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From waste to table: assessing the biological efficacy of fertilizers derived from anaerobic digestate

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Presentation outline

1. Aim of research
2. Fertilizer production
3. Fertilizer composition
4. Extraction tests
5. Plant studies
6. Plant biometric assessment
7. Plant composition assessment
8. Conclusions

Aim of this work

The aim of this study was to evaluate the biological efficacy of fertiliser derived from the digestate. For this purpose, the following points were assessed:

- nutrient availability
- the effect of fertilizer on plant growth parameters
- effect of the fertilizer on plant nutrition

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Fertilizer production

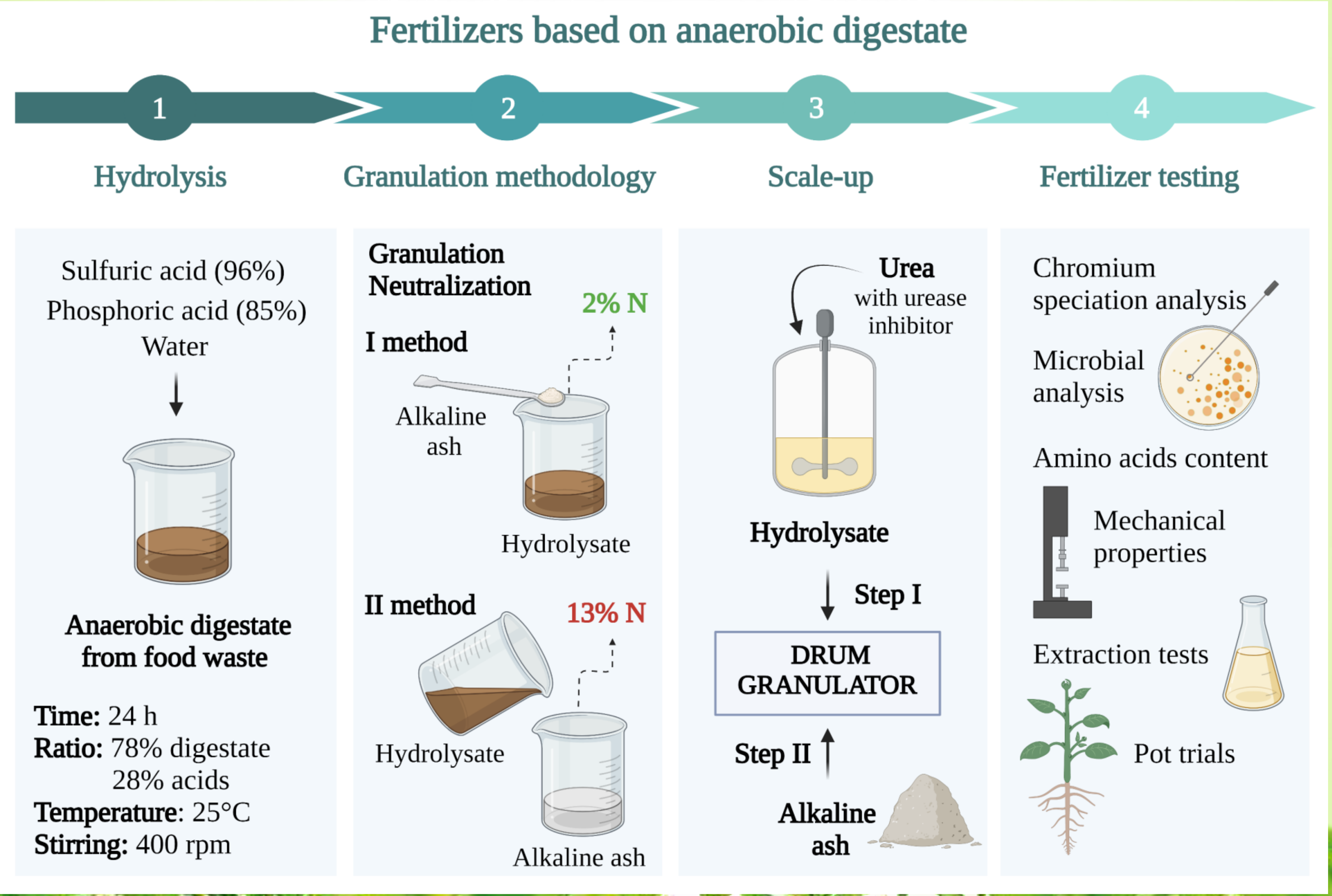

Fig.1. Fertilizer production technology

Fertilizer composition

Tab.1. Fertilizer composition

Materials	Macronutrients						
	C [%]	N [%]	P_2O_5 [%]	K_2O [%]	CaO [%]	MgO [%]	SO_3 [%]
FINAL FORMULATION	38,3 ±3,8	8,57 ±0,86	3,40 ±0,51	2,02 ±0,30	1,99 ±0,30	0,471 ±0,071	6,44 ±0,97
REQUIREMENT OF EU 2019/1009 REGULATION	**>7,5%**	**>2%**					

