penergetic p

penergetic
the natural biotechnology

Anwendungsbericht/User Application Report

Produkt/Product:
penergetic plant (Art. Nr. 4000)
penergetic soil (Art. Nr. 3800)

Fachberater/Consultant:
Agroconsult Poland

Anwender/User:
Institute of Agriculture, Warsaw University of Life Sciences (SGGW)

Datum/Date: 2016 - 2019

Summary of 3 Studies conducted by Warsaw University of Life Sciences (SGGW) about the reduction of mineral nitrogen fertilizer

Authors: Arkadiusz Artyszak and Dariusz Gozdowski.

Three studies[1], conducted by the Institute of Agriculture, Warsaw University of Life Sciences (SGGW) in Poland, tested the possibility of replacing 30% of the dose of mineral nitrogen with penergetic alone and penergetic in combination with plant growth promoting rhizobacter (PGPR).

Abstract

All studies show that despite the reduction of mineral nitrogen by 30%, the yield was higher when the penergetic soil and plant products were applied in combination with plant growth promoting rhizobacteria.

[…] The obtained results proved that it was possible to reduce the mineral application of nitrogen by 30% without a decrease in the biological and pure sugar yield, and even with an increase in the sugar yield caused by the application of the growth activators Penergetic (K + P) and Azoter. […] (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020)

[…] It was confirmed that the two combinations allowed a higher yield of maize grain by 2.9%[2] *and 8.8%*[3]*, respectively, compared to the full nitrogen dose. Positive changes in the content of some assimilable macro and microelements and soil organic carbon (SOC), and an increase in soil pH, were also observed. […]* (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020)

[…] It was confirmed that these two combinations allowed the obtention of a higher yield of grain by 13%, compared to the full nitrogen dose. Simultaneously, the grain quality did not change significantly. […] (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

---

[1] (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020) (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020) (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

[2] Treatment 1: 30% less mineral nitrogen + penegertic soil and plant

[3] Treatment 2: 30% less mineral nitrogen + penegertic soil and plant with Azoter

Study details

Crops:

- Sugar beet
- Maize
- Winter wheat

Dates: 2016-2019

- Sugar Beet: 2017 - 2019
- Maize: 2017 – 2019
- Winter Wheat : 2016 – 2019

Locations

- Seven field experiments with sugar beet
- Eight field experiments with maize for grain
- Nine field experiments with winter wheat

