https://doi.org/10.15414/agrobiodiversity.2018.2585-8246.062-068

AGROBIODIVERSITY 2018
FOR IMPROVING NUTRITION, HEALTH AND LIFE QUALITY
OPEN ACCESS

ALLELOPATHIC AND BIOCHEMICAL CHARACTERISTICS OF THE ROOT ENVIRONMENT OF *ASIMINA TRILOBA* (L.) DUNAL

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Received: 01. 11. 2018 Revised: 08. 11. 2018 Published: 10. 12. 2018

The paper is devoted to the study of the allelopathic and biochemical characteristics of the root environment of *Asimina triloba* (L.) Dunal (pawpaw) introduced from North America to M.M. Gryshko National Botanical Garden of NAS of Ukraine. The plants were divided into the following age groups: a) young plants (2–4 years old), b) plants of the middle age (5–7 years old), c) the old plants (14–16 years old) and d) the oldest plants (over 22 years old). Allelopathic and biochemical analyses were conducted in dynamics on phases of plant development during flowering, fruitage and the end of the growing season. Rhizosphere soil samples were collected at 0–20 cm layer. The fallow soil was used as a control. The presence of allelochemicals in root environment of *A. triloba* by modified Neubauer and Schneider method was established. As a result, the inhibition of the growth processes and accumulation of dry matter in the roots and shoots of acceptor plants with an increase in the age of pawpaw was observed. Biochemical state of the root environment was assessed by redox potential (*Eh*) values. The redox status varied from weakly to highly reducing soil conditions during the growing season. The lowest soil *Eh* level for the oldest plants was determined. The predominance of reduction processes in the rhizosphere soil of *A. triloba* indicates the accumulation of mobile organic compounds, which can function as allelochemicals. The content of phenolic compounds in the rhizosphere soil of *A. triloba* was 1.3–3.0 times higher than control. The concentration of phenolic allelochemicals increased with the age of plants, and also at the end of the growing season. Thus, *A. triloba* forms a powerful allelopathic regime of the root environment, which is due to the accumulation of free organic compounds, mainly phenolic nature.

Keywords: *Asimina triloba*, root environment, allelochemicals, phenolic compounds, redox potential

Introduction

Recently, in Ukraine, great attention is paid to the introduction of new and non-traditional plants into culture both for preserving biodiversity and for obtaining stable yields of high-

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quality production as a natural source of bioactive agents. *Asimina triloba* (L.) Dunal (pawpaw) is a promising new ornamental and fruit crop for dissemination on Ukraine territory, including botanical gardens, arboretums, farms, etc. Pawpaw is rich in various bioactive compounds, due to which it possesses valuable nutritional, antioxidant, insecticidal, medicinal, including anti-tumoral, properties, as well as high adaptive potential to adverse environmental factors (Cuendet et al., 2008; Farag, 2009; Pande and Akoh, 2010; Sedlacek et al., 2010; Ferreira et al., 2011; Brannan et al., 2015; Ortutu et al., 2015; Koul, 2016; Levon and Klymenko, 2016; Mangal et al., 2016; Avula et al., 2018; Nam et al., 2018a).

A. triloba belongs to the mainly tropical and subtropical family *Annona*ceae Juss. *A. triloba* is a native North American species. Pawpaw is widespread in the eastern United States, ranging from New York, and southern Michigan on the north, south to northern Florida, and west to eastern Texas, Nebraska, and Kansas; it is also present in Ontario, Canada (Hormaza, 2014). *A. triloba* is widely cultivated in Korea for its different parts, which contain inhibitors of cancer cells and antioxidant compounds (Nam et al., 2017; Nam et al., 2018a, b). The prerequisites for the successful introduction of new species are not only their adaptability and bioecological characteristics, but also to a large extent understanding the risks associated with allelopathic effects both in relation to other species and in monoculture (Zaimenko et al., 2017). One of the negative consequences of introduction may be the aggressive invasion of new species into natural areas. Therefore, the study of the allelopathic potential of new and non-traditional plants is actual and necessary both from a scientific and a practical standpoint. The allelopathic interactions of invasive shrub *Lonicera maackii* in comparison with native species *A. triloba* were investigated (McEwan et al., 2010). The morphometric parameters of introduced pawpaw seedlings in combination with various groups of ornamental species commonly used in Romania were studied (Szilagyi and Marian, 2011).

