

Evaluation of common wheat (*Triticum aestivum* L.) in respond to different types of fertilization

Albena Ivanova*, Dragomir Plamenov, Pavlina Naskova, Plamena Yankova

Technical University-Varna, Varna, Bulgaria

*E-mail: a.ivanova@tu-varna.bg

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Abstract

The topic of the role of fertilization, as the main agrotechnical factor for the realization of the productivity and quality of the grain in wheat, is the subject of a huge scientific and research work. In 2020-2021, two field experiments were carried out in parallel: at the field of study and experience of the Department of "Plant Production" at the Technical University - Varna and in the land of Krushari village, Krushari municipality, Dobrich region. The experiment was carried out in two replications with a plot size of 12 m² and a sowing rate of 600 germinated seeds/ m². Sowing was carried out on 06.11.2020 with winter common wheat variety Sladuna (selection of the Dobrudzha Agricultural Institute - General Toshevo). The experimental scheme includes a control variant without fertilization, a variant with foliar fertilization and a variant with soil fertilization. The following characteristics were determined: grain yield in kg/da (GY), thousand kernel weight in g (TKW) and test weight in kg (TestW). A biochemical analysis of the wheat grain was carried out and the content of protein, starch and ash substances was determined. It has been established that the independent action of the factors point (environmental conditions) and fertilization has a strong influence on the formation of the traits studied in wheat. The main agrotechnical factor for forming the amount of grain yield and protein content is applied fertilization. In both research points, foliar fertilization led to a greater increase in the values of the studied indicators compared to soil fertilization. At the Technical University-Varna, the environmental conditions have proven to be more favorable for the appearance of the investigated wheat traits.

Key words: wheat; foliar fertilization; soil fertilization; grain yield; protein

INTRODUCTION

The importance of wheat as a major cereal crop, providing about 20% of calories and protein (Wang et al., 2020; Al-Zubade et al., 2022; Guo et al., 2022), source of energy and nutrients, determines the continuous interest of researchers in the search for methods and means to increase the productivity and quality potential of the wheat grain. As the standard of living increases, the demand for high-quality wheat and for healthy foods in general increases more and more. With the increasing world population, food production need to increase by at least 50% by 2050 to meet the huge consumption (FAO, 2017).

The problem of the role of agrotechnics and fertilization for the realization of the productivity and quality of the grain in different varieties of wheat is the subject of enormous research work. The use of mineral fertilizers helps to increase the yields of the main agricultural crops worldwide by more than 50%. Overuse or unbalanced application of mineral fertilizers leads to serious problems - environmental pollution, reduction of soil fertility and all the resulting negative occurrences. The use of easily digestible and fast-acting fertilizer products in the appropriate form, combination, time and rates of application is essential for improving soil fertility, as it increases the nutrient content of the soil (Malcheva et al., 2018; Tsenov et al., 2021). Numerous studies

have been conducted in which the influence of various fertilizer products such as different methods of application, rates, timings and ratios has been traced throughout the growing season of a wide range of agricultural crops (Yankova et al., 2016; Baqir & Al-Naqeeb, 2019; Naskova et al., 2021; Plamenov et al., 2021; Fathi et al., 2022).

In the trend of gradual reduction of the imported amounts of mineral fertilizers and pesticides with the aim of protecting the environment, in order to increase the productivity of plants and yields, it is necessary to activate the biological components of plants. Therefore, the use of liquid fertilizers turns out to be a good alternative for obtaining quality plant production. Foliar nutrition has a number of advantages over ordinary soil fertilization, some of which are: it creates an opportunity to improve plant nutrition when soil fertilization cannot be relied on to have an effect; allows relatively small amounts of fertilizers to be distributed on the surface of the crop, regardless of the type of crop and the phase of development; the nutritional effect on plants is manifested much faster compared to soil fertilization; allows it to be combined with other agrotechnical measures (Patil & Chetan, 2018; Fahrurrozi et al., 2019; Ferrari et al., 2021; Sura & Al-Hilfy, 2022).

The aim of the present study is to investigate the impact of different fertilization methods (foliar and soil) on the productivity and quality of wheat in two points with contrasting meteorological conditions.