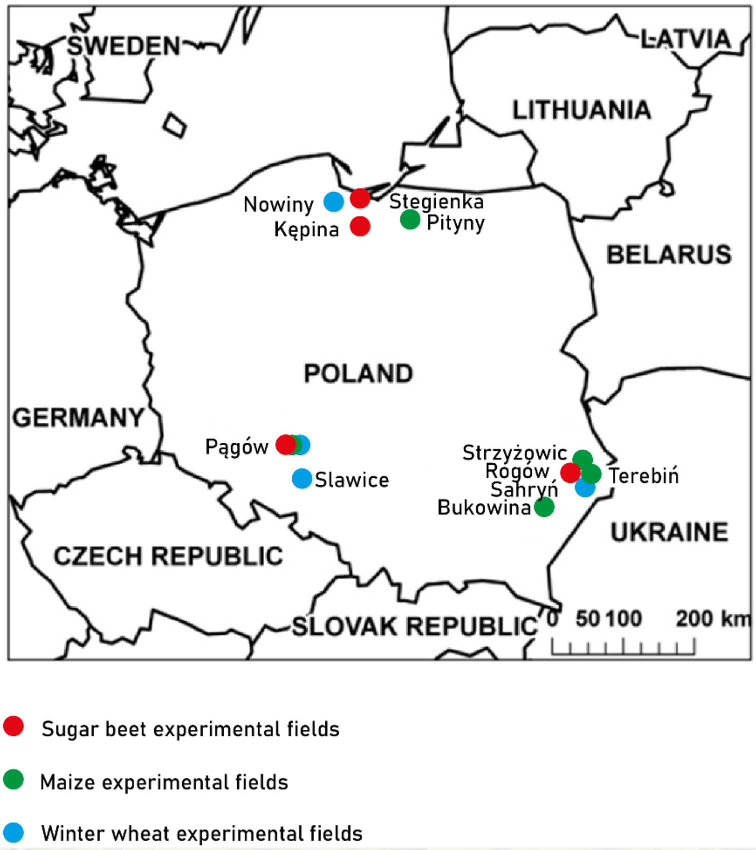

Figure 1: Locations of experimental fields for the three trials (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020) (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020) (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

Treatments

- Sugar beet

Treatment	Mineral Nitrogen[4]	Penergetic soil [5]	Penergetic plant[6]	Azoter[7]
0	100% (112 to 175 kg ha−1 N)	-	-	-
1	70% [8] (78 to 123kg ha−1 N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first herbicide spray in spring	300 g ha−1 with second herbicide spray in spring 300 g ha−1 at BBCH 16.	-
2	70%[9] (78 to 123 kg ha−1N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first herbicide spray in spring	300 g ha−1 with second herbicide spray in spring 300 g ha−1 at BBCH 16).	10 dm3 ha−1 with penergetic for soil on fore crop 10 dm3 ha−1 with penergetic for soil with first herbicide spray in spring

- Maize

Treatment	Mineral Nitrogen[10]	Penergetic soil	Penergetic plant	Azoter
0	100% (56 to 184 kg ha−1 N.)	-	-	-
1	70% (60% in Rogów) (34 to 110 kg ha−1 N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first herbicide spray in spring	300 g ha−1 with second herbicide spray in spring 300 g ha−1, 3 weeks later	-
2	70% (97 to 167 kg ha−1N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first herbicide spray in spring	300 g ha−1 with second herbicide spray in spring 300 g ha−1, 3 weeks later	10 dm3 ha−1 with penergetic for soil on fore crop 10 dm3 ha−1 with penergetic for soil with first

[4] Dose depending on location

[5] Depending on market: penergetic k or penergetic b

[6] Penergetic p for plants

[7] Azoter is a preparation which contains plant growth-promoting rhizobacteria (PGPR). The manufacturer states that the pH of the preparation is 5.8–8.5, a total number of living microorganisms (*Azotobacter chroococcum*, *Azospirillum brasilense*, *Bacillus megaterium*) is at least 4×109 colony-forming units (CFU) cm−3.

[8] 1st dose of nitrogen in spring is the same as in the control, 2nd, and 3rd nitrogen application with reduced dose

9 1st dose of nitrogen in spring is the same as in the control, 2nd, and 3rd nitrogen application with reduced dose

[10] Dose depending on location

- Winter wheat

Treatment	Mineral Nitrogen[11]	Penergetic soil	Penergetic plant	Azoter
0	100% (111–238 kg ha−1 N)	-	-	-
1	70% (97 to 167 kg ha−1N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first pesticide spray in spring	300 g ha−1 with second pesticide spray in spring 300 g ha−1, 3 weeks later	-
2	70% (97 to 167 kg ha−1N)	400 g ha−1 on the harvest residuals of the fore-crop 400 g ha−1 with first pesticide spray in spring	300 g ha−1 with second pesticide spray in spring 300 g ha−1, 3 weeks later	10 dm3 ha−1 with penergetic for soil on fore crop 10 dm3 ha−1 with penergetic for soil with pesticide spray in spring

