The influence of organic and inorganic chemical compounds to elemental content, bioactive compounds and morphological parameters of some field-grown winter wheat genotypes

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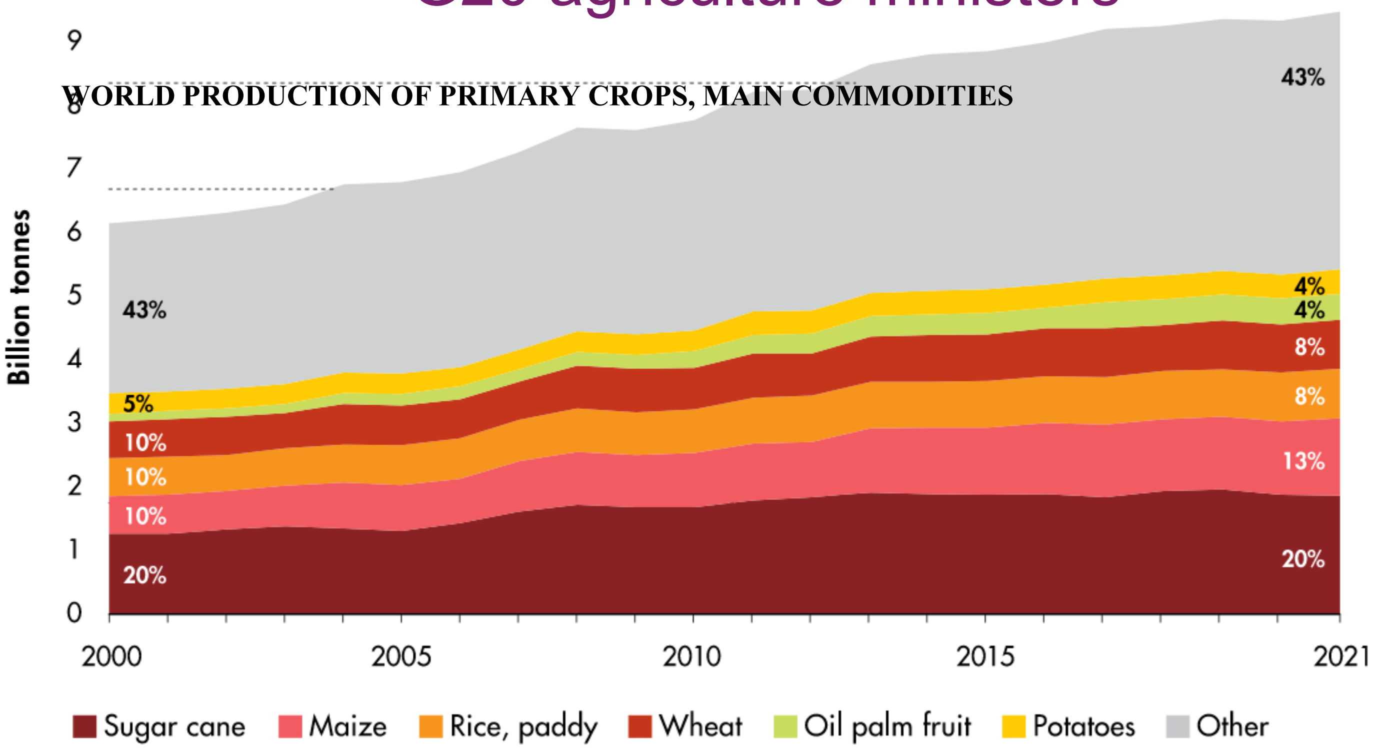
Why wheat?

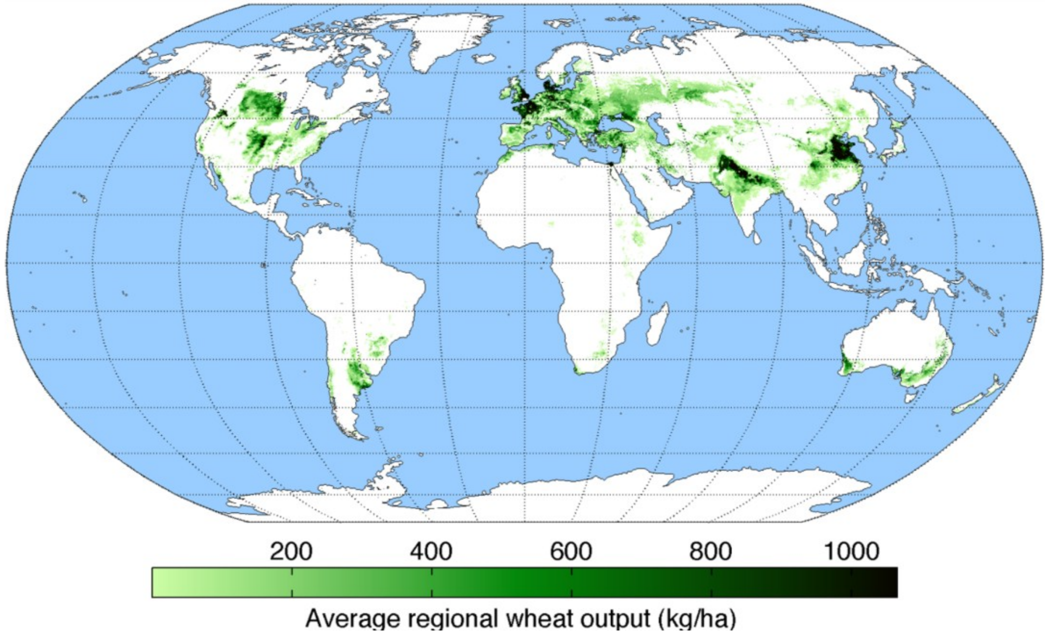
The most widely grown crop in the world

Wheat initiative – proposed by research and funding organizations and endorsed by
G20 agriculture ministers

