Research paper **P 3**

HOW DO AGROECOLOGICAL PRACTICES ALTER NON-ENZYMATIC ANTIOXIDANTS IN MAIZE GRAIN?

V. Dragičević, J. Vukadinović, M. M. Šenk, M. Simić and M. Brankov

Maize Research Institute Zemun Polje, Slobodana Bajića 1, 11185 Zemun Polje – Belgrade, Serbia (vdragicevic@mrizp.rs)

DOI: 10.68725/FDSQ_WORKSHOP.2026.9.14

ABSTRACT

Agroecology improves sustainability and biodiversity, preserving ecological balance. The objective of this study was to examine the impact of cover crops (oat and rye), combined with weed control measures (mechanical weed control, bio-herbicide, full and reduced herbicide rates, compared to the weedy check), on the status of non-enzymatic antioxidants. While rye, as a cover crop, promoted accumulation of phenolics and glutathione, thereby increasing the DPPH radical-scavenging capacity, fallow was associated with greater phytate accumulation, which may play a presumable role in grain yield development. It was shown that a combination of various agroecological practices could have a great impact on antioxidants in maize grain.

INTRODUCTION

Owing to the growing trend in the EU to reduce the use of pesticides by 50% by 2030 [1], more sustainable farming practices were promoted as a way to restore agroecosystems and biodiversity. Serbia is in the process of aligning agricultural policies with the EU Common Agricultural Policy, so it is important to reduce pesticide application.

Cover crops provide many benefits, from soil moisture preservation, reduction of soil erosion and nutrient runoff to weed suppression [2,3]. Due to the fact that there are no documented data on nutrient status in grain of agroecologically grown maize, the objective of this study was to examine the impact of cover crops (oat and rye), together with various weed control measures (mechanical weed control, bio-based herbicide, full and reduced herbicide rates, compared to the weedy check) on the status of non-enzymatic antioxidants.

EXPERIMENTAL

The research started in 2023, at the experimental field of the Maize Research Institute "Zemun Polje", Belgrade, Serbia (44°52′ N 20°20′ E). The experiment included three replications, where the main plot was cover crop (CC), sown in November 2023: rye (*Secale cereale* L.), oat (*Avena sativa* L.), and fallow (NoCC). Sub–plots were weed control measures: herbicides nicosulfuron + tembotrione, applied either at the recommended rate (FLR) or at ½FLR,

bioherbicide (BH) – pelargonic acid; mechanical control (MC), done using an inter-row cultivator, and the weedy check (WC). After CCs termination (April 2024), maize (ZP388) was sown.

After harvest, maize grains were dried at 60°C and milled. After extraction with 5% trichloroacetic acid, phytic P (P_{phy}) and glutathione (GSH) were determined spectrophotometrically [4,5]. Soluble phenolics (Phen) were determined after extraction with double-distilled water [6] and expressed as μg of *3-hydroxy-4-methoxycinnamic acid* g^{-1} dry matter. DPPH radical scavenging activity was performed using the method by Brand-Williams et al. and Wong et al. [7,8]. Results were presented as mean±standard deviation (SD). Correlation analysis between maize grain yield (GY) and analysed antioxidants (Pearson's correlation coefficients) was also performed.

RESULTS AND DISCUSSION

Irrespective of the greater variability in the concentration of antioxidants, the rye variant had the highest average values of phenolics, GSH, and DPPH radical reduction capacity (Table 1). Comparing weed control treatments, it is obvious that higher Pphy and DPPH radical reduction capacity were in FLR, followed by ½FLR, indicating that herbicides, by removing weeds, are able to increase the antioxidant capacity of the maize grain [9]. It is interesting that phytate mainly contributed to the reduction capacity of DPPH radical (Table 2), which could be tied to the greater resistance to oxidative stress [10].

The highest Pphy was in NoCC+FLR and oat+FLR (Table 1), while the highest reduction capacity of DPPH radical was in NoCC+FLR, again evidencing that the variant with fallow supports accumulation of non-enzymatic antioxidants in maize grain, particularly phytate, which could be potentially tied to greater phosphorus availability and certain microbial activity [11]. BH contributed mainly to the accumulation of phenolics and GSH in maize grain, with the highest value obtained in combination with rye, evidencing the distinctive impact of CCs and weed control measures on antioxidants in maize grain [12]. This could be one of the reasons for the significant positive correlation between maize grain yield and the reduction capacity of the DPPH radical and phytate (Table 2), supporting the hypothesis that grain yield and further grain performance closely rely on antioxidants, particularly phytate [10,13].

Table 1. The concentration of non-enzymatic antioxidants in maize grain (mean±SD).