[11] *Dose depending on location*

Results

Sugar beet

Trait	Treatment			p-Value Based on ANOVA		
	0	1	2	Treatment (T)	Environment (E: Year × Location)	Inter-Action: T × E
Plant density at harvest, thousand plants ha^{-1}	90.16 a *	95.10 b	94.71 b	0.054	<0.001	0.735
Yield of leaves, t ha^{-1}	49.95 a	47.75 a	53.99 b	0.002	<0.001	<0.001
Yield of roots, t ha^{-1}	84.46 a	90.65 b	94.17 b	<0.001	<0.001	0.051
Yield of roots and leaves, t ha^{-1}	134.41 a	138.40 a	148.16 b	<0.001	<0.001	0.002
Biological yield of sugar, t ha^{-1}	14.20 a	15.05 b	16.00 c	<0.001	<0.001	0.003
Pure sugar yield, t ha^{-1}	12.41 a	13.19 b	14.07 c	<0.001	<0.001	0.002
Harvest Index	0.64 a	0.66 b	0.65 ab	0.052	<0.001	<0.001
Foliage coefficient	0.60 b	0.54 a	0.58 ab	0.027	<0.001	<0.001
Content of sucrose in roots, %	16.80 ab	16.63 a	16.96 b	0.109	<0.001	0.001
The content of α-amino nitrogen in the roots, mmol kg^{-1}	21.36 a	21.11 a	20.89 a	0.894	<0.001	0.176
Potassium content in the roots, mmol kg^{-1}	39.84 b	35.15 a	36.09 a	<0.001	<0.001	0.002
Sodium content in the roots, mmol kg^{-1}	3.53 b	3.22 ab	2.90 a	0.125	<0.001	0.019
Standard molasses losses, %	1.51 b	1.45 a	1.45 a	0.052	<0.001	0.396
Sugar yield losses, %	2.11 b	2.05 a	2.05 a	0.052	<0.001	0.396
Refined sugar content, %	14.69 ab	14.58 a	14.91 b	0.106	<0.001	0.001
Sugar productivity, %	87.29 a	87.57 ab	87.75 b	0.121	<0.001	0.188
Alkalinity coefficient	2.24 b	1.91 a	1.96 a	0.001	<0.001	<0.001
The fresh mass of the leaves of the plant, kg	0.55 b *	0.51 a	0.57 b	0.014	<0.001	<0.001
Fresh root mass, kg	0.94 a	0.96 a	1.00 a	0.136	<0.001	0.002
Fresh plant biomass, kg	1.49 ab	1.47 a	1.57 b	0.038	<0.001	0.002

* The same letters within rows indicate a lack of significant differences between means at $\alpha = 0.05$.

Figure 2: The influence of Penergetic activators and Azoter bacterial preparation on the yield, the technological quality of the roots and traits of sugar beet plants (2017–2019), and the effects of treatment, environment (location x year) and their interaction. (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020)