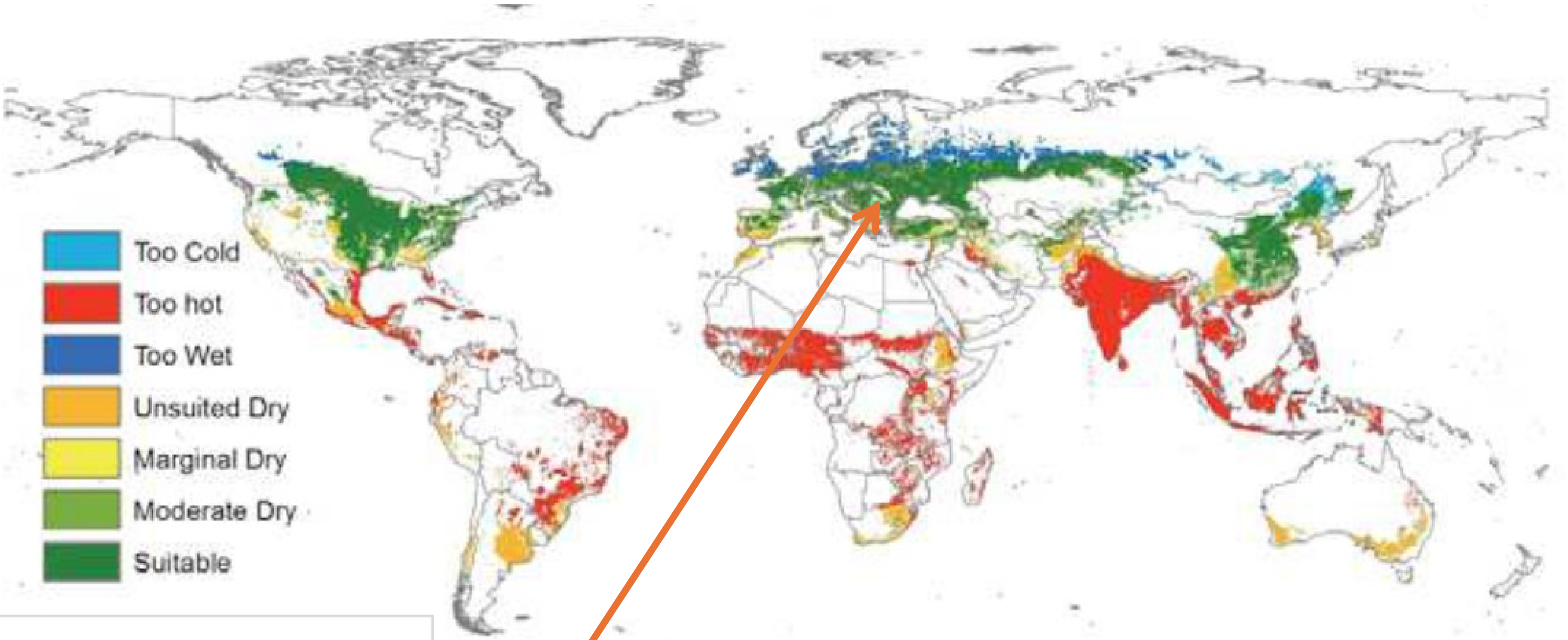
WORLD PRODUCTION OF PRIMARY CROPS, MAIN COMMODITIES

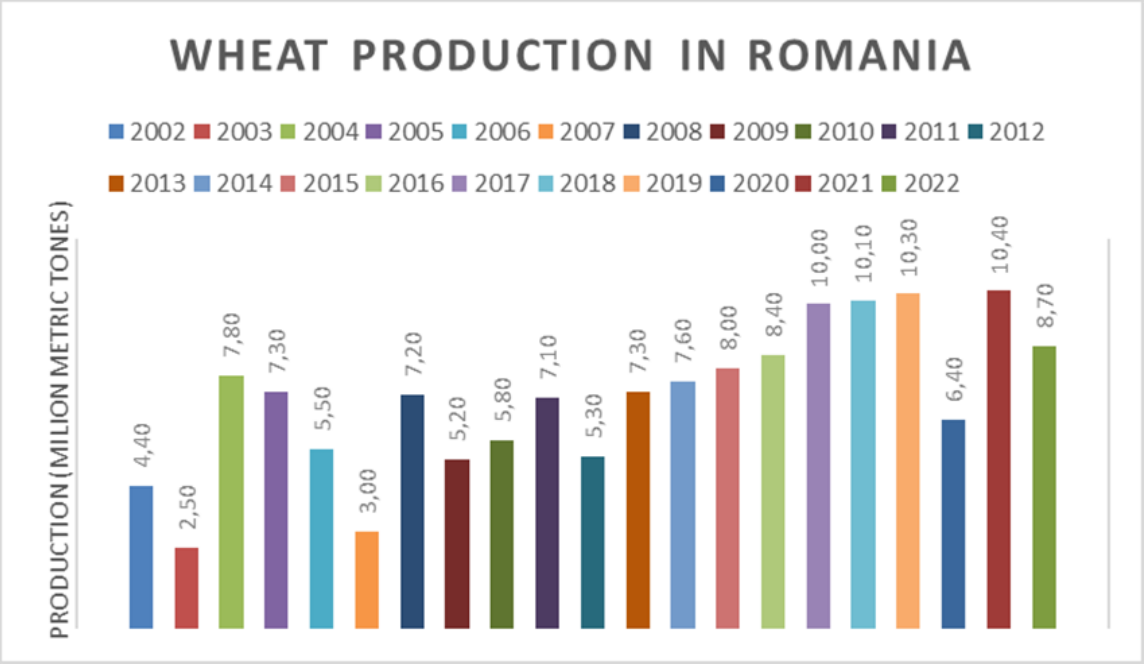


Note: Percentages on the figure indicate the shares in the total; they may not tally due to rounding.
Source: FAO. 2022. Production: Crops and livestock products. In: *FAOSTAT*. Rome. [Cited October 2023].
https://www.fao.org/faostat/en/#data/QCL
Download: https://doi.org/10.4060/cc8166en-fig21



Land sustainability of winter wheat under a high emissions scenario





Romania ~ 10 million tones /year
TOP 20 in the world and TOP 5 in EU

Food and Agriculture Organization

Purpose and conditions of experiment

to test whether genotypes with supposed better adaptability would show better physiological parameters and, ultimately, increased quality and productivity.

8 winter wheat genotypes:

V1: Andrada
V3: Glosa

V2: Ariesan
V4: Izvor

V5: Exotic
V7: Bezostaia longstanding witness

V6: Renan
V8: Apache

Bifactorial experiment

basic mineral fertilization (NPK 50:50:0) applied in autumn after plant emergence

Two foliar treatments applied

at the intensive growth stage (stem elongation)

2.4-D	MME
synthetic auxin 2.4-dichlorophenoxyacetic acid	mixture of microelements
dose 20 ppm	Fe (1000 mg L^{-1}), B, Mn, S and Mg (each of 500 mg L^{-1})

Biochemical parameters
Chlorophyll a **Chl a** (mg/g)
Chlorophyll b **Chl b** (mg/g)
Total carotenoids content **TC** (mg/g)
Total polyphenols content **TP** (mg AG/g)
Total flavonoids content **TF** (mg rutin/g)
Antioxidant capacity **DPPH** (Trolox/g)