Materials	Micronutrients				Toxic elements				
	Cu [%]	Fe [%]	Mn [%]	Zn [%]	As [mg/kg]	Cd [mg/kg]	Cr (VI) [mg/kg]	Ni [mg/kg]	Pb [mg/kg]
FINAL FORMULATION	0,376 ±0,056	0,343 ±0,051	0,0470 ±0,0070	1,23 ±0,18	35,0±5,2	1,73±0,26	<0,500	6,97±1,04	<6,00
REQUIREMENT OF EU 2019/1009 REGULATION					**40**	**<3**	**2**	**50**	**120**

Extraction tests

Extraction test

Water extraction
-
EN 15958:2011

Leachability

Neutral amonium citrate extraction
-
EN 15957:2011

Bioavailability

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Extraction tests

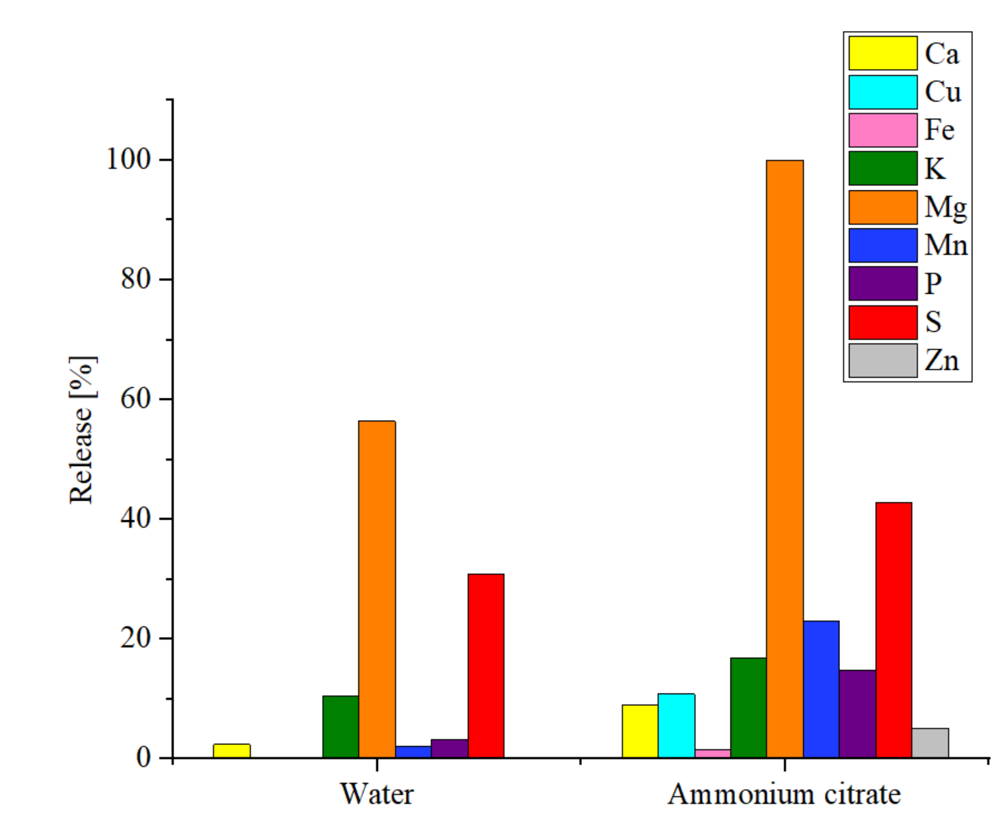

Fig.2. Results of extraction tests

Tab.2. Macronutrient release

Extraction solution	Release (%)				
	Ca	K	Mg	P	S
Water	2.43	10.5	56.4	3.19	30.9
Ammonium citrate	9.00	16.8	100	14.8	42.7

Tab.3. Micronutrient release

Extraction solution	Release (%)			
	Cu	Fe	Mn	Zn
Water	0.317	0.004	2.19	0.08
Ammonium citrate	10.8	1.48	22.9	5.06

Plant studies

1. **Model plant:** wheat

2. **Fertilization:** control with out fertilization (**W**), reference mineral fertilizer with similar composition (**RF**), anaerobic digestate (sanitized) (**AD**), granular organic-mineral fertilizer (**GF**) – each group in 3 replications

3. **Dosage**: in relation to nitrogen requirements (170 kg N/ha): 75%, 100% and 150%