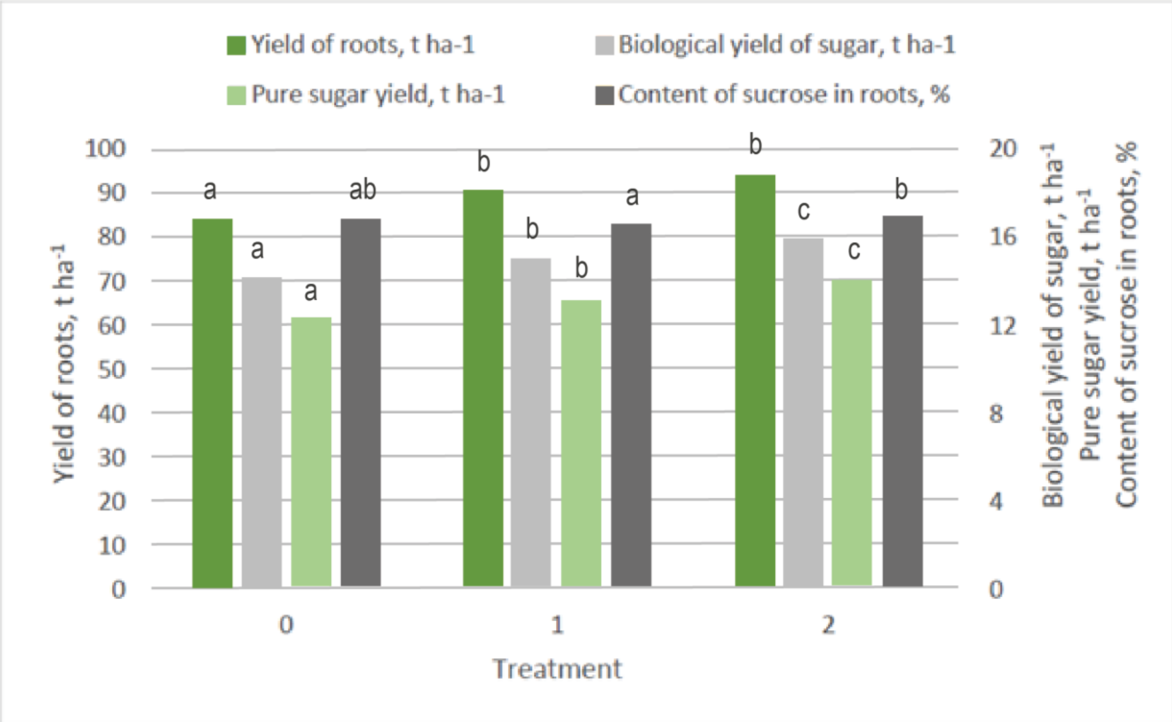

Figure 3: The influence of Penergetic activators and Azoter bacterial preparation on the yield of roots, sugar yield and sucrose content (2017-2019). Same letters next to means indicate lack of significant difference between means at 0.05 probability level. (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020)

Trait	Mean	Minimum	Maximum	Standard Deviation (SD)	Coefficient of Variation (CV), %
Plant density at harvest, thousand plants ha^{-1}	93.32	65.00	112.04	11.89	12.74
Yield of leaves, t ha^{-1}	50.56	21.60	106.48	21.91	43.34
Yield of roots, t ha^{-1}	89.76	61.11	117.66	15.38	17.14
Yield of roots and leaves, t ha^{-1}	140.3.	93.06	204.63	28.51	20.31
Biological yield of sugar, t ha^{-1}	15.08	9.87	21.14	2.98	19.76
Pure sugar yield, t ha^{-1}	13.23	8.32	18.96	2.75	20.79
Harvest Index	0.65	0.45	0.81	0.09	13.81
Foliage coefficient	0.57	0.24	1.24	0.25	43.44
Content of sucrose in roots, %	16.80	14.45	20.29	1.55	9.22
The content of α-amino nitrogen in the roots, mmol kg^{-1}	21.12	11.00	44.10	6.86	32.46
Potassium content in the roots, mmol kg^{-1}	37.03	27.00	55.00	6.63	17.90
Sodium content in the roots, mmol kg^{-1}	3.22	1.15	13.40	1.59	49.29
Standard molasses losses, %	1.47	1.16	2.20	0.22	15.23
Sugar yield losses, %	2.07	1.76	2.80	0.22	10.82
Refined sugar content, %	14.73	12.31	18.28	1.64	11.15
Sugar productivity, %	87.53	81.45	90.30	2.03	2.32
Alkalinity coefficient	2.04	1.05	4.14	0.55	27.19
The fresh mass of the leaves of the plant, kg	0.54	0.22	1.10	0.22	40.14
Fresh root mass, kg	0.97	0.56	1.42	0.14	14.49
Fresh plant biomass, kg	1.51	0.85	2.11	0.26	17.24

Figure 4: Descriptive statistics for all experiments with sugar beet (2017 – 2019). (Artyszak & Gozdowski, Fertilizer reduction trial in sugar beet, 2020)