Elemental content (µg/g)
18 elements determined by NAA
REGATA@IBR-2 reactor
Na, Mg, Al, Cl, K, Ca, Sc, Mn, Fe,
Zn, Br, Rb, Sr, Mo, Sb, Cs, Ba, Th

Productivity and quality parameters

Productivity
Spike length **SL** (cm)
Number of grains per spike **NrG/S** (pcs/spike)
Grains weight per spike **GW/S** (g/spike)
Weight of 1000 grains **GW** (g)

Quality
Moisture content **M** (%)
Protein content **PROT** (%)
Wet gluten content **Wet Gl** (%)
Zeleny index **ZI** (ml)
Hectolytic mass **HLM** (kg/hl)

Elemental content (µg/g) compared to literature data

Element	Experiment			Literature	Element	Experiment			Literature
	Control	2.4-D	MME			Control	2.4-D	MME	
Na	63-194	72-131	64-112	250-10000	Zn	24,6-31.8	20.5-34.7	22.3-32.7	35.7-200
Mg*	1.8-3.9	1.4-2.7	1.6-3.1	0.079-2.9	Br	37.8-83	28.5-94	37.5-68	7.5-11
Al*	0.15-0.21	0.11-0.21	0.14-0.20	0.0059-0.084	Rb	12.3-18	11.3-20	11.2-18	6.8-88
Cl*	2.1-7.3	1.5-4.5	1.1-3.2	5.5-27	Sr	32-70	39-66	37-64	0.1-37.4
K*	23.5-30	19,2-45	16.4-27	8.6-657	Mo	0.42-1.1	0.44-0.9	0.38-0.87	0.47-2.5
Ca*	5.0-10	5.2-8.1	4.5-8.3	0.05-6.5	Sb	0.01-0.05	0.02-0.05	0.02-0.06	0.02-0.98
Sc	0.01-0.05	0.03-0.05	0.02-0.06	0.01-0.15	Cs	0.03-0.08	0.02-0.09	0.02-0.13	0.01-0.26
Mn	43-85	46-73	38-85	2-44	Ba	38-81	31-77	32-73	9.8-158
Fe*	0.14-0.29	0.12-0.25	0.13-0.32	0.15-1.42	Th	0.020-0.053	0.020-0.067	0.010-0.065	<0.007-0.17

*content in mg/g

Impact of treatments on elemental content compared to control

Significance level	0.1	0.05	0.02
	0.1	0.05	0.02

$$RD(\%) = (Ctreat - Cc) * 100/Cc$$

	Na		Mg		Al		Cl		K		Ca		Sc		Mn		Fe	
	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME
V1	87	13	14	12	32	7	52	52	-8	-18	4	-18	140	94	30	52	37	13
V2	-12	32	47	29	-35	15	50	-31	0,0	-23	4	48	0	107	35	16	36	68
V3	14	-17	-28	-39	-8	-18	-24	-30	-10	11	-25	-40	7	10	-32	-15	12	-2
V4	9	5	-15	-23	-7	-7	-46	-26	-17	-23	-19	-12	96	113	4	6	31	1
V5	44	-2	-3	-42	-30	-24	15	-66	-21	-18	10	-26	58	79	-6	-42	-8	39
V6	-26	-28	-1	26	27	23	9	11	-18	-30	6	24	16	-60	-7	50	-16	-37
V7	-4	-37	-40	-10	-9	-16	-30	-67	69	-3	-40	-22	23	-36	-4	17	31	-28
V8	-22	-49	-32	-36	-14	-19	-26	-82	11	-7	-43	-45	73	82	-25	-36	5	24

	Zn		Br		Rb		Sr		Mo		Sb		Cs		Ba		Th	
	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME
V1	32	-6	20	24	-7	-15	61	12	-36	-65	297	408	-4	20	15	-27	12	-8
V2	6	-13	-16	-40	15	-13	31	44	-25	-22	-27	186	12	222	-43	-4	-20	141
V3	5	-7	-18	-23	29	21	-6	-37	-24	-12	60	3	-5	8	-20	-60	-13	-17
V4	11	-9	-28	10	10	-27	4	-13	61	44	118	212	51	26	2	-17	139	93
V5	7	17	25	23	27	3	9	-20	8	56	-65	-35	-30	-23	-11	18	-17	-3
V6	-27	17	-45	26	-20	-6	-14	28	70	61	9	-26	1	-63	50	92	4	-78
V7	-4	11	13	-51	16	5	-44	-47	27	58	8	-33	-13	-72	-25	-26	60	-55
V8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Impact of treatments on biochemical parameters compared to control

Significance level			
	0.1	0.05	0.02
	0.1	0.05	0.02

$$RD(\%) = (Ctreat - Cc) * 100/Cc$$

	Chl a		Chl b		TC		TP		TF		DPPH	
	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME	2.4-D	MME
V1	29.3	17.1	25.0	16.3	-51.1	10.9	7.8	19.5	14.6	36.6	37.9	50.0
V2	-22.7	-13.5	-22.5	-17.3	-11.6	18.7	14.3	4.0	2.5	2.5	3.0	0.5
V3	-10.2	-20.4	-0.6	-12.8	-99.0	-1.6	-21.5	-27.0	-20.1	-18.6	-37.6	-32.9
V4	-12.7	-16.8	0.0	-11.0	-82.1	-68.6	-24.7	-13.1	-7.5	-9.7	-13.0	-13.2
V5	7.4	-14.0	16.7	-16.8	-86.9	-14.5	10.4	-4.5	35.6	2.2	10.9	-42.7
V6	11.3	22.6	18.8	27.6	-81.1	-52.4	53.7	21.2	69.3	16.9	20.8	-16.6
V7	-5.0	-12.6	-6.6	-17.5	13.5	45.2	21.4	-5.9	19.3	-10.6	41.2	2.6
V8	1.6	-5.4	6.2	2.1	9.3	-39.9	31.8	26.4	26.7	-0.8	15.9	-24.0

Correlation Matrix
Biochemical parameters
for each experimental line

C	*Chl a*					
Chl a	1,00	*Chl b*				
Chl b	**0,98**	1,00	*TC*			
TC			1,00	*TP*		
TP	0,66	0,55		1,00	*TF*	
TF	0,75	0,68		**0,93**	1,00	*DPPH*
DPPH	0,66	0,56		0,82	0,72	1,00

2.4-D	*Chl a*					
Chl a	1,00	*Chl b*				
Chl b	0,74	1,00	*TC*			
TC		-0,59	1,00	*TP*		
TP				1,00	*TF*	
TF				0,80	1,00	*DPPH*
DPPH				0,71	0,77	1,00