4. **Duration:** 30 days

Fig.3. Plant tests

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Plant biometric assessment

Tab.4. Results of biometric assesment

Group	N dose	Stem length	Chlorophyll	Root length	Root area	Root diameter	Fresh root mass	Fresh steam mass
	%	cm	mg/m^2	cm	cm^2	mm	g	g
W	-	19.1 ± 4.5[a,b,c]	347 ± 27[a,b]	377 ± 56	45.9 ± 9.6	0.387 ± 0.042	3.32	5.90
RF	**75**	33.9 ± 8.3[a]	419 ± 39[a]	387 ± 122	52.6 ± 13.6	0.440 ± 0.042	4.91	21.3
	100	34.0 ± 6.2[b]	394 ± 3935	481 ± 187	60.6 ± 21.2	0.408 ± 0.039	6.37	18.3
	150	37.0 ± 5.5[c]	428 ± 21[b]	326 ± 81	42.7 ± 7.4	0.425 ± 0.048	5.42	20.2
W	-	19.1 ± 4.5[a,b,c]	347 ± 27[a,b]	377 ± 56	45.9 ± 9.6	0.387 ± 0.042	3.32	5.90
AD	**75**	30.2 ± 9.1	405 ± 40	467 ± 117	53.5 ± 15.0	0.362 ± 0.020	3.86	11.4
	100	27.2 ± 9.7	405 ± 40	409 ± 118	54.7 ± 10.8	0.436 ± 0.056	3.37	9.38
	150	30.2 ± 7.3	401 ± 40	377 ± 129	47.9 ± 17.9	0.437 ± 0.132	3.78	12.3
W	-	19.1 ± 4.5[a,b,c]	347 ± 27[a,b]	377 ± 56	45.9 ± 9.6	0.387 ± 0.042	3.32	5.90
GF	**75**	36.0 ± 7.1[a,c]	422 ± 24[a]	376 ± 169	47.9 ± 18.8	0.412 ± 0.056	4.35	14.2
	100	34.6 ± 6.9[b,d]	437 ± 39[b]	291 ± 148	43.7 ± 19.0	0.506 ± 0.097	4.39	16.4
	150	19.1 ± 1.8[c,d]	420 ± 50[c]	241 ± 106	28.5 ± 8.5	0.413 ± 0.121	2.10	9.21

