



**Fig. 4:** Quantity of gluten in grain of winter wheat Zolotokolosa variety depending on the year of cultivation and predecessor

during the period of grain filling [15].

As a rule, grain with high gluten content had more protein. A high-protein grain was after all (especially preferred) predecessors of winter wheat in 2013 and 2015 years. Content of protein and gluten in wheat grain meets the parameters of strong wheat when sowing after peas,



**Fig. 5:** Content of protein in the grain of winter wheat Zolotokolosa variety depending on the year of growing and predecessor

white mustard, winter rape and soybean (Fig. 5).

The content of protein after these predecessors was 13.5-14.3% in 2013 and 13.1-13.5% in 2015. For all years of cultivation, the largest amount of protein in grain was formed when sowing winter wheat after peas for grain – 12.1-14.3%.

Significantly less amount of protein in winter wheat grain was formed in damper 2014 and 2016, especially when sowing winter wheat after sunflower, winter barley and winter wheat. After these predecessors, the protein content was less than 11.0%, fluctuating within 10.5-10.9%. The worst among all predecessors that have an effect on the accumulation of protein was sunflower. After this predecessor it was a minimum average content of protein for four years-11.2%, and the variation of protein, depending on the year, was 0.3-0.7%. The largest variation in the protein content was observed when growing wheat after the white mustard-0.3-1.3%.

Such a biochemical index of grain quality as a protein is a rather varied feature, which depends on many factors, and one of the main is crop rotation (Bakaeva and Saltykova, 2007).

The highest collection of protein per hectare was when cultivating wheat after peas-9.35 centners/ha, the minimum-when sowing after sunflower-5.08 centners/ha. If we take protein output from 1 hectare of wheat, sowing it after peas for grain, as 100%, we obtain 96.98 and 91.72% after winter wheat and white mustard, after soybeans and corn for grain-85.98 and 74.54 %, and after winter barley, winter wheat and sunflower-72,21; 67.68 and 54.38%.

### Conclusion

1. The selection of predecessors for winter wheat significantly affects the value of yield, the difference in yield between the best and the worst predecessor in our research is up to 66.9%, or 25.6 centners/ha.
2. Variation of yield is 3.1-12.1 centners per hectare, depending on the year of cultivation, which confirm the calculations of part effect. The selection of predecessor has the most effect on its value- 82.36%, and the year of cultivation significantly less-14.83%.
3. Correlation is high between the yield and weigh of 1000 grains ( $r = 0.9049$ ) and average between the yield and vitreousness ( $r = 0.6807$ ).
4. More gluten and protein in winter wheat grain form under more dry conditions during the period of filling the grain and ripening. The most favourable conditions that affected the quality of grain were in 2013. Analyzing predecessors, the highest quality indexes

were noted when sowing wheat after peas for grain, amount of gluten in grain higher than after other predecessors-1.05-29.27%, and amount of protein-1.54-13.85%.

5. According to the results of research, we recommend sowing winter wheat Zolotokolosa variety after peas for grain, winter rape and white mustard; these variants give the highest yield and quality of grain.

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