In view of the above mentioned, the purpose of the work was to analyse the allelopathic and biochemical characteristics of the root environment of *Asimina triloba* as a new fruit crop for Ukrainian horticulture.

Material and methodology

Plant material and soil source

The object of research was the root environment of *Asimina triloba* from orchard plots of M.M. Gryshko National Botanical Garden of Ukraine National Academy of Sciences. Plants were divided into the following age groups: a) young plants (2–4 years old), b) plants of the middle age (5–7 years old), c) the old plants (14–16 years old) and d) the oldest plants (over 22 years old). Rhizosphere soil samples were collected at 0–20 cm layer. The fallow soil was used as a control. The soil is dark grey podzolized.

Allelopathic and biochemical analyzes were conducted in dynamics on phases of plant development during flowering (I), fruitage (II) and the end of the growing season (III).

Allelopathic activity

Allelopathic activity of the soil was studied by modified Neubauer and Schneider method (Black, 1993). Winter wheat (*Triticum aestivum* L., Poliska 90 cultivar) was used as the test plant.

Biochemical analyses

The redox potential (*Eh*) was measured in soil suspension modelling soil solution at the soil to distilled water ratio as 1 : 1 by potentiometric technique (Labuda and Vetchinnikov, 2011; Fiedler et al., 2007). Phenolic compounds were extracted from the soil by desorption method using an ion exchanger KU-2-8 (H^+) (Pavliuchenko et al., 2014).

Data analysis

Experimental data were statistically analyzed using the software package Microsoft Excel.

Results and discussion

The presence of allelochemicals in the root environment of *A. triloba* was established. As a result, the inhibition of the growth processes and accumulation of dry matter in the roots and shoots of acceptor plants (*Triticum aestivum*) with an increase in the age of pawpaw was observed. The allelopathic activity of the root environment was the largest at the end of the growing season (Figure 1, 2). It should be noted that the rhizosphere soil of young pawpaw plants caused an insignificant allelopathic effect on test plants throughout the growing season.