MME	*Chl a*					
Chl a	1,00	*Chl b*				
Chl b	0,87	1,00	*TC*			
TC			1,00	*TP*		
TP				1,00	*TF*	
TF				0,74	1,00	*DPPH*
DPPH				0,82	**0,91**	1,00

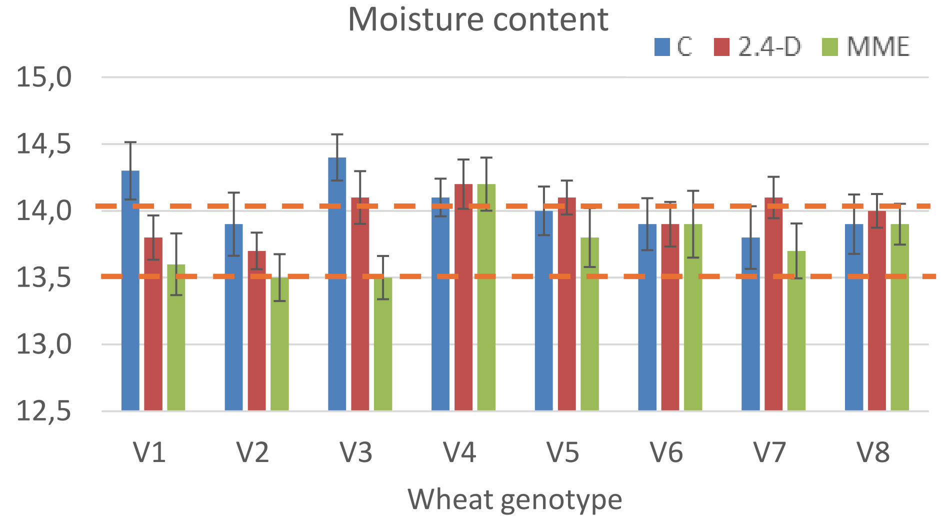
Correlation Matrix
Biochemical parameters vs quality and productivity parameters for each experimental line

C	*M*	*PROT*	*Wet Gl*	*ZI*	*HLM*	*SL*	*NrG/S*	*GW/S*	*GW*
Chl a						-0,58			0,53
Chl b						-0,59			
TC		-0,55	-0,54	-0,67					
TP	0,51					-0,66			
TF					0,66	-0,59			
DPPH									

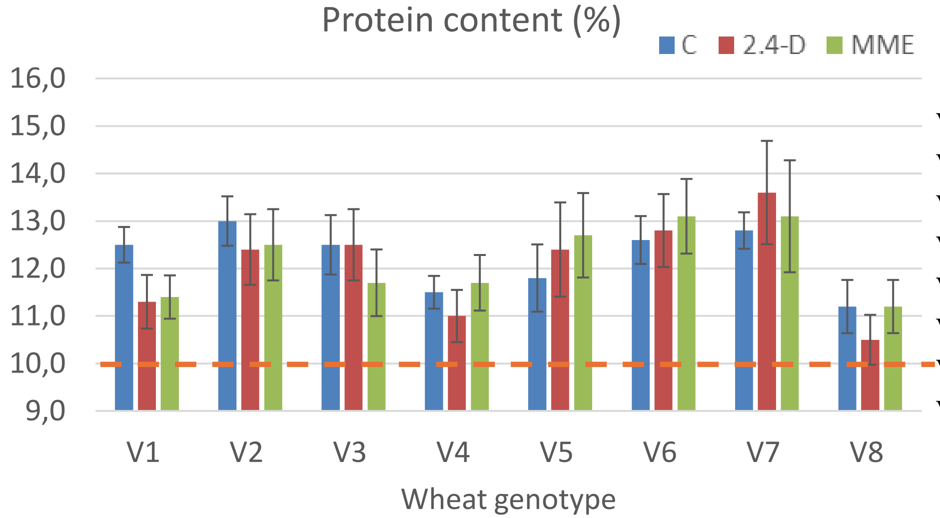
2.4-D	*M*	*PROT*	*Wet Gl*	*ZI*	*HLM*	*SL*	*NrG/S*	*GW/S*	*GW*
Chl a							0,72	0,51	-0,52
Chl b	0,52								-0,62
TC									
TP		0,74	0,75	0,73			-0,58		
TF		0,71	0,71	0,71			-0,74	-0,67	
DPPH		0,57	0,57	0,61			-0,62	-0,65	

MME	*M*	*PROT*	*Wet Gl*	*ZI*	*HLM*	*SL*	*NrG/S*	*GW/S*	*GW*
Chl a						0,62			
Chl b									
TC	-0,72								0,57
TP						0,76			
TF									0,53
DPPH									

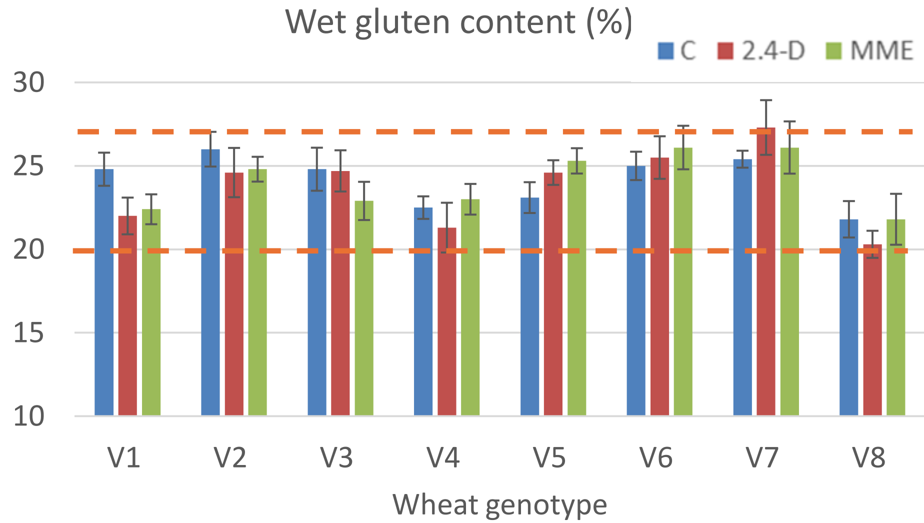
Impact of treatments on quality and productivity parameters compared to control



