IOCAG 2022
The 1st International Online Conference on Agriculture:
ADVANCES IN AGRICULTURAL SCIENCE AND TECHNOLOGY
10–25 FEBRUARY 2022 | ONLINE

Yield and quality of winter wheat (*Triticum aestivum* L.) depending on multi-component foliar fertilization

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INTRODUCTION

Winter wheat covers a large sown area and yields high grain yields compared to oth-er cereals. Černý et al. [1] emphasize the great needs of this species for both macronutri-ents and micronutrients. They proved that mineral fertilization significantly increased the wheat yield, especially in soils with lower nutrient abundance. Fageria et al. [2] conclude that essential nutrients for crops are applied to the soil to be taken up by the root system. It is also possible to use macronutrients and microelements in the form of foliar fertilizers. It has an important economic and environmental aspect. In agricultural practice, foliar spraying is often preceded by an assessment of the nutritional status of plants and the ar-chitecture of the field. Various methods, both destructive and nondestructive, serve this purpose [3]. Jankowski et al. [4] emphasize that foliar fertilizers allow increasing the yield of wheat without damaging the natural environment.

METHODS AND RESULTS

A field experiment was carried out at the Podkarpackie Agricultural Advisory Center in Boguchwała (21° 57'E, 49° 59'N), Poland. The tests were performed in the 2017/2018 - 2019/2020 seasons. The investigated factor were various variants of winter wheat fertilization, as presented in Table 2. The experiment was performed in a randomized block design with four replications. The RGT Kilimanjaro (RAGT Semences) variety was selected for the study.

The following were selected for foliar fertilization:
- YaraVita Gramitrel contains per g·L^{-1}: 64 nitrogen, 250 magnesium, 50 copper, 150 manganese, 80 zinc,
- YaraVita Kombiphos contains per g·L^{-1}: 440 phosphorus, 75 potassium, 67 magnesium, 10 manganese, 5 zinc,
- YaraVita Thiotrac contains in g·L^{-1}: 200 nitrogen, 750 sulfur.

Table 1. Results of field and laboratory measurements

Parameter	Variant of foliar fertilization							
	A	B	C	D	E	F	G	H
Number of ears (pcs·m^2)	586	588	587	586	590	589	588	589
Number of grains per spike	31.2	31.4	31.5	31.7	32.0	32.2	32.3	32.4
1000 grain weight (g)	41.3^c	41.6^{bc}	41.8^b	42.3^{ab}	42.0^b	42.5^a	42.8^a	42.8^a
Yield (t·ha^{-1})	7.55^c	7.68^{bc}	7.73^b	7.82^{ab}	7.97^{ab}	8.06^{ab}	8.13^a	8.17^a
SPAD	50.3^c	51.2^b	51.0^b	53.8^a	51.4^b	54.2^a	54.0^a	54.4^a
LAI	3.95^c	4.09^a	4.12^a	3.98^b	4.13^a	4.09^a	4.12^a	4.15^a
MTA	57.3^a	55.2^b	55.0^b	53.5^c	55.0^b	53.4^c	53.3^c	53.2^c
Gs	692.2^a	690.2^{ab}	688.4^{ab}	675.2^{ab}	687.2^{ab}	678.6^{ab}	372.2^{ab}	371.3^b
Protein (% DM)	13.8^c	14.2^b	14.2^b	14.6^a	14.2^b	14.7^a	14.7^a	14.8^a
Starch (% DM)	62.4	62.3	62.1	62.3	62.5	61.9	61.5	61.3
Ash (% DM)	1.46	1.48	1.48	1.46	1.49	14.48	1.51	1.50
Fiber (% DM)	2.88^a	2.82^b	2.81^b	2.77^c	2.80^b	2.76^c	2.76^c	2.75^c
P (g·kg^{-1})	3.31	3.28	3.35	3.25	3.36	3.23	3.36	3.34
K (g·kg^{-1})	3.83	3.80	3.86	3.79	3.85	3.78	3.87	3.86
Mg (g·kg^{-1})	1.21	1.28	1.23	1.19	1.32	1.27	1.22	1.30
Cu (mg·kg^{-1})	2.24^b	2.29^a	2.22^a	2.18^b	2.34^a	2.33^a	2.18^a	2.26^a
Mn (mg·kg^{-1})	25.3^b	25.6^a	25.3^a	24.9^b	25.8^a	25.7^a	25.4^a	26.1^a
Zn (mg·kg^{-1})	37.2^b	37.8^a	37.4^a	36.4^b	37.8^a	37.6^a	37.2^a	37.9^a

Table 2. Scheme of diversified fertilization of winter wheat (L·ha^{-1})

Variant of foliar fertilization	Development phase (skale BBCH)			
	BBCH 14	BBCH 28	BBCH 49	BBCH 73
(A) - Control	-	-	-	-
(B) - YaraVita Gramitrel	1	1	1	
(C) - YaraVita Kombiphos	-	4	3	-
(D) - YaraVita Thiotrac	-	-	-	5
(E) - YaraVita Gramitrel+YaraVita Kombiphos	1 + 0	0.5 + 2	0.5 + 2	-
(F) - YaraVita Gramitrel + YaraVita Thiotrac	1	1	1	5
(G) - YaraVita Kombiphos + YaraVita Thiotrac	-	4	3	5
(H) - YaraVita Gramitrel + YaraVita Kombiphos + YaraVita Thiotrac	1 + 0	0.5 + 2	0.5+ 2	5

CONCLUSIONS

Foliar fertilization is a commonly used procedure in plant cultivation. As a result of the experiment, it was shown that both the composition of the fertilizer, the dose and the time of application modify the size and quality of winter wheat grain yield. Therefore, it is important to determine the best variant of foliar fertilization for agricultural practice. The experiment showed that the best results were obtained when combined with three fertilizers in the fall and spring. Smaller effects were obtained after the combined application of two fertilizers and the lowest after the application of a single fertilizer (Table 1).

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