	Pphy	Phen.	GSH	DPPH
		NoCC		
WC	2.59 ± 0.01	734.3 ± 13.09	345.2 ± 12.81	59.59 ± 0.78
FLR	3.02 ± 0.12	595.6 ± 4.32	383.3 ± 2.30	68.30 ± 1.02
½FLR	2.99 ± 0.08	567.2 ± 22.94	475.8 ± 15.21	65.12 ± 1.02
BH	2.66 ± 0.07	738.8 ± 36.58	599.2 ± 6.57	54.65 ± 0.49
MC	2.99 ± 0.11	514.7 ± 1.63	473.0 ± 5.81	58.74 ± 0.61
Mean	2.85 ± 0.08	630.1 ± 15.71	455.3 ± 8.54	61.28 ± 0.78
		Oat		
WC	2.60 ± 0.05	635.4 ± 10.24	386.7 ± 4.63	53.38 ± 0.49
FLR	3.03 ± 0.09	626.4 ± 18.20	465.3 ± 11.72	65.12 ± 0.29
½FLR	2.87 ± 0.06	612.9 ± 15.85	471.7 ± 13.21	55.82 ± 0.25
BH	2.59 ± 0.06	642.9 ± 21.05	530.0 ± 0.43	51.20 ± 0.45
MC	2.71 ± 0.06	615.9 ± 12.14	501.9 ± 10.22	55.19 ± 1.06
Mean	2.76 ± 0.06	626.7 ± 15.50	471.1 ± 8.04	56.14 ± 0.51
		Rye		
WC	2.53 ± 0.06	810.8 ± 21.43	342.6 ± 0.43	64.37 ± 0.20
FLR	2.72 ± 0.19	795.8 ± 8.22	485.2 ± 8.27	68.25 ± 0.49
½FLR	2.87 ± 0.08	684.1 ± 24.29	521.5 ± 12.49	67.45 ± 0.86
BH	2.55 ± 0.04	895.5 ± 28.03	601.4 ± 9.29	58.27 ± 1.06
MC	2.66 ± 0.10	637.6 ± 17.27	549.0 ± 5.24	64.27 ± 0.78
Mean	2.66 ± 0.09	764.7 ± 19.85	499.9 ± 7.15	64.52 ± 0.68

Table 2. Correlation between analyzed non-enzymatic antioxidants and maize grain yield (GY), Pearson's correlation coefficients (r)

	GY	Pphy	Phen	GSH
Pphy	0.52*			
Phen	-0.09	-0.69*		
GSH	0.04	-0.07	0.15	
DPPH	0.55*	0.45*	0.07	-0.22

* Significant at $p<0.05$

CONCLUSION

The combination of various agroecological practices that serve as weed control could contribute significantly to the maize grain yield quality, from the perspective of non-enzymatic antioxidants. While rye, as CC, promoted accumulation of phenolics and GSH, consequently increasing the reduction capacity of DPPH radical, it was shown that fallow was responsible for phytate accumulation, which plays a presumed role in grain yield development.

Acknowledgement
The author(s) declared that financial support was received for this work and/or its publication, funded by the European Union under Grant Agreement No. 101083589. Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them. This work was partially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040; Sustainable Development Goals - Zero Hunger).

REFERENCES

[1] A. Tataridas, P. Kanatas, A. Chatzigeorgiou, S. Zannopoulos, I. Travlos, *Agronomy,* 12, 2022, 589.
[2] O.A. Osipitan, J.A. Dille, Y. Assefa, Radicetti E., et al., *Crop Sci*., 59 2019, 833-842.
[3] J.S. Bergtold, S. Ramsey, L. Maddy, J.R. Williams, *Renew. Agric. Food Systems*. 34, 2019, 62-76.
[4] V. Dragicevic, S. Sredojević, V. Perić, A. Nišavić, et al. *Acta Period. Technol.*, 42, 2011, 11–21.
[5] M. Sari-Gorla, S. Ferrario, L. Rossini, C. Frova, et al. *Euphytica,* 67, 1993. 221–230.
[6] A. Simić, S. Sredojević, M. Todorović, L. Đukanović, et al. *Seed Sci. Technol.*, 32, 2004, 213–218.
[7] W. Brand-Williams, M.E. Cuvelier, C. Berset, *LWT - Food Scie. Technol. 28*, 1995, 25–30,
[8] S.P. Wong, L.P. Leong, J.H. William Koh,. *Food Chem.* 99, 2006, 775–783.
[9] J. Mesarović, J. Srdić, S. Mladenović-Drinić, V. Dragičević, et al. *J. Cereal Sci.*, 87, 2019, 132-137.
[10] E. Doria, L. Galleschi, L. Calucci, C. Pinzino, et al, *J. Exp. Bot.*, 60, 2009, 967–978.
[11] M. Hallama, C. Pekrun, S. Pilz, *et al. Plant Soil* 463, 2021, 307–328.
[12] V. Dragicevic, Ž. Dolijanović, B. Janosevic, M. Brankov, et al. *Agronomy*, 11, 2021, 981.
[13] A. Z. Oo, H. Asai, K.Songyikhangsuthor, B. Vongphouthone, et al., *Front. Agron.,* 2026, 1743691.