Maize

Trait	Treatment 0	Treatment 1	Treatment 2	p-Value Based on ANOVA: Treatment (T)	Environment (E: Year x Location)	Inter-Action: TxE
Grain yield (14% H_2O), t ha^{-1}	12.53 a*	12.89 b	13.63 c	<0.001	<0.001	0.205
Grain moisture, %	28.65 c	26.91 a	27.99 b	<0.001	<0.001	<0.001
Yield of straw, t ha^{-1}	31.91 b	29.05 a	28.18 a	<0.001	<0.001	<0.001
Height of plants, cm	260.20 a	267.50 b	271.75 c	<0.001	<0.001	<0.001
Grain yield per plant (14% H_2O), g	170.05 a	174.66 b	183.57 c	<0.001	<0.001	0.088
Weight of 1000 grains (14% H_2O), g	431.88 a	444.25 b	443.50 b	<0.001	<0.001	<0.001
Number of grains per cob, pcs.	391.1 a	395.2 a	416.7 b	<0.001	<0.001	0.017

* Same letters within rows indicate lack of significant difference between means at $\alpha = 0.05$.

Figure 5: Influence of Penergetic activators and Azoter bacterial preparation on yield and traits of maize plants (2017–2019) and effects of treatment and environment (location x year) and their interaction. (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020)

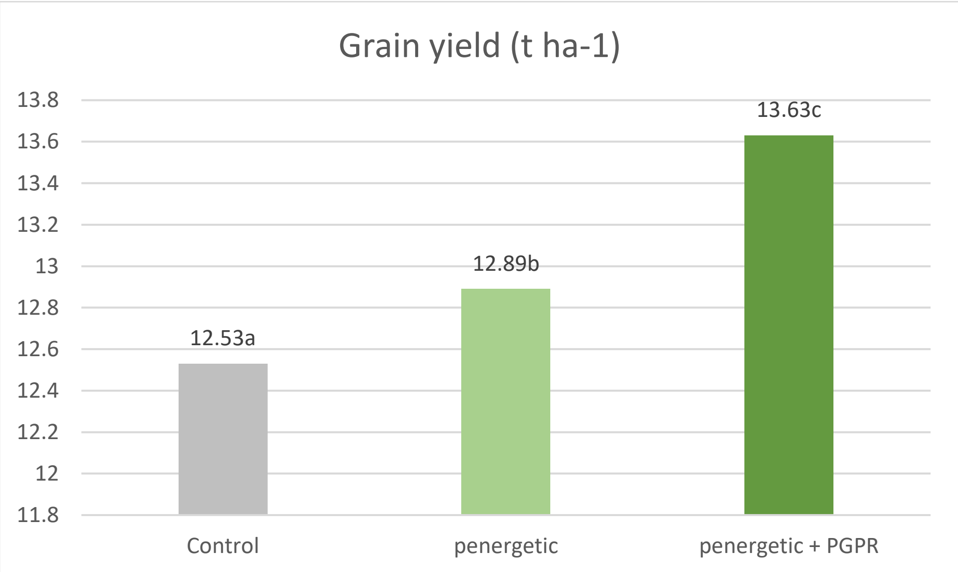

Figure 6: Influence of Penergetic activators and Azoter bacterial on yield and traits of maize plants (2017–2019). Same letters next to means indicate lack of significant difference between means at 0.05 probability level. (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020)

Trait	Mean	Minimum	Maximum	Standard Deviation (SD)	Coefficient of Variation (CV), %
Grain yield (14% H_2O), t ha^{-1}	13.02	5.90	19.76	3.45	26.49
Grain moisture, %	27.85	20.80	45.20	5.55	19.91
Yield of straw, t ha^{-1}	29.72	17.00	51.50	8.53	28.72
Height of plants, cm	266.48	190.00	319.00	24.58	9.22
Grain yield per plant (14% H_2O), g	176.09	76.82	250.14	49.13	27.90
Weight of 1000 grains (14% H_2O), g	439.88	400.00	476.00	19.29	4.38
Number of grain s per cob, pcs.	401.0	174.6	618.4	114.1	28.45

Figure 7: Descriptive statistics for all experiments with maize (2017–2019), (Artyszak & Gozdowski, Fertilizer reduction trial in maize, 2020)