M	2.4-D	MME
V1	-3,5	-4,9
V2	-1,4	-2,9
V3	-2,1	-6,3
V4	0,7	0,7
V5	0,7	-1,4
V6	0,0	0,0
V7	2,2	-0,7
V8	0,7	0,0



PROT	2.4-D	MME
V1	-9,6	-8,8
V2	-4,6	-3,8
V3	0,0	-6,5
V4	-4,3	1,7
V5	5,1	7,6
V6	1,6	4,0
V7	6,2	2,3
V8	-6,2	0,0

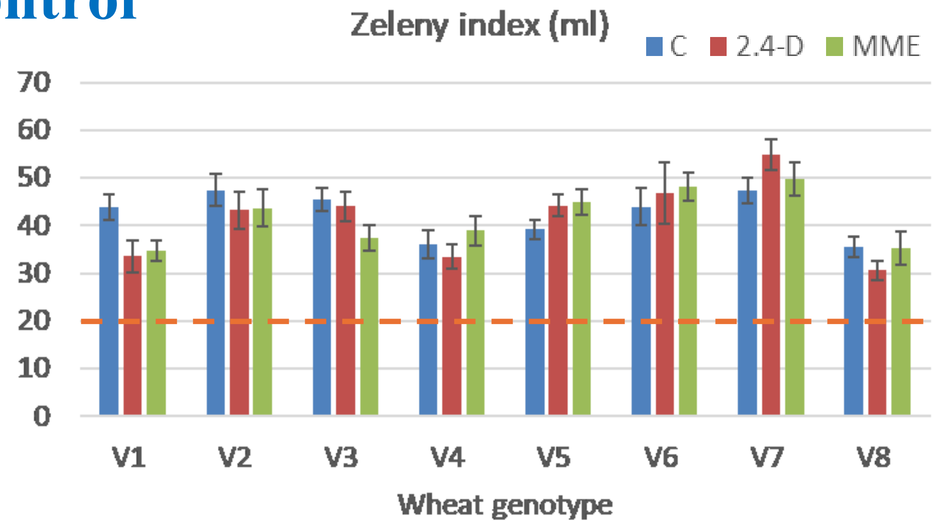


Wet Gl	2.4-D	
V1	-11,3	[illegible]
V2	-5,4	-4,6
V3	-0,4	-7,7
V4	-5,3	2,2
V5	6,5	9,5
V6	2,0	4,4
V7	7,5	2,8
V8	-6,9	0,0

Significance level			
	0.1	0.05	0.02
	0.1	0.05	0.02

$$RD(\%) = (Ctreat - Cc) * 100/Cc$$

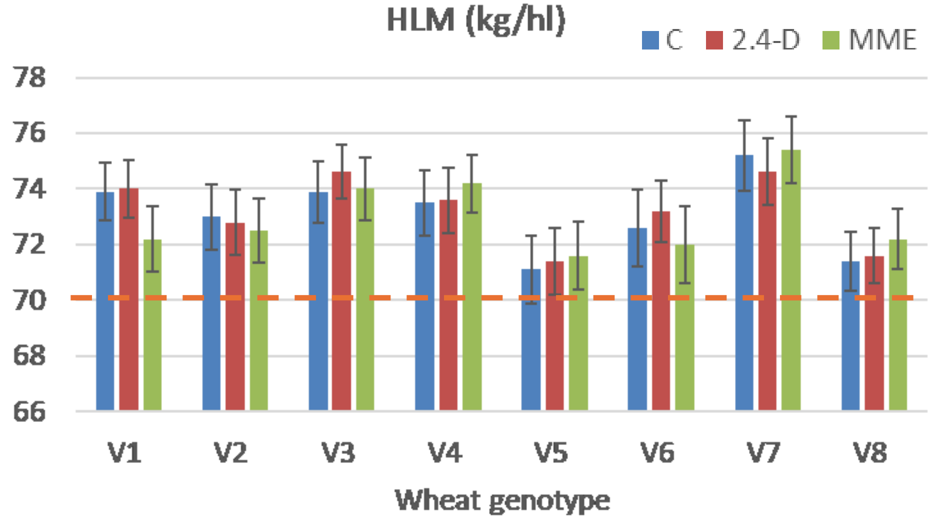
Impact of treatments on quality and productivity parameters compared to control