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Plant biometric assessment

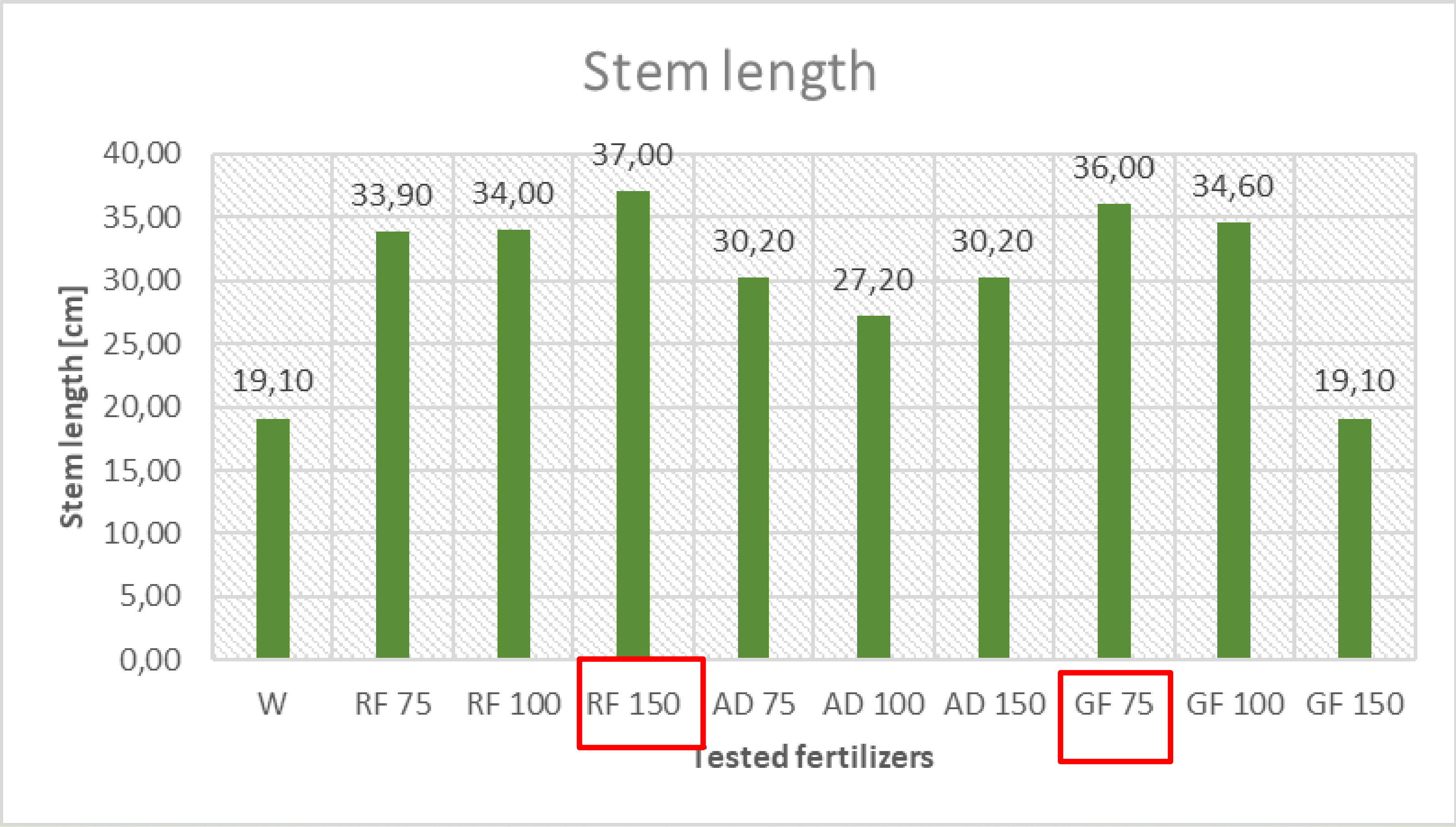

Fig.4. Stem length

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Plant biometric assessment

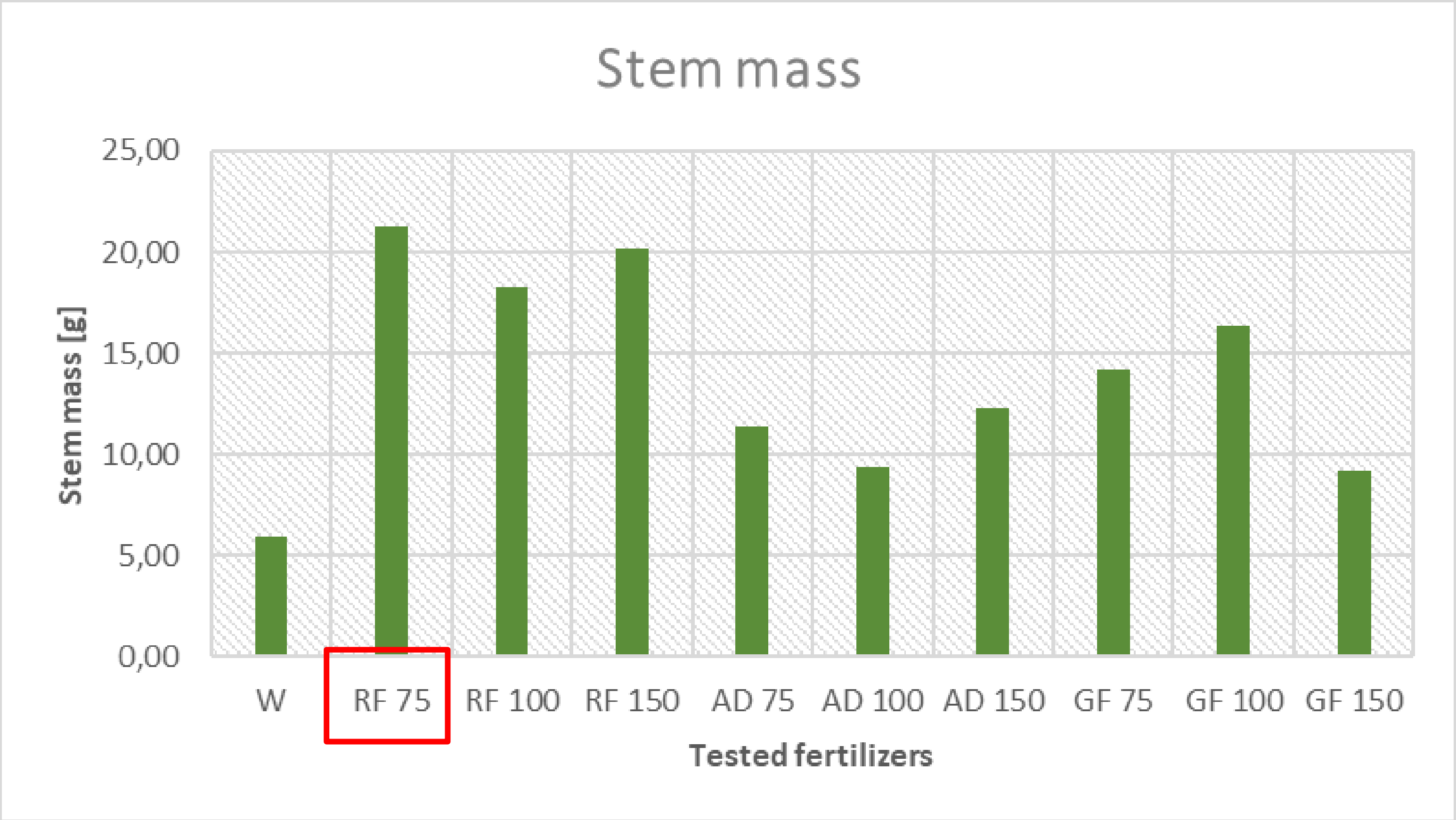

Fig.5. Stem biomass

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Plant biometric assessment

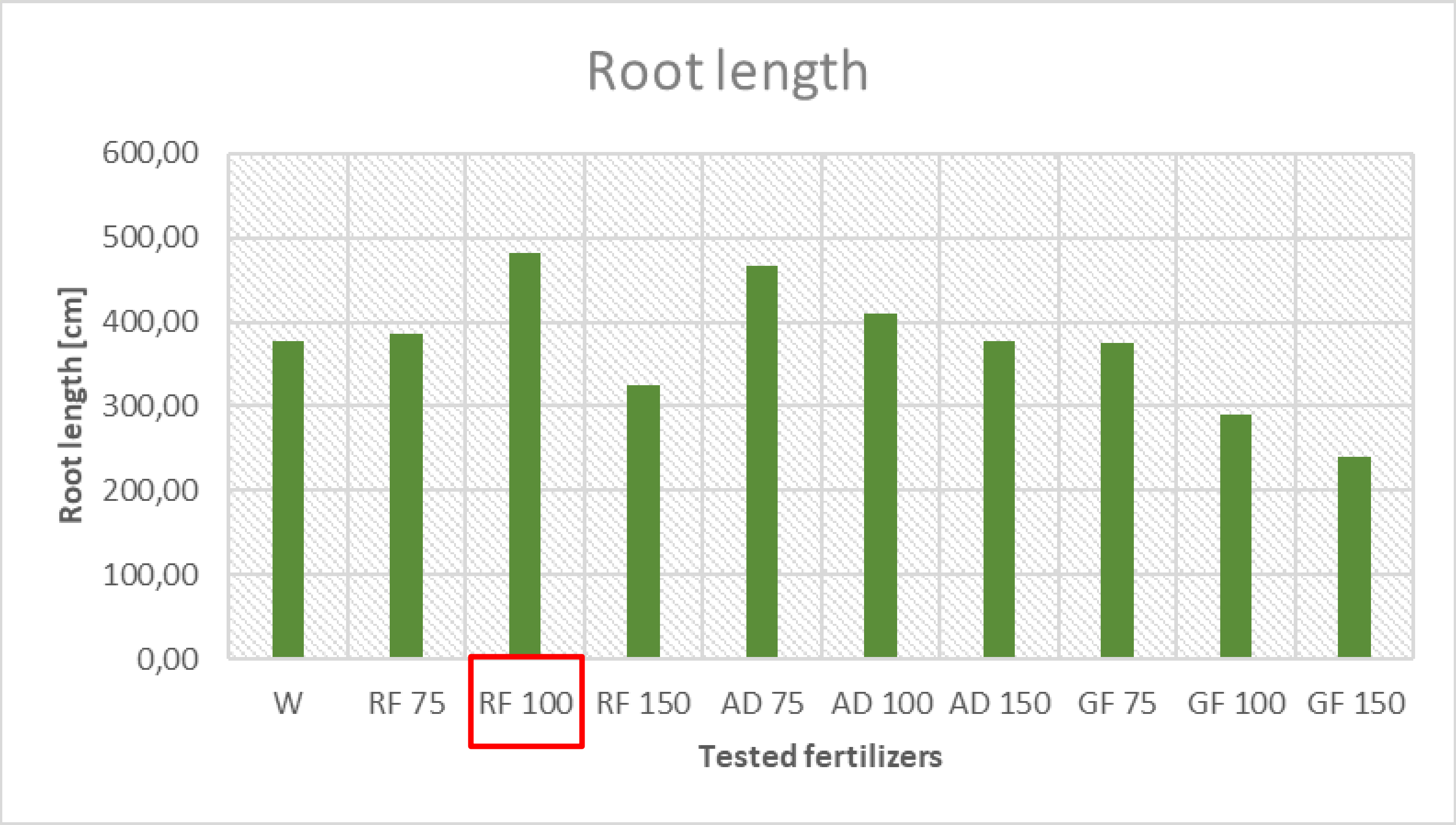

Fig.6. Root length

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Plant biometric assessment

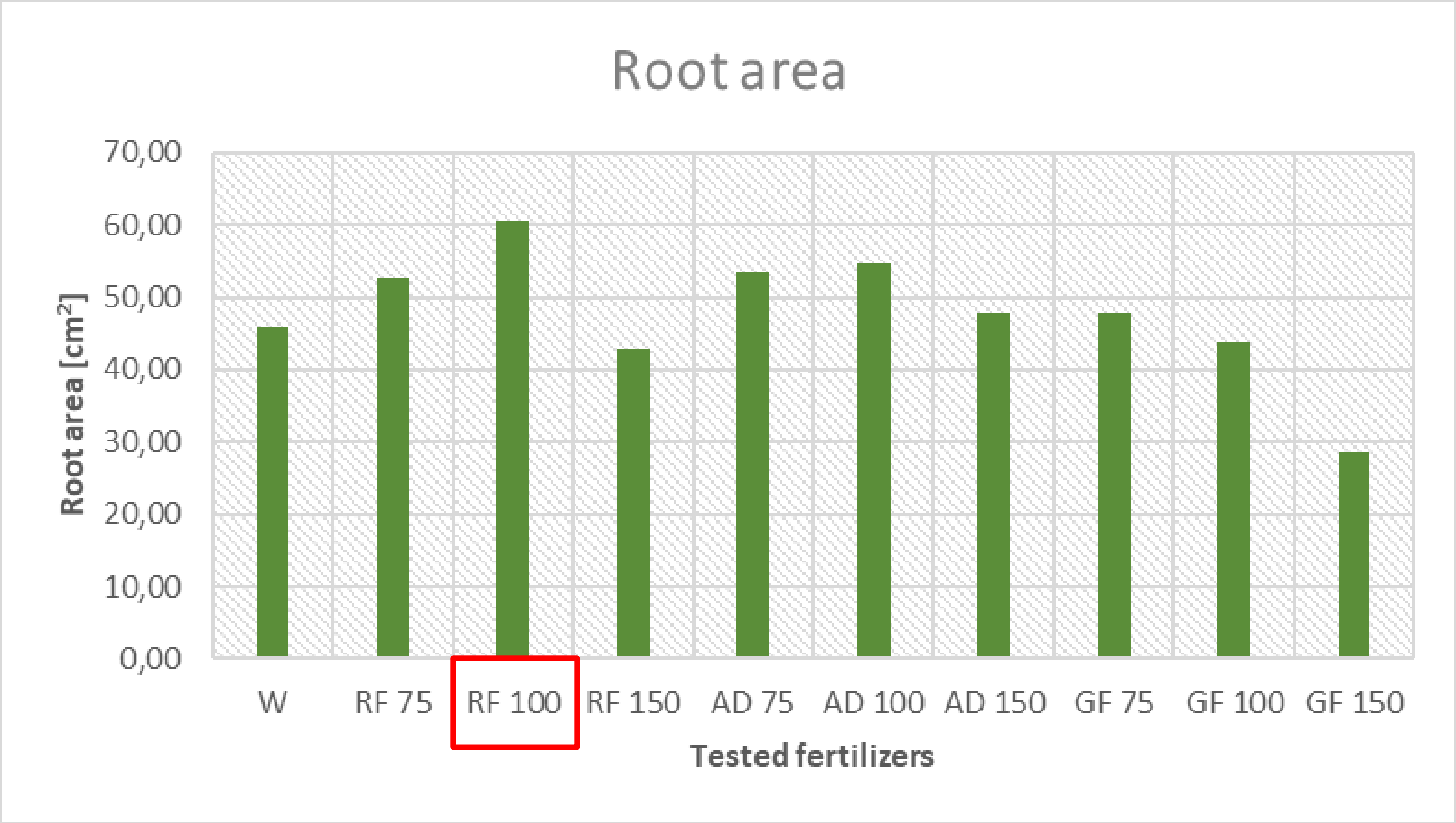