Winter wheat

	Treatment			*p*-Value Based on ANOVA		
Trait	**0**	**1**	**2**	**Treat-Ment (T)**	**Environ-Ment (E: Year × Location)**	**Inter-Action: T × E**
Grain yield at moisture 14%, t ha^{-1}	7.30 a *	8.26 b	8.30 b	<0.001	<0.001	0.128
Grain moisture, %	12.21 a	12.23 a	12.27 a	<0.001	0.630	0.001
Yield of straw, t ha^{-1}	5.57 a	6.01 ab	6.37 b	<0.001	0.012	0.184
Spike density, pcs. m^{-2}	627.25 a	641.44 a	630.06 a	<0.001	0.384	0.035
Number of non-productive shoots, pcs. m^{-2}	55.50 b	42.72 a	46.11 a	<0.001	0.008	0.160
Total number of shoots, pcs. m^{-2}	682.75 a	683.89 a	676.17 a	<0.001	0.772	0.144
Weight of 1000 grains (14% H_2O), g	41.87 a	44.42 b	44.14 b	<0.001	<0.001	0.043
Protein content, % d.m.	14.57 b	14.57 b	14.37 a	<0.001	0.004	<0.001
Content of wet gluten, % d.m.	29.92 b	29.77 ab	29.51 a	<0.001	0.026	<0.001
Grain uniformity (fractions separated at sieves 2.5 × 25 mm), %	79.83 a	81.29 b	82.21 c	<0.001	<0.001	<0.001
Hagberg falling number, s	308.72 a	320.67 b	322.22 b	<0.001	0.005	0.002
Zeleny sedimentation value (SDS), mL	48.60 b	47.71 a	48.92 b	<0.001	0.020	<0.001
Height of plants, cm	67.14 a	69.67 b	71.93 c	<0.001	<0.001	<0.001
Number of grains per spike, pcs.	42.52 a	46.30 b	46.18 b	<0.001	<0.001	0.009

* The same letters within rows indicate lack of significant differences between means at $\alpha = 0.05$.

Figure 8: Influence of Penergetic activators and Azoter bacteria preparation (Azoter Trading, Bratislava, Slovakia) on yield and traits of winter wheat plants (2016/17–2018/2019) and effects of treatment and environment (location year) and their interaction. For the treatments, marginal means for all experiments together are presented. (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

