GSC Biological and Pharmaceutical Sciences

eISSN: 2581-3250 CODEN (USA): GBPSC2

Cross Ref DOI: 10.30574/gscbps

Journal homepage: https://gsconlinepress.com/journals/gscbps/

(RESEARCH ARTICLE)

Check for updates

Sea water flood resilience of five plant species with conservation status over the Bulgarian Black Sea Coast

Stoyan Vergiev *

Department of Ecology and Environmental Protection, Technical University of Varna, Varna, Bulgaria.

GSC Biological and Pharmaceutical Sciences, 2021, 16(03), 019–023

Publication history: Received on 27 July 2021; revised on 31 August 2021; accepted on 02 September 2021

Article DOI: https://doi.org/10.30574/gscbps.2021.16.3.0260

Abstract

The Bulgarian Black Sea coastal zone is relatively protected from sea floods. Only extreme meteorological events such as unusual storms can cause flooding of coastal areas. Crucial for the application of rapid methods for vulnerability assessment of coastal plant communities from flooding caused by unusual storms over the Bulgarian Black Sea Coast is to obtain experimental data for sea water flood resilience. This study aims to determine the plant species survival in simulated flooding experiments in order to identify sea water flood resilience of five plant species with conservation status: *Centaurea arenaria* M. Bieb. ex Willd., *Crambe tataria* Sebeok, *Aurinia uechtritziana* (Bornm.) Cullen & Dudley, *Silene thymifolia* Sm., and *Stachys maritima* Gouan. As a result of a simulated flooding experiment, Critical Decomposition Time (CDT) was obtained. The five species were within the most vulnerable group (CDT < 48 h). The CDT was significantly shorter than floods with a maximum duration for the Bulgarian Black Sea Coast. Only the values of the parameter beginning of decomposition of the leaves were accelerated by higher water temperatures. Other parameters were unrelated to different water temperatures. The investigated species have low survival rates and low degree of sea water flood resilience and their communities will not be able to recover after flooding with maximum duration within one vegetation season.

Keywords: Vulnerability assessment; Plant communities; Conservation status; Floods; The Black Sea Coast

1. Introduction

The Bulgarian Black Sea coastal zone is relatively protected from sea floods due to the small amplitude tides and the lack of flowing large rivers [1, 2]. Only extreme meteorological events such as unusual storms can cause flooding of coastal areas [1, 3].

Coastal zones provide habitats for many rare and endangered species, which will be lost due to the combination of negative consequences of flooding and erosion as well as increased human impact [4, 5, 6]. The flora of the beaches has dramatically changed during the last decades. Several species were extinct and others have lost territories that are occupied [7].

Preceding inventorization and distribution investigation of vascular plants as well as flood mapping over the Bulgarian Black Sea Coast identifies five plant species with conservation status as threatened by flooding [8]. The present study is focused on *Centaurea arenaria* M. Bieb. ex Willd., *Crambe tataria* Sebeok, *Aurinia uechtritziana* (Bornm.) Cullen & Dudley, *Silene thymifolia* Sm., and *Stachys maritima* Gouan.

Although, the coastal plant communities are well adapted to salinity due to regular exposure to sea water, some of the species are vulnerable and sensitive to the impact of waves and storms [9]. The necessity to assess and quantify this

* Corresponding author: Stoyan Vergiev
Department of Ecology and Environmental Protection, Technical University of Varna, Varna, Bulgaria.

negative effects and consequences on natural habitats requires the development of rapid models for vulnerability assessment.

Different flood scenarios and models have been developed in order to assess possible negative consequences to coastal areas from storms [1, 10]. It is of great significance to obtain experimental data on plant survival in order to apply the rapid method for vulnerability assessment of coastal plant communities from flooding caused by unusual storms over the Bulgarian Black Sea Coast [2]. Proposed by Vergiev *et al.* [2] model allows experimental results to be applied directly to the present situation and to predict the effects of future storm events to the dune vegetation.

This study aims to determine the plant species survival in simulated flooding experiments in order to identify sea water flood resilience of five plant species with conservation status over the Bulgarian Black Sea Coast.

2. Material and methods

Thirty whole plants from each investigated species were eradicated from *ex-situ* collection of the Technical University of Varna in April 2021 and were planted in washed and sterilized sand in 10 × 10 × 17 cm^3 plastic pots. After a month of acclimatization in the Biological Laboratory of the Technical University of Varna, the plants with pots, separated in three equal groups, were completely submerged in three 100 l glass tanks full of sea water with maintained constant temperatures of 4±1, 13±1, and 23±1 °C, respectively, for 480 hours. The water was changed twice a day in order to avoid water decay processes [2, 3, 4].

Visible morphological changes of different parts of the plants (leaves, stems, roots) and the effect of flooding on the viability of the studied specimens were recorded and assessed in 12 parameters. The beginning of decomposition of leaves, stems, roots was identified when visible changes of decay were more than 15% of the whole vegetative organ surface. Complete decomposition was when the visible decomposition of an organ exceeded 50% of its surface [3].

3. Results and discussion

Preceding identified as threatened by inundation plant species with conservation status were shown on Table 1. Current conservation status was checked also.

