PHYSICAL CHEMISTRY 2021

15th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

Proceedings
Volume II

The Conference is dedicated to the

30th Anniversary of the founding of the Society of Physical Chemists of Serbia

and

100th Anniversary of Bray-Liebhafsky reaction

September 20-24, 2021
Belgrade, Serbia

Title: Physical Chemistry 2021 (Proceedings) **ISBN** 978-86-82475-40-8
Volume II: ISBN 978-86-82475-39-2
Editors: Željko Čupić and Slobodan Anić
Published by: Society of Physical Chemists of Serbia, Studentski Trg 12-16, 11158, Belgrade, Serbia
Publisher: Society of Physical Chemists of Serbia
For Publisher: S. Anić, President of Society of Physical Chemists of Serbia
Printed by: ″Jovan″, <Printing and Publishing Company, 200 Copies
Number of pages: 6+388, Format A4, printing finished in December 2021

Text and Layout: ″Jovan″

200 - *Copy printing*

ENERGY DISTRIBUTION BETWEEN MAIZE AND WEEDS

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ABSTRACT

The aim of the study was to investigate the variations in accumulation of dry substance and water in maize and weeds, induced by two herbicide types (applied pre- and post-emergence). Weeds tend to captivate higher energy amounts than crop plants. Greater free energy of water indicated increased energy consumption for non-spontaneous processes in weeds. Relatively unchanged net heat of combustion of maize and lower net heat of combustion of weeds indicated herbicide ability to reduce energy accumulation by weeds and to remain it constant in maize plants.

INTRODUCTION

Plant growth is result of gradual accumulation of dry substance and water. Process of photosynthesis is the main factor of energy conversion into the dry substance, while the water enables environment for chemical reactions and homeostasis upholding. Crop plants and weeds, which live at the same field are competitors, combat each with other for resources, such as sunlight, water, nutrients, etc. [1]. Weed control could be obtained by application of different measures, including herbicides. Some of them could have positive effect on chlorophyll synthesis, as well as energy balance of crops [2,3].

The objective of this study was to investigate the variations in accumulation of dry substance and water in maize plants and weeds, under the influence of two herbicide types (applied pre sowing and after sowing).

METHODS

The experiment was established in the experimental field of the Maize Research Institute Zemun Polje, Serbia. The maize hybrid ZPSC 388 was sown in the second half of April in 2014, 2015 and 2016. Two herbicides were tested: pre-emergence (pre-em; applied immediately after sowing) and post-emergence (post-em; applied in maize phase 5-8 leaves). Weeds and maize plants were sampled 3 weeks after post- and 6 weeks after pre-emergence herbicide application. Total fresh and dry substance (after drying at 60 °C) of weeds per 0.25 m^2 area and fresh and dry substance of five whole maize plants were measured. Based on subtraction between fresh and dry substance, free energy of free water (ΔG for maize ΔG_M and weeds ΔG_W) was calculated using sorption isotherm [4, 6]:

$$\Delta G = -RT \ln(a_w)$$

The net heat of combustion (NHC) was calculated after dry substance combustion, using loss-on-ignition method [5], by multiplying with coefficients 16.52 MJ kg^{-1} for maize (NHC_M) [6] and 17.33 MJ kg^{-1} for weeds (NHC_W) [7]. The chlorophyll content in maize leaves was measured with a SPAD-502 Plus chlorophyll meter (Minolta, Tokyio, Japan) and leaf area index (LAI) with LI – 3100 area meter (LI Cor, Lincoln, NE). The grain yield (GY) was measured at the end of the maize growing period.

The data are presented with standard deviation (SD) and the dependences between examined parameters were obtained by correlation (Pearson's coefficients).

RESULTS AND DISCUSSION

The values of water based free energy of maize and weeds (Fig. 1) were mainly lower in both herbicide treatments: Nevertheless, when ΔG_W and ΔG_M were compared, ΔG_M was lower, with exception of 2016, when ΔG_M was higher in regard to ΔG_W, indicating stress and energy consumption for non-spontaneous processes to maintain equilibrium [3, 4].