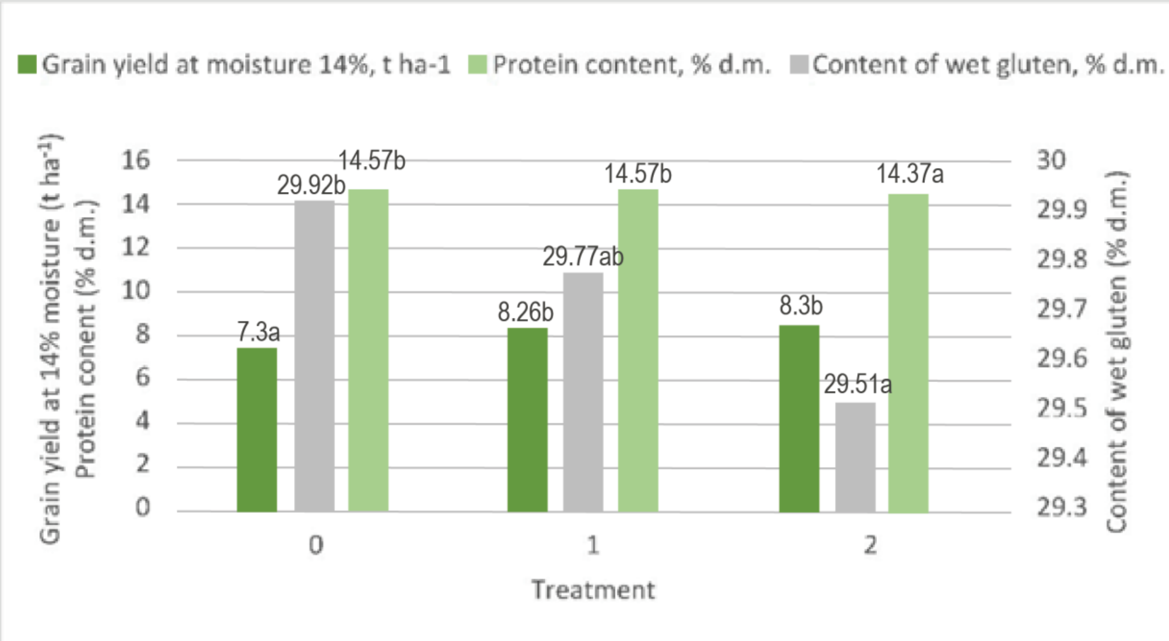

Figure 9: Means of grain yield, protein content and wet gluten of treatments of winter wheat in years 2017–2019. For the treatments, marginal means for all experiments together are presented (different letters indicate significant differences at 0.05 probability). (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

Trait	Mean	Minimum	Maximum	Standard Deviation (SD)	Coefficient of Variation (CV), %
Grain yield at moisture 14%, t ha^{-1}	7.95	2.62	11.48	1.76	22.19
Grain moisture, %	12.24	9.80	15.00	1.55	12.65
Yield of straw, t ha^{-1}	5.99	1.84	14.72	2.58	43.17
Spike density, pcs. m^{-2}	632.92	393.00	885.00	130.19	20.57
Number of non-productive shoots, pcs. m^{-2}	48.11	3.00	180.00	37.47	77.88
Total number of shoots, pcs. m^{-2}	680.94	431.00	977.00	150.23	22.06
Weight of 1000 grains (14% H_2O), g	43.48	24.40	54.30	6.64	15.26
Protein content, % d.m.	14.50	12.20	16.80	1.14	7.83
Content of wet gluten, % d.m.	29.73	20.80	36.90	4.03	13.55
Grain uniformity (fractions separated at sieves 2.5 × 25 mm), %	81.11	66.00	91.80	6.54	8.07
Hagberg falling number, s	317.20	241.00	390.00	35.15	11.08
Zeleny sedimentation value (SDS), mL	48.41	21.00	71.00	16.08	33.22
Height of plants, cm	69.58	48.50	94.50	11.85	17.04
Number of grains per spike, pcs.	45.00	31.00	64.80	7.67	17.05

Figure 10: Descriptive statistics for all experiments with winter wheat (2017–2019). (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