MATERIAL AND METHODS

The experiment was carried out on an educational and experimental field of the "Plant Production" Department at the Technical University-Varna - point 1 (P-1) and in the land of the village of Krushari, Krushari municipality, Dobrich region - point 2 (P-2) in 2020-2021. The experiment was carried out in two replications with a plot size of 12 m² and a sowing rate of 600 germinated seeds/ m². The treatment of the area intended for the experiment consists of a double disking after a sunflower predecessor. Immediately before sowing, the area was leveled and the plots and paths were subsequently shaped. Sowing was carried out on 06.11.2020 with winter common wheat variety Sladuna (selection of the Dobrudzha Agricultural Institute - General Toshevo). The experimental scheme includes a control variant with-

out fertilization, a variant with foliar fertilization and a variant with soil fertilization. In the fertilizer variants for the entire growing season of wheat, the total nitrogen rate in active substance is 18 kg/da. Fertilizers were applied three times: at sowing and twice, as nutrition during the growing season during the tillering (March) and booting (April) phases. In the variants with foliar fertilization, foliar fertilizers from the Burall company were used: ASUAN (with content SO₃-6%, N-30-31%, NH₄⁺-8,2%, NH₂⁻-15-16%, NO₃⁺-6-6,2%) and Burall-NPK Ni (with content N-4%, P-2,5%, K-2,5%, Ni-0,1%). In the variants with soil fertilization, granular fertilizers are used MAP (with content N-11%, P₂O₅-52%) and ammonium nitrate (with content N-34%), as MAP was applied at sowing, and ammonium nitrate as nutrition during the growing season. The following characteristics were determined: grain yield in kg/da (GY), thousand kernel weight in g (TKW) and test weight in kg (TestW). The biochemical analysis of the wheat grain was carried out in the Agroecological Laboratory of the Technical University - Varna according to variants and replications. For this purpose, a NIR-analyzer (Model: DA7200 NIR, Producer: Perten Instruments AB, Sweden) was used, and three grain samples from each replication of the specific fertilizer variant were analyzed for content of protein, starch and ash substances.

The statistical processing of the data was carried out using the SPSS 19 software product.

RESULTS AND DISCUSSION

The productivity and quality of wheat depend on the environmental conditions, the genetic potential of the variety and the applied agricultural techniques. Precipitation, its distribution and combination with temperature conditions during the growing season are a decisive meteorological factor for growth and development (Figure 1). In general, during the growing season of wheat during the study period, the distribution of rainfall in both points is unevenly. The total amount of rainfall for the entire growing season is 620.10 l/m² in the first point and 474.30 l/m² in the second point. Precipitation in the autumn - in the germination-tillering phases and in the first point (P-1) before sowing the wheat, the amount of precipitation was low (33 l/m²) and this slightly delayed its friendly germination. However,

the amount of precipitation for October-March forming the autumn-winter soil moisture reserve during the study period was 384.2 l/m², which helped the development of plants at the beginning of the spring vegetation. In the month of April, when the plants are in the booting phase, the rainfall was 58.3 l/m² and was favorable for the formation of productivity. In the month of May, when the plants move to the next phase of development (ear emergence from boot-anthesis), the amount is again low (22.8 l/m²) and reaches a peak in the month of June of 154.8 l/m², when the grain is poured (milk development).

In the second point (P-2), before wheat sowing, the month of October is characterized by an optimal amount of moisture – 53.75 l/m². This has contributed to uniform and timely germination of the crop. In the following two months (November and December), the amount of precipitation decreased by more than 50% compared to the month of October, respectively 22.75 l/m² and 23.25 l/m². The sum of October-March precipitation forming the autumn-winter soil moisture stock during the study period at this point is 172.3 l/m², which is again more than 50% lower than at the first point. The month of January is almost rainless with record lows for a winter month of just 3.5 l/m². During the spring critical period (April-May) moisture storage is low, 29.5 l/m² and 43.75 l/m² respectively. The amount of precipitation (228.75 l/m²) in the month of June is the highest for the entire vegetation, but it is of no economic importance for wheat productivity.

Regarding the temperature regime, the differences between the two points are greater at the beginning of the wheat vegetation. During its sowing, the average day-night temperature in Technical University-Varna (P-1) was lower by about 5°C (7.1°C) compared to the village of Krushari (P-2), where a value of 12.6°C was measured. In the first point (P-1) after the warm month of October (16.2°C), in the month of November the average day-night temperature dropped to 7.1°C, while in the second point (P-2) the month of November still has a high measured value of 10.5°C, and the average day-night temperature dropped to 3.6°C in December. This is also a prerequisite for the faster garnishing of crops in the village of Krushari (P-2). In the second point (P-2), the month of January stands out, where the average day-night temperature measured is 0.2°C. During the spring period, the month of April remains cooler in the first point (P-1) with a temperature of 8.4°C, and in the second point (P-2) – 10.1°C, i.e. warming started earlier. Spring critical period - is of decisive importance for the growth and development of plants.