ZI	2.4-D	MME
V1	-23,3	-20,8
V2	-8,9	-8,0
V3	-3,1	-17,8
V4	-6,9	8,1
V5	12,8	14,5
V6	6,6	9,8
V7	15,9	5,1
V8	-13,8	-0,8

Significance level			
	0.1	0.05	0.02
	0.1	0.05	0.02

$$RD(\%) = (Ctreat - Cc) * 100/Cc$$

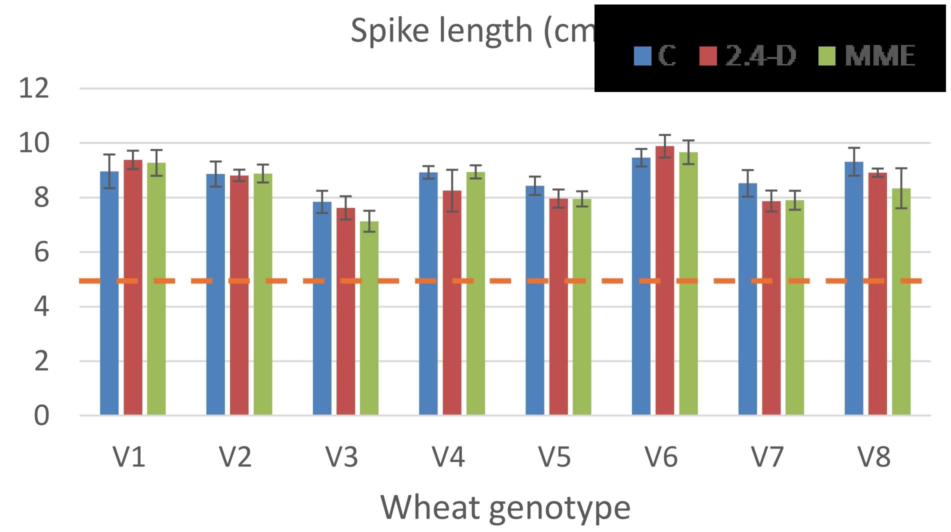


HLM	2.4-D	MME
V1	0,1	-2,3
V2	-0,3	-0,7
V3	0,9	0,1
V4	0,1	1,0
V5	0,4	0,7
V6	0,8	-0,8
V7	-0,8	0,3
V8	0,3	1,1

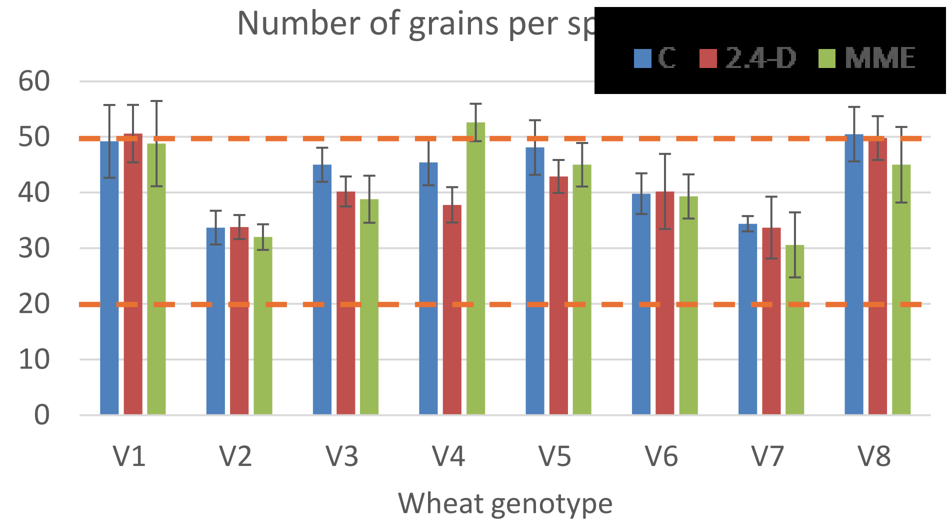
Impact of treatments on quality and productivity parameters compared to control

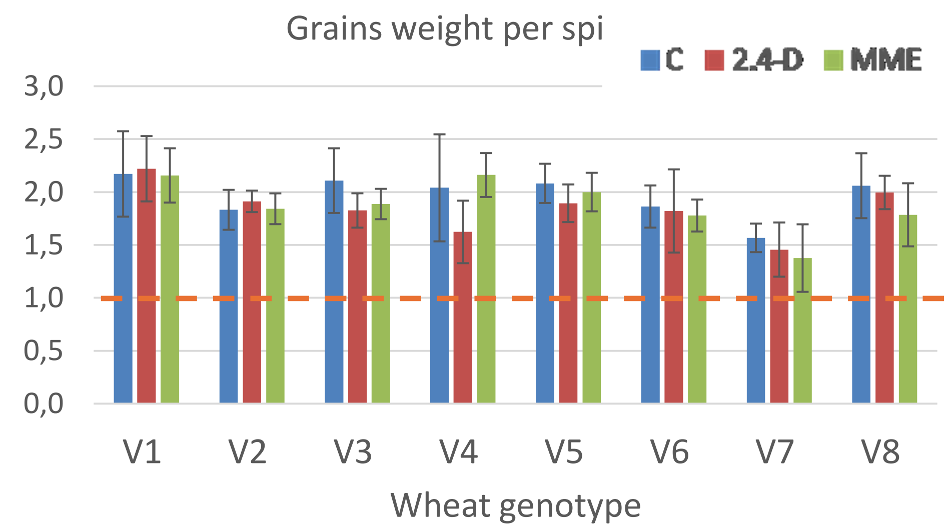
Significance level			
	0.1	0.05	0.02
	0.1	0.05	0.02

$$RD(\%) = (Ctreat - Cc) * 100/Cc$$

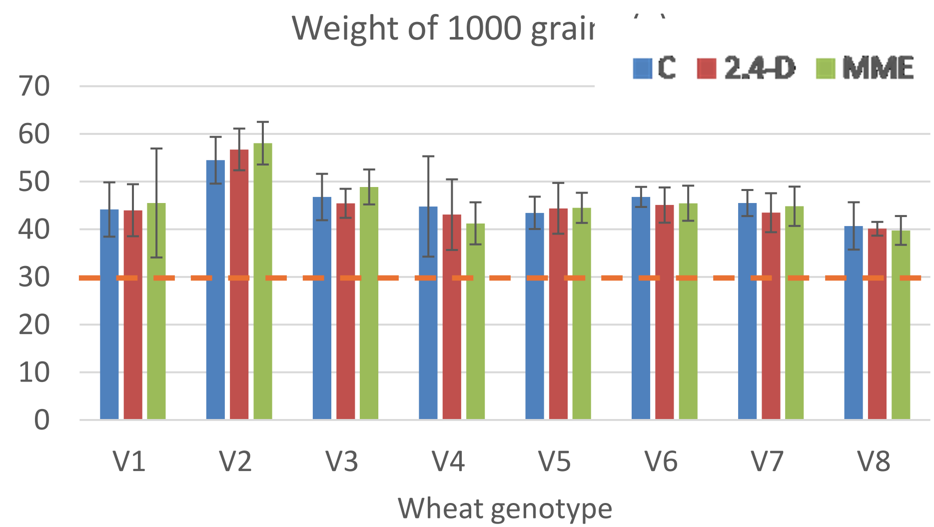


	SL		NrG/S	
	2.4-D	MME	2.4-D	MME
V1	4,7	3,5	2,8	-0,8
V2	-0,6	0,2	0,3	-5,0
V3	-2,8	-9,1	-10,7	-13,8
V4	-7,5	0,2	-16,7	15,9
V5	-5,6	-5,7	-10,8	-6,4
V6	4,4	2,1	1,0	-1,3
V7	-7,6	-7,3	-2,0	-11,0
V8	-4,3	-10,4	-1,4	-10,9





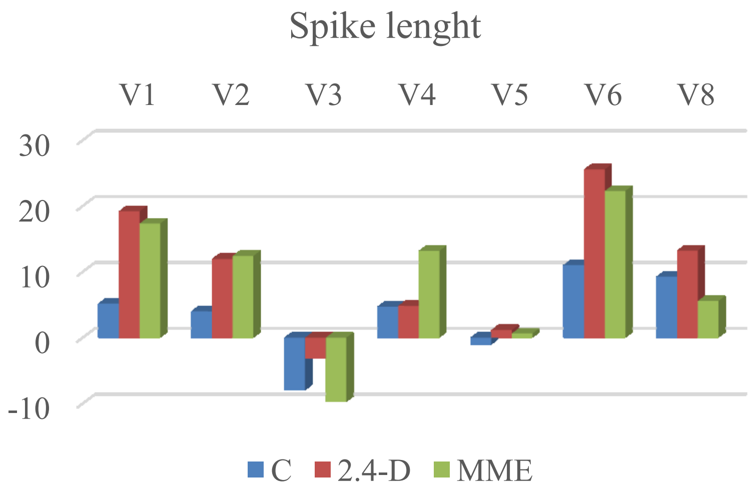
	GW/S		GW	
	2.4-D	MME	2.4-D	MME
V1	2,3	-0,6	-0.3	3.1
V2	4,4	0,6	4.2	6.6
V3	-13,4	-10,5	-2.8	4.5
V4	-20,4	5,9	-3.8	-7.9
V5	-9,0	-3,9	2.2	2.4
V6	-2,3	-4,6	-3.7	-2.8
V7	-7,1	-12,2	-4.5	-1.5
V8	-3,1	-13,3	-1.5	-2.3