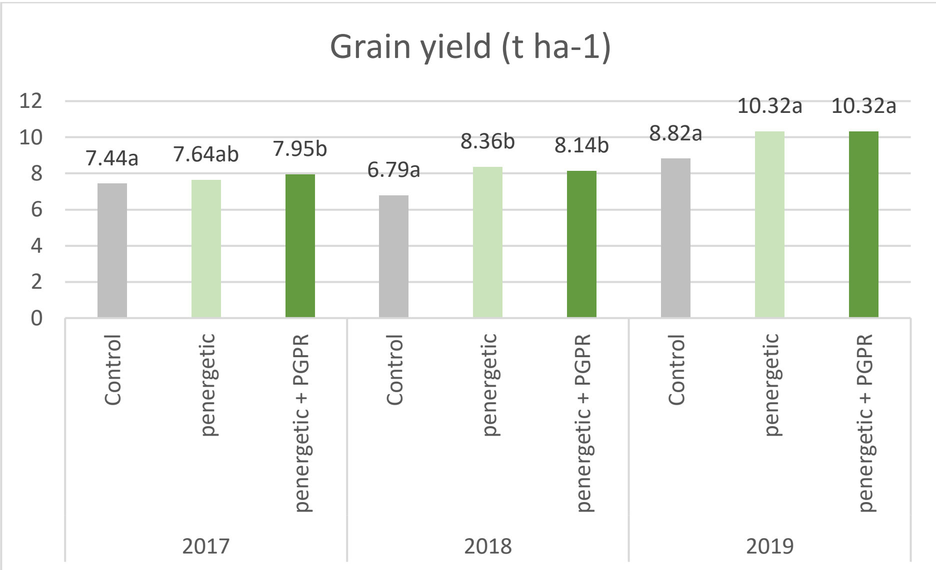

Figure 11: grain yield of treatments of winter wheat in years 2017–2019. For the treatments, marginal means for all experiments together are presented (different letters indicate significant differences at 0.05 probability). (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

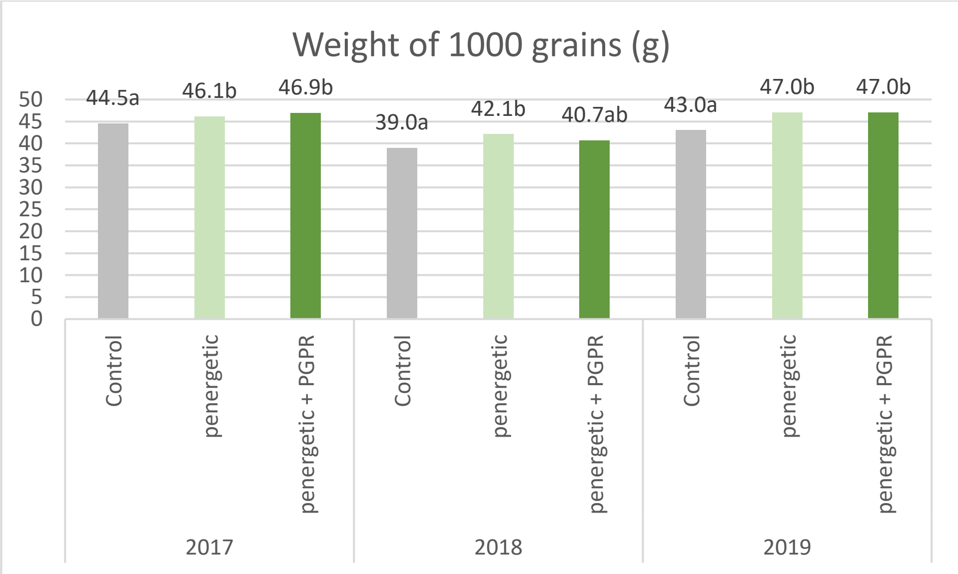

Figure 12: Weight of 1000 grains (g) of treatments of winter wheat in years 2017–2019. For the treatments, marginal means for all experiments together are presented (different letters indicate significant differences at 0.05 probability). (Artyszak & Gozdowski, Fertilizer reduction trial in winter wheat, 2021)

References

Artyszak, A., & Gozdowski, D. (2020, October 23). Is It Possible to Replace Part of the Mineral Nitrogen Dose in Maize for Grain by Using Growth Activators and Plant Growth-Promoting Rhizobacteria? Agronomy, 10(11), 1647. *MDPI AG*. Retrieved from http://dx.doi.org/10.3390/agronomy10111647

Artyszak, A., & Gozdowski, D. (2020, August 26). The Effect of Growth Activators and Plant Growth-Promoting Rhizobacteria (PGPR) on the Soil Properties, Root Yield, and Technological Quality of Sugar Beet. Agronomy, 10(9), 1262. *MDPI AG*. Retrieved from http://dx.doi.org/10.3390/agronomy10091262

Artyszak, A., & Gozdowski, D. (2021, May 22). Is It Possible to Maintain the Quantity and Quality of Winter Wheat Grain by Replacing Part of the Mineral Nitrogen Dose by Growth Activators and Plant Growth-Promoting Rhizobacteria (PGPR)? Sustainability, 13(11), 5834. *MDPI AG*. Retrieved from https://www.mdpi.com/2071-1050/13/11/5834