Many studies have been carried out, in which the influence of individual agrotechnical factors on the formation of the productivity of different genotypes of wheat and the structural elements of the yield is studied. The yields of common wheat depend on the genetic potential of the variety and the growing conditions - weather conditions and the level of applied agricultural technology. Evaluating the relationship

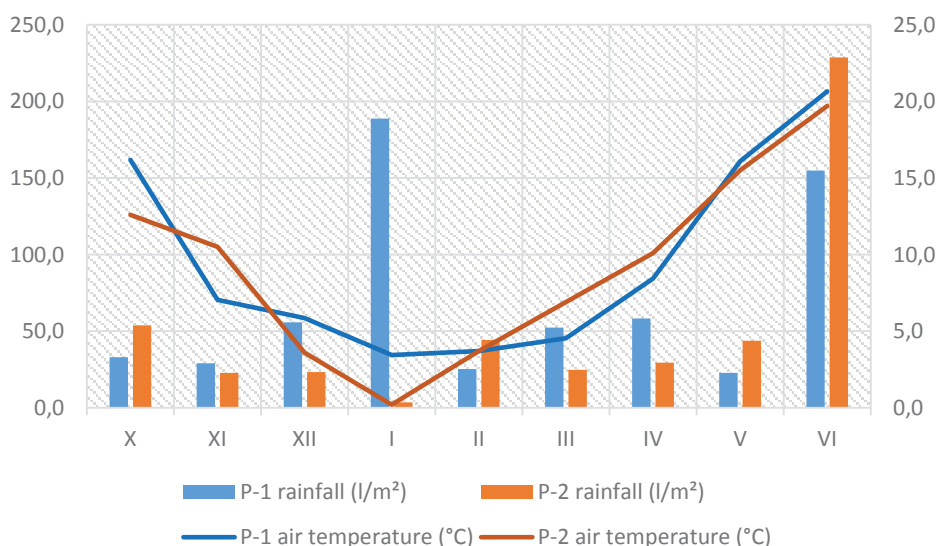


Figure 1. Weather conditions during the study period

between yield and its forming factors is of decisive importance, and it is necessary to clarify the conditions for high efficiency of imported fertilizers. The formation of a high grain yield in wheat is related to the optimization of the applied mineral fertilization depending on the specific soil-climatic conditions of the environment and the type of the predecessor (Rekani et al., 2017; Abdul -Ratha & Jasim, 2018).

The analysis of variances shows the independent influence of the studied factors, as well as the interaction between them in both study points (Table 1). In the present study, the analysis of variance shows that the independent action of the factors fertilization and point is statistically reliable for almost all the indicators studied except the content of ash substances. The data indicate that the grain yield value (GY) and the protein content of the wheat grain are most strongly influenced by fertilization. The location of the experiment (environmental conditions) is the factor that has the greatest influence on thousand kernel weight (TKW), test weight (TestW) and starch content. The combined interaction was not statistically proven, but still had a leading effect on protein, starch and ash content.

Grain yield is an annual total that is determined by the complex interaction of variety with environmental conditions, particularly in latitudes where annual variation in growing conditions is common. Fertilization is an essential and dynamic part of cultivation technology and must be combined with other agrotechnical measures under specific agro-

ecological conditions (Anderson, 2010; Gorjanovic et al., 2010). Fertilization, as an element of agrotechnics, affects the tolerance of agricultural crops, as determining not only the fertilizer norms, but also the ratio of the nutritional elements in them, the way and the period of their application (Atanasov et al., 2019).

In the two investigated points, the type of fertilization (foliar and soil) had a different effect on the obtained grain yield (Figure 2). For 100%, the control variants, where no fertilization was applied, were accepted. Based on them, the effect of foliar and soil fertilization was calculated. At the Technical University-Varna (P-1), two-time foliar feeding during the spring vegetation increased grain yield by 27% compared to the zero control, and mineral fertilization by 11%. In the village of Krushari (P-2), foliar fertilizers increased the yield of grain by 17% compared to the zero control, and granular fertilizers - by 9%. In the first research point (P-1), a greater increase was observed in both types of fertilization compared to the second point (P-2). One of the probable reasons for this is the more favorable weather conditions and in particular the better moisture storage in P-1. Unfavorable conditions in the second point (P-2) led to a smaller increase in the obtained yield in both methods of fertilization. This regularity was also established in our previous studies (Ivanova & Tsenov, 2011; Ivanova et al., 2011). In a field trial conducted by Tsenov et al. (2021) also proved the stronger positive effect

Table 1. Anova of investigated factors.

Source of variation Indicators		Fertilization	Point	Fertilization x Point
GY	SS	71176.433	7342.931	1156.254
	Sig.	0.000	0.017	0.472
TKW	SS	11.050	292.468	0.323
	Sig.	0.095	0.000	0.903
TestW	SS	3.362	11.603	0.122
	Sig.	0.000	0.000	0.254
Protein content	SS	7.502	4.025	0.653
	Sig.	0.000	0.000	0.059
Starch content	SS	14.545	17.424	1.978
	Sig.	0.000	0.000	0.009
Ash content	SS	0.003	0.006	0.012
	Sig.	0.673	0.212	0.222

(+5-10%) of studied organic fertilizers in the form of pellets compared to mineral fertilizers on grain yield in varieties of common winter wheat.