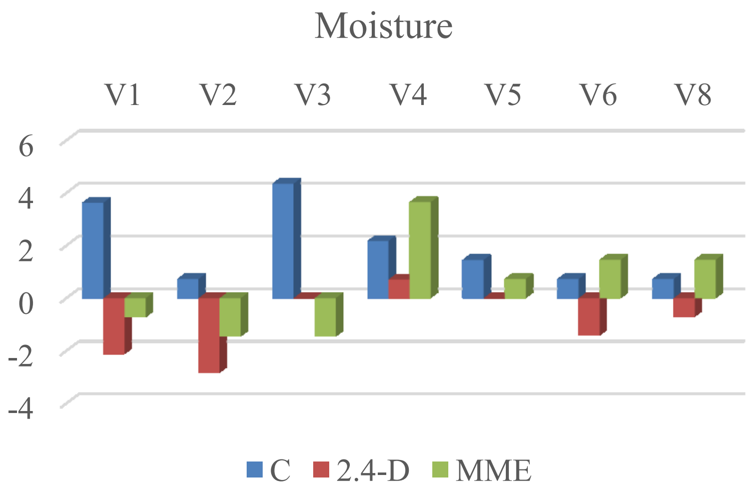


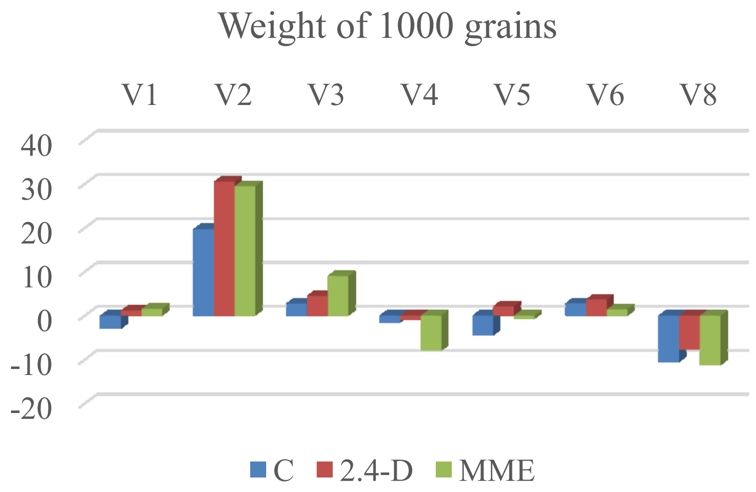
Impact of treatments on quality and productivity parameters compared to Bezostaia genotype

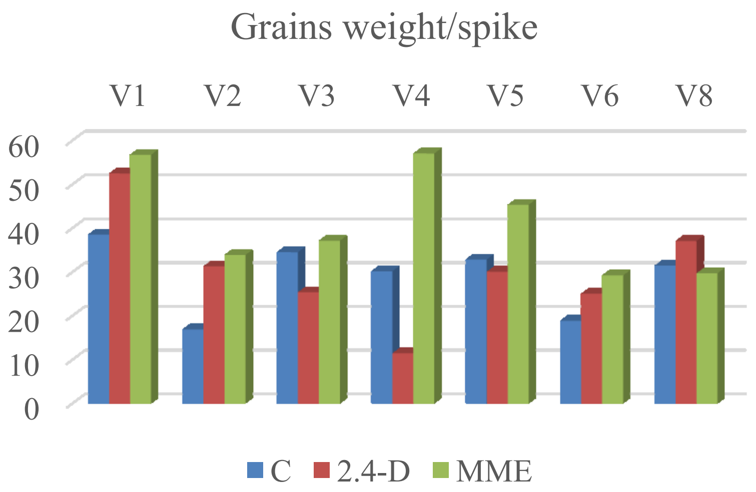
$$RD(\%) = (Ctreat - CV7) * 100/CV7$$

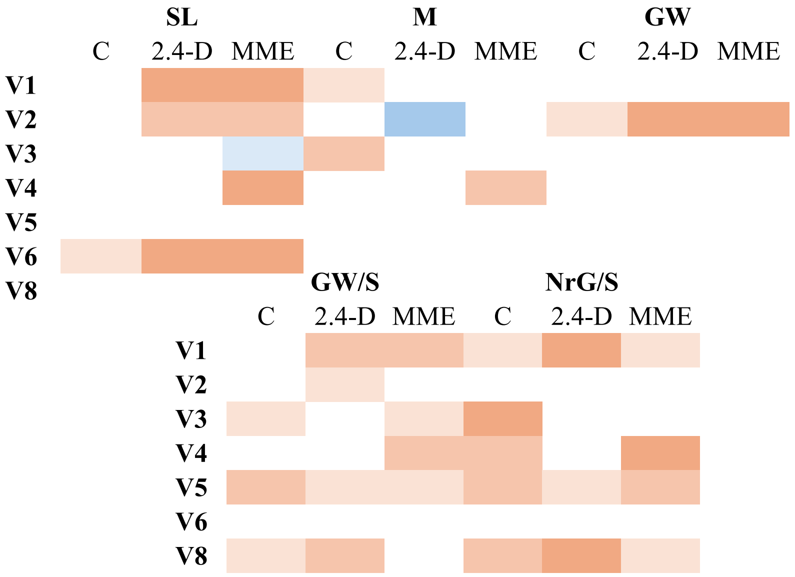
Significance level			
	0.1	0.05	0.02
	0.1	0.05	0.02