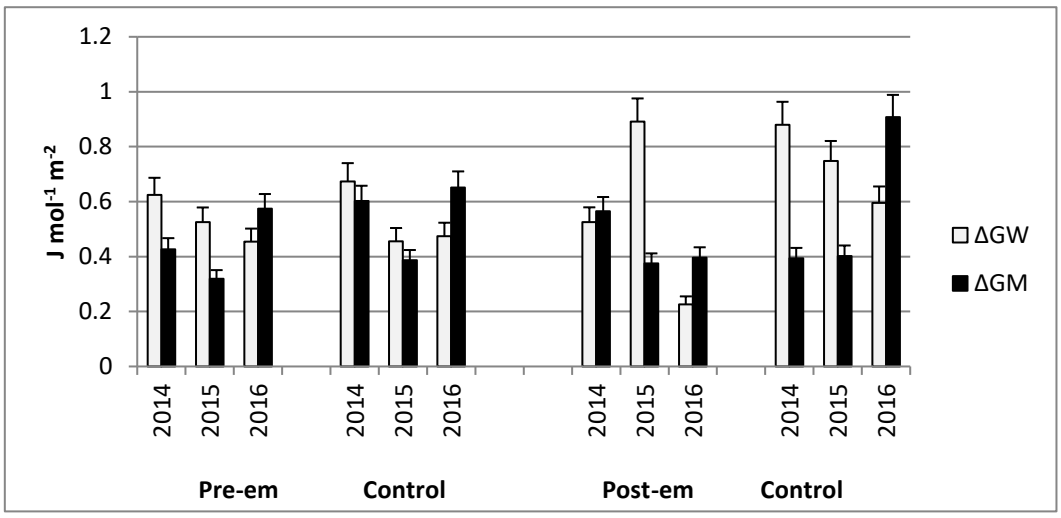

Figure 1. The influence of year and applied herbicides on free energy of weeds (ΔG_W) and maize (ΔG_M)

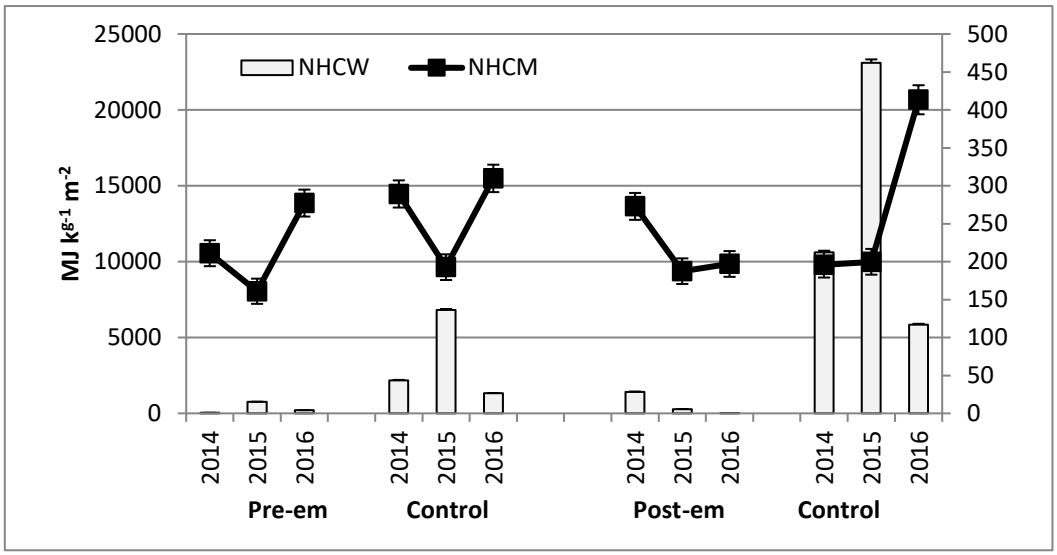

Figure 2. The influence of year and applied herbicides on net heat of combustion of weeds (NHC_W) and maize (NHC_M)

The general difference between maize and weeds was present in net heat of combustion, having greater values in weed samples. Relatively lower NHC_W values in treatments with herbicides, particularly post-em herbicide, indicated that herbicide induced stress increased energy consumption on biochemical processes in weeds [3]. On the other hand, average values of NHC_M mainly remained constant, with variations present between years. Only in post-em control in 2016, NHC_M and ΔG_M had the highest values.

Table 1. Correlation between leaf area index (LAI), grain yield (GY) and chlorophyll content (Chl.) and free energy of weeds (ΔG_W) and maize (ΔG_M), as well as net heat of combustion of weeds (NHC_W) and maize (NHC_M) (Pearson's correlation coefficients)

	LAI	GY (t ha^{-1})	Chl. (SPAD units)
ΔG_W (J mol^{-1} m^{-2})	-0.371*	-0,415*	-0.257
ΔG_M (J mol^{-1} m^{-2})	0.005	0.205	0.357*
NHC_W (MJ kg^{-1} m^{-2})	-0.685*	-0.678*	-0.726*
NHC_M (MJ kg^{-1} m^{-2})	0.013	0.214	0.365*

*Significant at 5% probability level

The correlation between maize growth parameters (leaf area index, grain yield and chlorophyll content) and energy parameters of maize and weeds (ΔG_M, ΔG_W, NHC_M and NHC_W) revealed significant and negative interdependence between ΔG_W and NHC_W in regard to leaf area index and grain yield (Tab. 1), testifying about negative impact of weeds and their ability to captivate higher energy amounts than crop plants, thus affecting crop energy balance and yield potential [1]. Positive correlation between chlorophyll content and energy parameters of maize (ΔGM and NHCM) supports standpoint that photosynthesis is main factor of crop energy production, as well as yield potential [8].

CONCLUSION

Weeds tend to captivate higher energy amounts than crop plants, thus decreasing maize yield parameters. Greater ΔG_W values indicated increased energy consumption for non-spontaneous processes in weeds. Lower values of NHC_W and relatively invariable NHC_M, particularly in post-em treatment indicated herbicide ability to reduce energy accumulation by weeds and to keep it constant in maize plants.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant no. TR-31037.

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