Fig.7. Root area

Plant biometric assessment

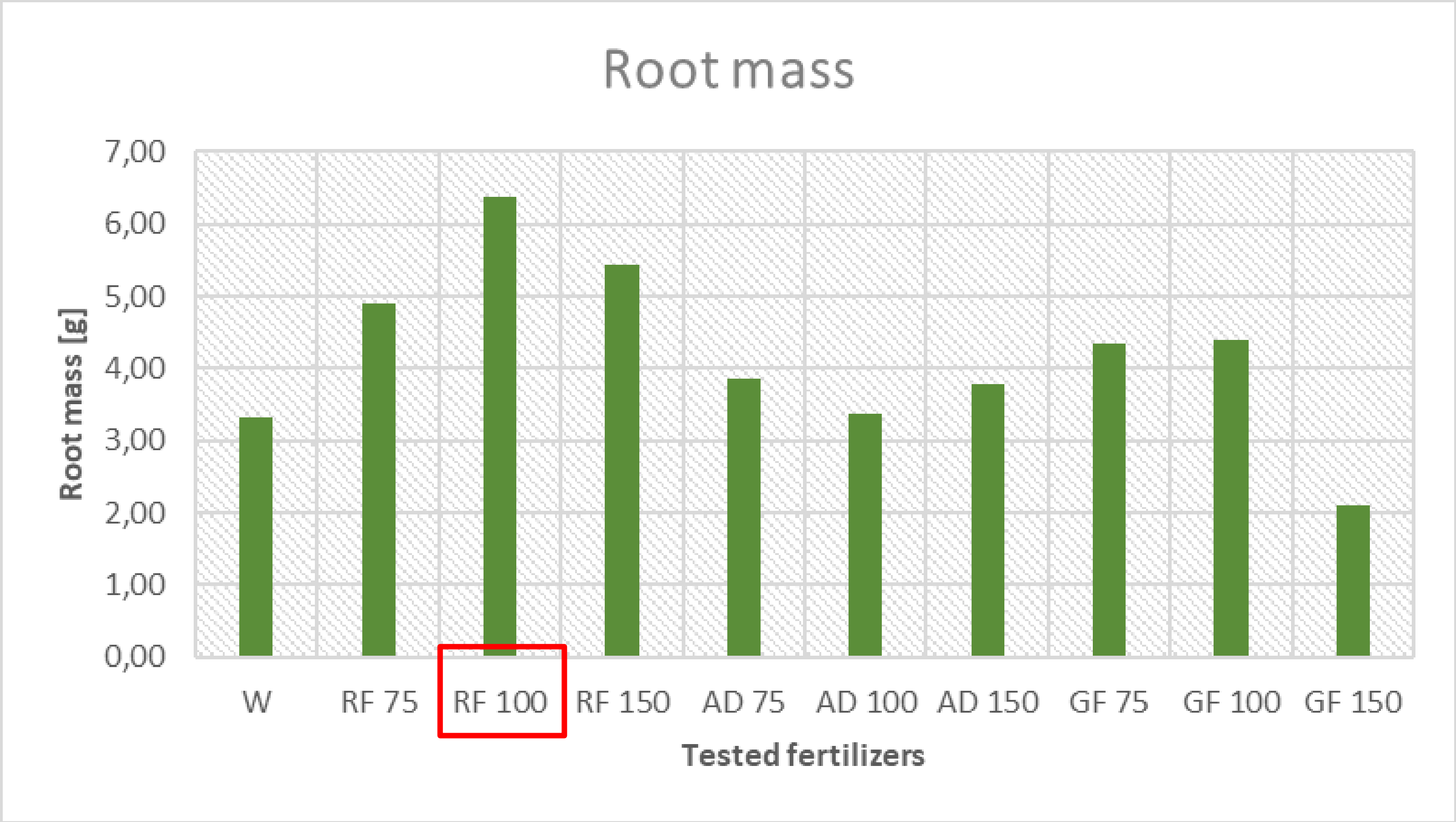

Fig.8. Root mass

Plant biometric assessment

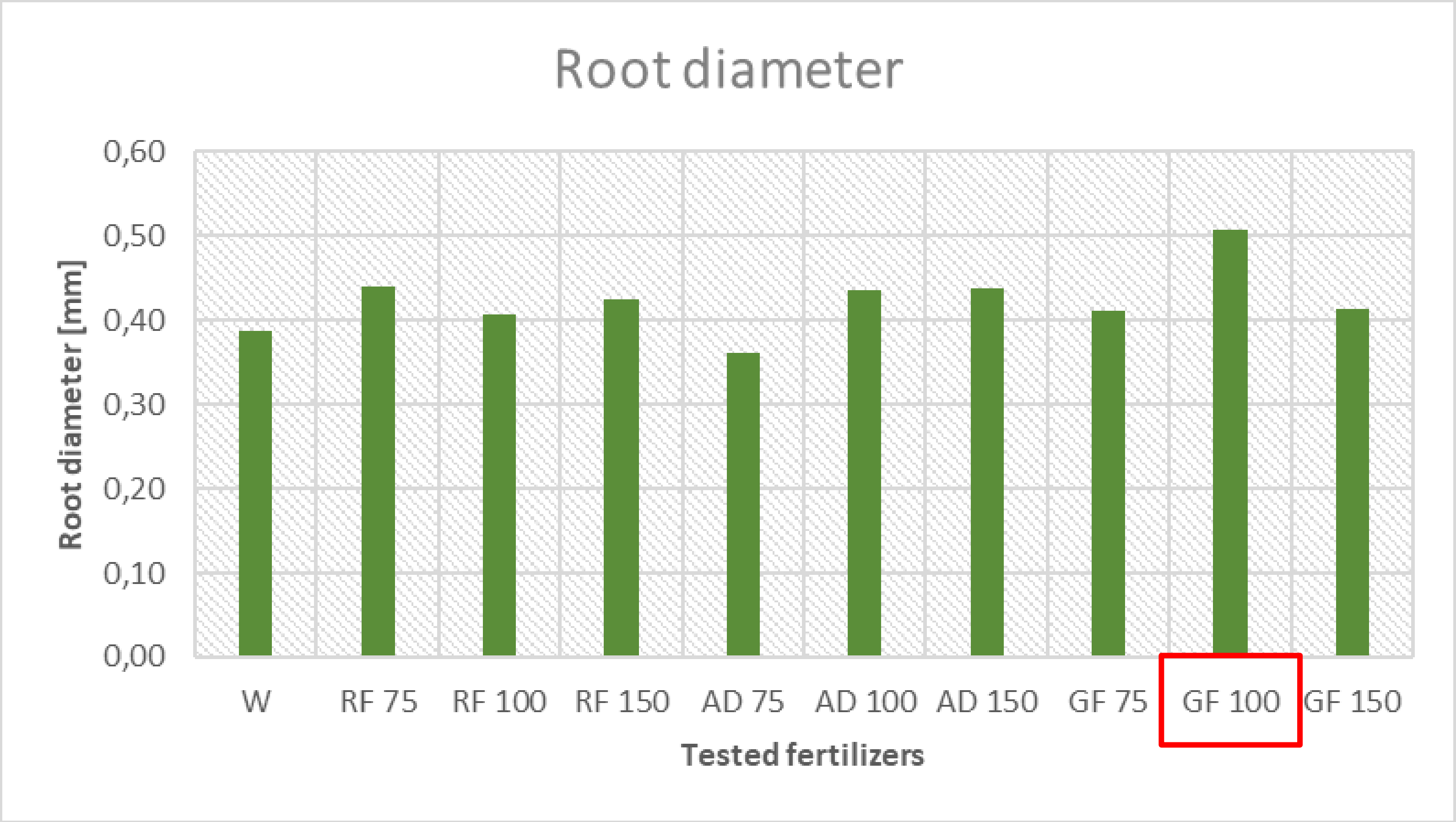

Fig.9. Root diameter

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Plant biometric assessment

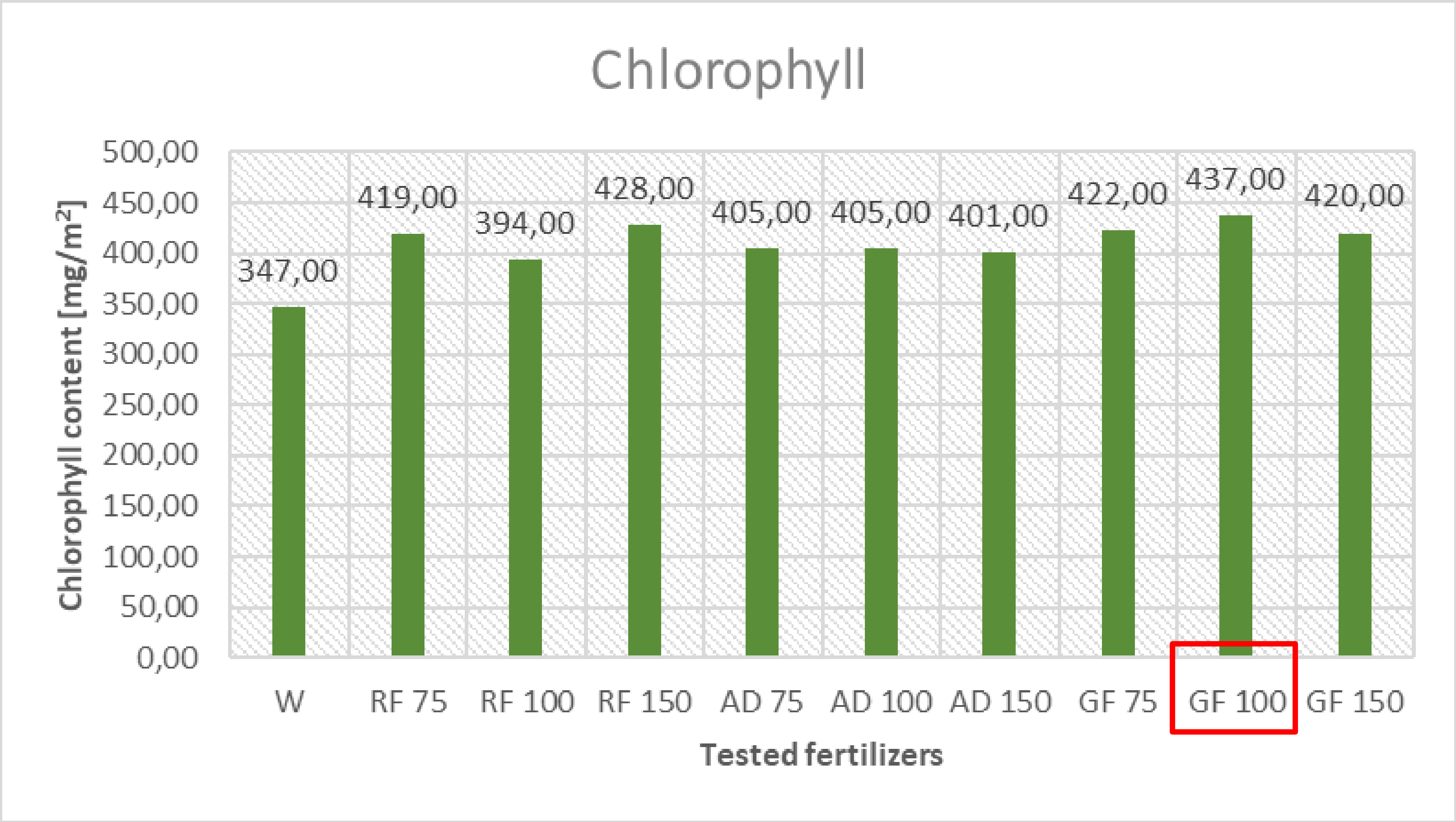

Fig.10. Chlorophyll content

Plant biomass analysis

Tab.5. Results of biomass analysis

Group	N dose	N	P	K	Cu	Mn	Zn	Fe
	%	%	mg/kg d.m.	%	mg/kg d.m.			
W	-	1.26 ± 0.13	5180±777	3.89 ±0.58	6.74 ± 1.01	35.0 ± 5.3	64.4 ± 9.7	221 ± 33