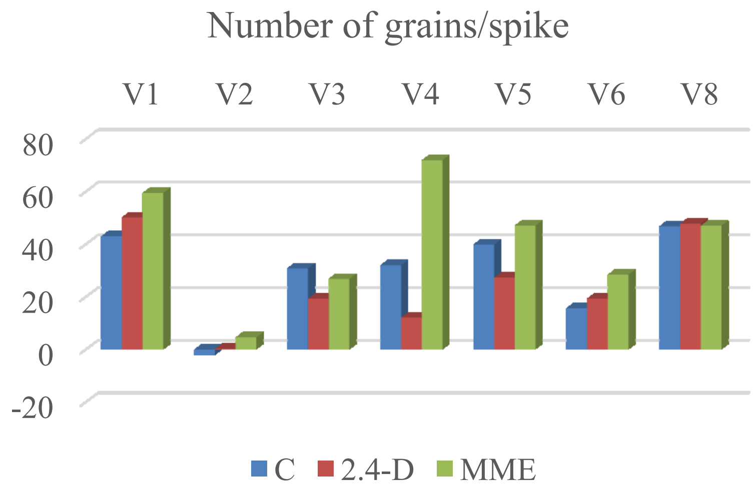










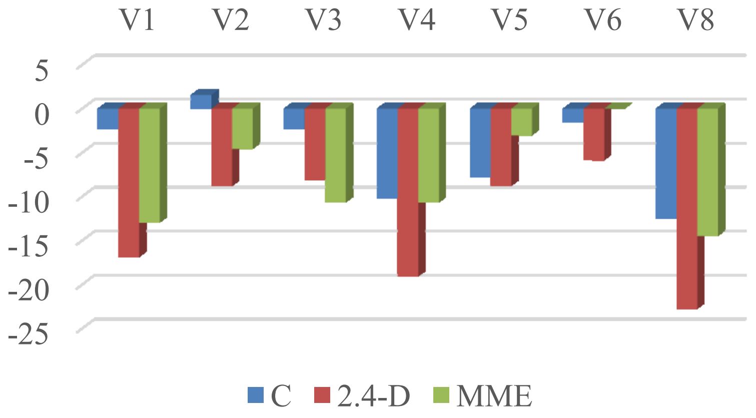


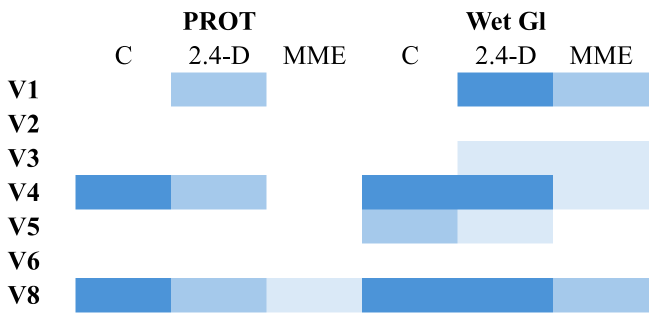
Impact of treatments on quality and productivity parameters compared to Bezostaia genotype

$$RD(\%) = (Ctreat - CV7) * 100/CV7$$

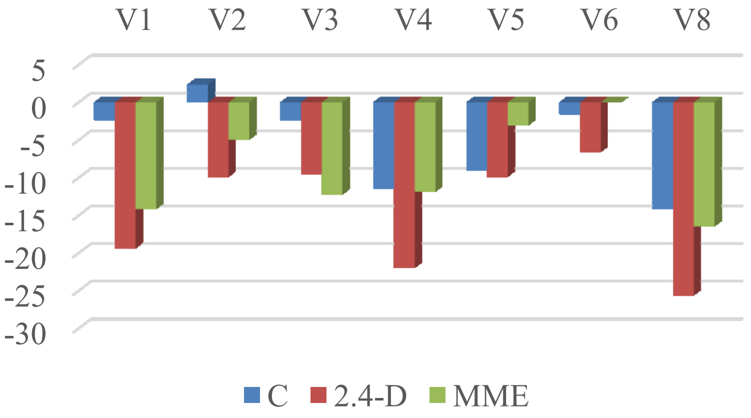
Significance level	0.1	0.05	0.02
	0.1	0.05	0.02

Protein

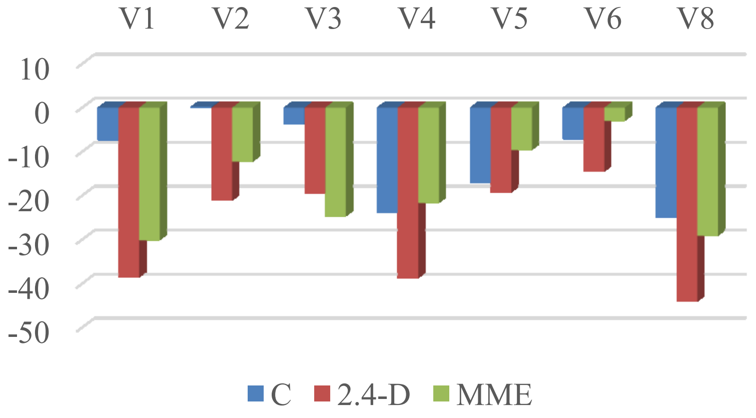


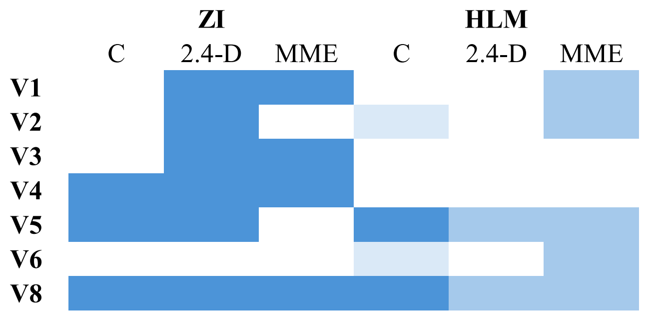


Wet gluten

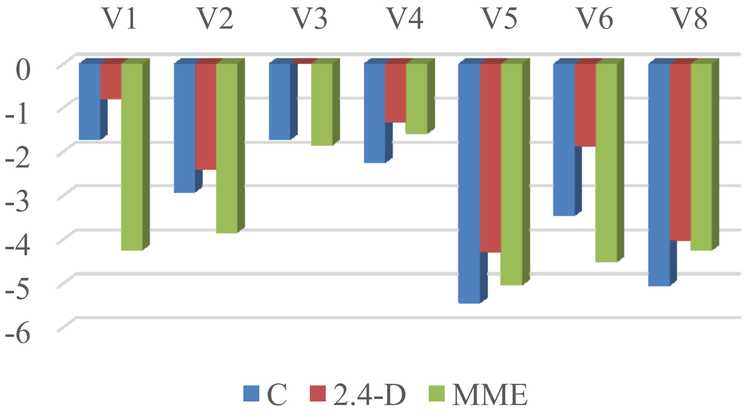


Zeleny index





HLM



Conclusions

1. The use of the two treatments induces changes:
- in the elemental content compared to the control
- the relationship between different categories of parameters
- in the quality and productivity of the genotypes used

but the changes do not question the use of the respective genotypes.

2. Compared to the long-term witness (Bezostaia genotype), even though the weight of the grains and their number per ear present a positive difference for most of genotypes, hectolytic weight and basic quality parameters: the content of protein and wet gluten and the Zeleni index show results lower than the witness.

Thank you!

شكرًا لك

谢谢

Спасибо!

Mulțumesc!

Hvala!