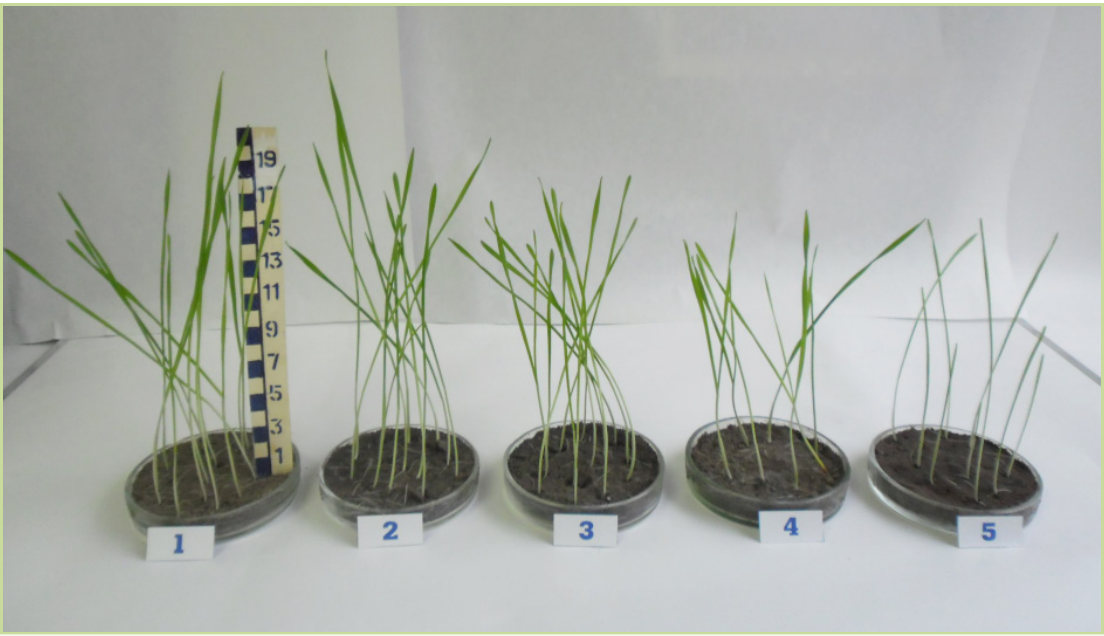

Figure 1 Allelopathic activity of root environment of *Asimina triloba* (test plant – *Triticum aestivum*): 1 – control; 2 – young plants; 3 – plants of the middle age; 4 – the old plants; 5 – the oldest plants

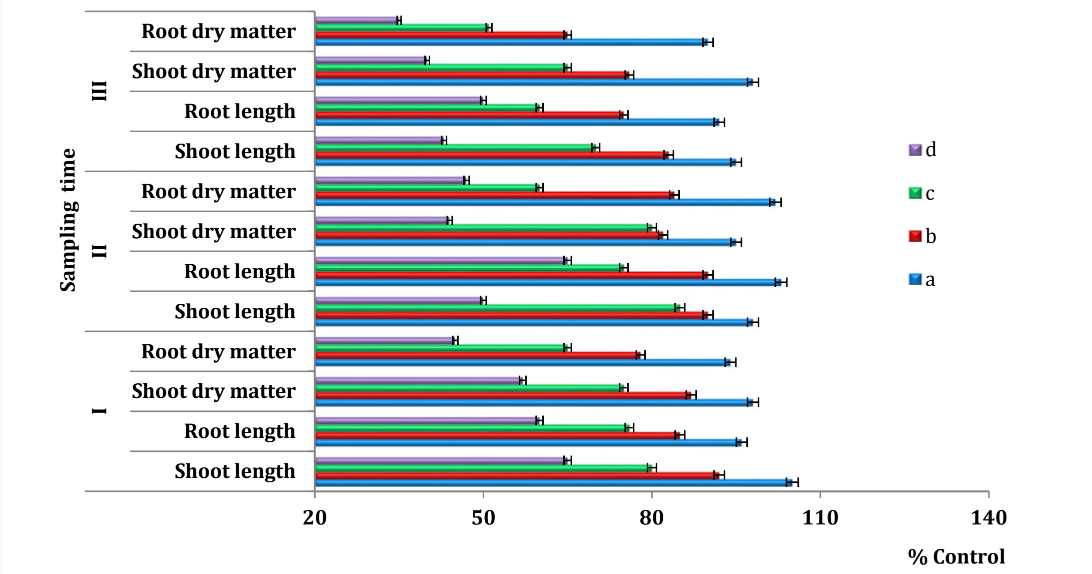

Figure 2 Allelopathic activity of root environment of *Asimina triloba* (test plant – *Triticum aestivum*),% control: a – young plants; b – plants of the middle age; c – the old plants; d – the oldest plants

Biochemical state of the root environment was assessed by redox potential (*Eh*) values. Redox potential is a measure of the ratio of oxidized to reduced forms in a solution (Tokarz and Urban, 2015). Oxidation–reduction (redox) reactions in soils are mainly controlled by microbial activity, the presence of oxygen and carbon supplies (Fiedler et al., 2007; Tokarz and Urban, 2015). *Eh* varies depending on many factors, such as temperature, humidity, aeration, the content of organic matter, soil horizon (Husson, 2013). Plants can significantly influence *Eh* in the soil environment through root exudates (Husson, 2013). The redox potential is used as an indicator of the oxygenation status and the content of biogenic forms and toxins in the soil environment (Tokarz and Urban, 2015). Therefore, *Eh* fluctuations are important for the detection of phytotoxic allelochemicals in the root environment.