RF	75	1.89 ± 0.19	9130 ±1370	5.32 ±0.79	10.9 ± 1.6	45.3 ± 6.8	71.9 ± 10.8	226 ± 34
	100	1.97 ± 0.20	9520 ±1430	5.21 ±0.78	5.94 ± 0.89	52.2 ± 7.8	70.5 ± 10.6	250 ± 37
	150	2.55 ± 0.25	12400 ±1860	5.15 ±0.77	6.16 ± 0.93	60.3 ± 9.0	82.3 ± 12.3	217 ± 33
W	-	1.26 ± 0.13	5180 ±777	3.89 ±0.58	6.74 ± 1.01	35.0 ± 5.3	64.4 ± 9.7	221 ± 33
AD	75	2.84 ± 0.28	3770 ±566	4.53 ±0.67	8.00 ± 1.20	35.6 ± 5.3	152 ± 23	250 ± 37
	100	3.01 ± 0.30	3600 ±539	4.45 ±0.66	4.84 ± 0.73	42.9 ± 6.4	58.3 ± 8.7	462 ± 69
	150	3.86 ± 0.39	3910 ±587	5.34 ±0.79	4.85 ± 0.73	43.6 ± 6.5	65.3 ± 9.8	356 ± 53
W	-	1.26 ± 0.13	5180 ±777	3.89 ±0.58	6.74 ± 1.01	35.0 ± 5.3	64.4 ± 9.7	221 ± 33
GF	75	2.52 ± 0.25	4360 ±654	4.78 ±0.71	5.62 ± 0.84	36.5 ± 5.5	60.0 ± 9.0	519 ± 78
	100	3.26 ± 0.33	5110 ±767	4.90 ±0.73	8.60 ± 1.28	41.9 ± 6.3	78.2 ± 11.7	424 ± 64
	150	3.84 ± 0.38	6170 ±925	5.09 ±0.76	10.8 ± 1.63	40.0 ± 6.0	86.8 ± 13.0	708 ± 106

Conclusion

1. The obtained fertilizer meet the quality requirements of the legislation.

2. The resulting fertilizer are characterised by favourable availability of nutrients.

3. The resulting fertilizers have a positive effect on plant growth parameters in the early growth stage and on plant nutrition.

4. Biological effectiveness should be assessed over the full growing season

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Conversion of anaerobic digestates from biogas plants: Laboratory fertilizer formulation, scale-up and demonstration of applicative properties on plants

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Fig.11. Published paper

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Thank you for you attention!