Depending on the type of applied fertilization, the wheat reacted differently in the two research points, as a result of which different values were obtained from the studied traits - yield and quality indicators (Table 2). The quality of the wheat grain can be improved both by selection and by agrotechnical means. While selection methods accumulate permanent and variable favorable properties, agrotechnics are needed to achieve effects quickly and for greater flexibility under different conditions. Protein content is one of the most important indicators characterizing wheat grain quality (Nankova et al., 2020; Sura & Al-Hilfy, 2022).

Quite naturally, in both points, the lowest results were obtained in the control variants, where no fertilization was applied. In the variants where foliar fertilization was applied, the highest values were obtained in both research points. The amount of grain yield (GY), test weight (TestW), protein and starch content are the indicators that, according to the type of applied fertilization, fall into separate statistically proven groups. The difference between the two research points in terms of the shown indicators consists in the fact that in the Technical University-Varna (P-1) the values of these indicators fall into two groups, and in the village of Krushari (P-2) - into three groups. In the first point of the study (P-1), the average yields obtained with soil fertilization are in one statistical group with the non-fertilized version,

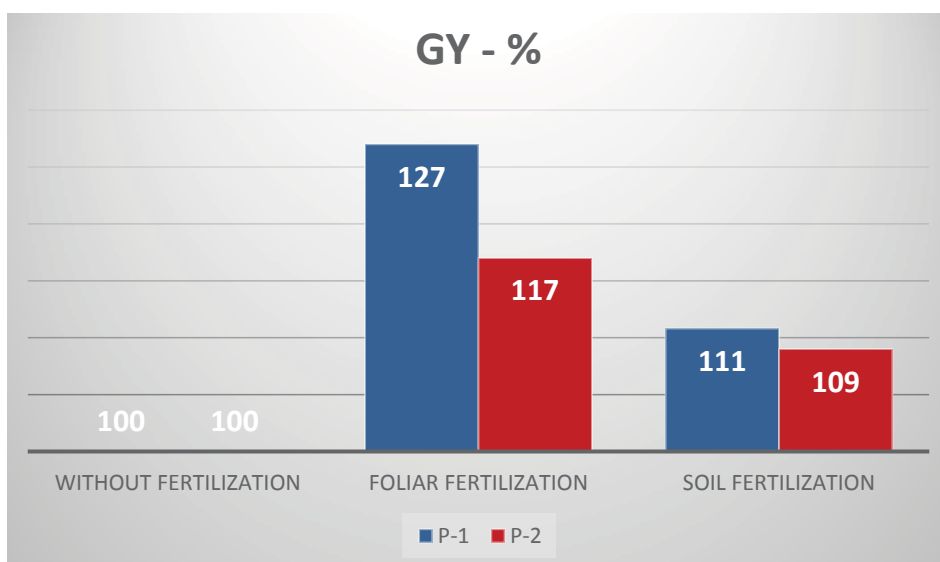


Figure 2. Effect of the type of fertilization on grain yield

Table 2. Means of the indexes according to fertilization in the two research points.

Indicators Fertilization	P-1						
	GY	TKW	TestW	Protein content	Starch content	Ash content	
Without	526.222a	38.94a	83.60a	11.81a	65.87a	1.66a	
Foliar	715.778b	41.02a	84.60b	13.68b	67.31b	1.76a	
Soil	583.111a	40.31a	84.40b	13.02b	67.58b	1.76a	
Indicators Fertilization	P-2						
	Without	464.860a	28.97a	81.35a	10.92a	62.65a	1.80a
	Foliar	650.520c	31.59a	82.75b	12.90c	64.60b	1.76a
	Soil	561.310b	30.09a	82.60b	11.20b	66.28c	1.76a

- the same letter shows not significant difference between the values

while in the second point (P-2) the differences are more clearly emphasized and these signs fall into three statistically reliable groups. This also shows that the favorable environmental conditions in the first research point (P-1) level the differences in the values of the investigated indicators depending on the method of fertilization, while the unfavorable environmental conditions in the second research point (P-2) deepen them and the investigated signs fall into separate statistically reliable groups. The characters thousand kernel weight (TKW) and ash content fall into one group in both study points.

CONCLUSIONS

The independent action of the factors point (environmental conditions) and fertilization has a strong influence on the formation of the traits studied in wheat.

The main agrotechnical factor for forming the amount of grain yield and protein content is applied fertilization.

In both research points, foliar fertilization led to a greater increase in the values of the studied indicators compared to soil fertilization.

At the Technical University-Varna, the environmental conditions have proven to be more favorable for the appearance of the investigated wheat traits.

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