Weakly and moderately reducing conditions prevailed in the root environment of young plants, the middle age and the old plants of *A. triloba*. The lowest soil *Eh* values for the oldest plants were established. In this case, the redox status varied from moderately to highly reducing soil conditions during the growing season. The predominance of reduction processes (*Eh* < 400 mV) in the rhizosphere soil of *A. triloba* indicates the accumulation of mobile organic compounds, which can function as allelochemicals.

Phenolic compounds are the most important and common plant allelochemicals in the ecosystems, as well as precursors of humic substances in soils (Macias et al., 2004; Li et al., 2010). The pawpaw different tissues are rich natural source of phenolic acids and flavonoids such as gallic acid, epigallocatechin, catechin, chlorogenic acid, caffeic acid, ellagic acid, epicatechin, epigallocatechin gallate, p-coumaric acid, gallocatechin gallate, ferulic acid, epicatechin gallate, rutin, catechin gallate, naringin,and quercetin (Pande and Akoh, 2010;

Brannan et al., 2015; Ortutu et al., 2015; Levon and Klymenko, 2016; Nam et al., 2017). These phenolic compounds may be released to the root environment from *A. triloba* different parts by means of root exudation, leaching and decay of plant residues in soil. Therefore, the next stage of our research was to determine the content of phenolic compounds in the root environment of pawpaw. The content of phenolic allelochemicals in the rhizosphere soil of *A. triloba* was 1.3–3.0 times higher than control (Figure 3). The concentration of phenolic compounds increased with the age of plants, and also at the end of the growing season.

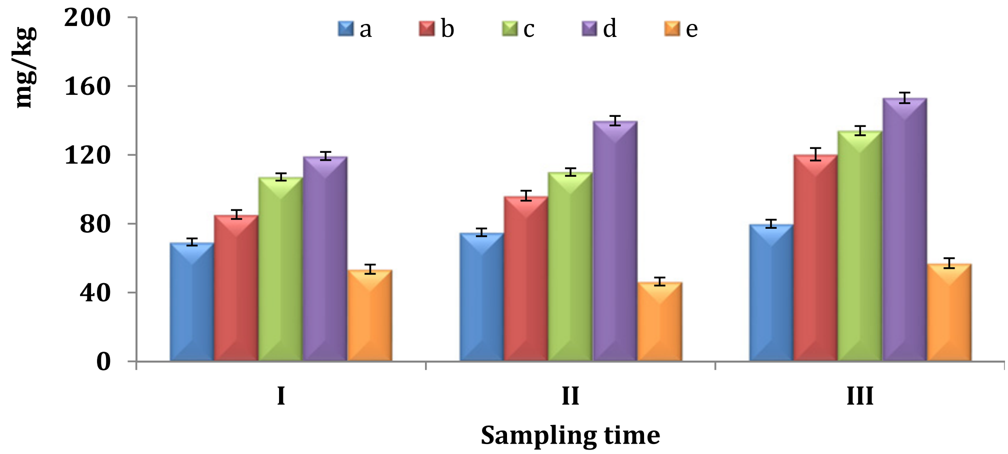

Figure 3 Phenolic compounds content in soil under *Asimina triloba*, mg.kg^{-1}: a – young plants; b – plants of the middle age; c – the old plants; d – the oldest plants; e – control

Conclusions

Thus, *Asimina triloba* forms a powerful allelopathic regime of the root environment, which is due to the accumulation of free organic compounds, mainly phenolic nature. Long-term cultivation of *A. triloba* enhances the intensity of soil reduction processes and its allelopathic effect on the root environment, which leads to an increase in phytotoxicity.

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