Table 1 Conservation status of the investigated species

Latin name	Family	BDA	RDB
Centaurea arenaria M. Bieb. ex Willd.	*Asteraceae*	+	
Crambe tataria Sebeok	*Brassicaceae*	+	En
Aurinia uechtritziana (Bornm.) Cullen & Dudley	*Brassicaceae*	+	En
Silene thymifolia Sm.	*Caryophyllaceae*		En
Stachys maritima Gouan	*Lamiaceae*	+	En

BDA – Bulgarian Biological Diversity Act (2002) – Annex 3 [11]. RDB - Red Data Book of the Republic of Bulgaria [12], EN – Endangered.

The parameter Critical decomposition time (CDT) was proposed and was substantiated in several studies for the Bulgarian Black Sea Coast [2, 3, 6, 7, 9]. It presents the time expression of plant species survival by linking the duration of flooding and resilience of plant species. Although the CDT is subjectively defined on visible morphological changes and represents the smallest degree of irreversible decay of vegetative organs (more than 15% of the whole vegetative organ surface), it indicates that the plants will not survive after flooding with longer duration and their communities will not be able to recover [2].

Most of the experimental methods used to study the response of investigated plants to sea water are focused to substrate salinity and salt spray from the waves. These standard methods are inapplicable to define the flood resilience are well adapted to substrate salinity due to their regular exposure to sea water [3, 4]. Numerous studies demonstrated that direct submergence in sea water flood simulations were more appropriate than the indirect experiments for studying substrate salinity and salt spray [3, 7, 9]. Therefore, in order to understand the effects of sea water inundation on these species, two experiments based on direct submergence were chosen.

One of the variables that can affect the survival ability of the investigated species is sea water temperature. Three sea water flood simulations with different temperatures were carried out in order to study the relation between temperature and CDT [3]. In winter and early spring, when the storm events at the Black Sea Coast occur, average surface sea water temperature is about 4ºC. Other two treatments with temperatures of 13ºC (average surface sea water temperature) and 23ºC (average summer surface sea water temperature) were included in the simulated experiment [3].

Table 2 shows the results from conducted flooding simulations as well as CDT.

Table 2 Results from simulated flooding experiment. Data in bold present CDT

Plant	T ºC	Parameters											
		Beginning of decomposition of			Complete decomposition of			Growth of		Beginning of decomposition of newly grown		Complete decomposition of newly grown	
		leaves	stems	roots	leaves	stems	roots	stems	roots	stems	roots	stems	roots
Centaurea arenaria	4	48	180	204	108	360	384	190	120	300	320	400	408
	13	46	180	204	102	360	380	190	120	300	320	400	406
	23	**46**	180	204	102	360	380	190	120	300	320	400	406
Crambe tataria	4	46	168	192	96	312	336	n/a	n/a	n/a	n/a	n/a	n/a
	13	42	168	192	96	312	336	n/a	n/a	n/a	n/a	n/a	n/a
	23	**42**	168	192	96	312	336	n/a	n/a	n/a	n/a	n/a	n/a
Aurinia uechtritziana	4	46	172	192	96	300	348	n/a	148	n/a	300	n/a	372
	13	46	172	192	96	300	348	n/a	148	n/a	300	n/a	372
	23	**46**	172	192	96	300	348	n/a	148	n/a	300	n/a	372
Silene thymifolia	4	44	168	192	84	384	312	n/a	120	n/a	384	n/a	408
	13	42	168	192	84	384	312	n/a	120	n/a	384	n/a	408
	23	**42**	168	192	84	384	312	n/a	120	n/a	384	n/a	408
Stachys maritima	4	42	160	180	84	192	240	n/a	n/a	n/a	n/a	n/a	n/a
	13	40	160	180	84	192	240	n/a	n/a	n/a	n/a	n/a	n/a
	23	**40**	160	180	80	192	240	n/a	n/a	n/a	n/a	n/a	n/a

The beginning of the decay of leaves was the first visible morphological changes. The time frame of this parameter for the investigated species is between 40 and 48 hours.

According to Vergiev *et al.* [2, 3] this value have to be accepted as CDT. In the practice of the rapid method for vulnerability assessment of coastal plant communities from flooding caused by unusual storms over the Bulgarian Black Sea Coast, the investigated species can be divided by CDT into 3 groups. The five species were within the most vulnerable group (CDT < 48 h). The CDT was significantly shorter than floods with a maximum duration for the Bulgarian Black Sea Coast [1, 2].

This value of the CDT is comparable with the results of *Crambe maritima* L., *Artemisia vulgaris* L., and *Eryngium maritimum* L. [2].

Only the value of the parameter beginning of decomposition of the leaves were accelerated by higher water temperatures, consistent with previous studies of vulnerable species [2] and contrary to experiments with psammophytes from the family *Poaceae* [3, 9] and the family *Cyperaceae* [7, 13]. Other parameters were unrelated to different water temperatures.

The investigated species have low survival rates and low degree of sea water flood resilience and their communities will not be able to recover after floods with maximum duration within one vegetation season.

4. Conclusion

The value of the CDT for *Centaurea arenaria* M. Bieb. ex Willd., *Crambe tataria* Sebeok, *Aurinia uechtritziana* (Bornm.) Cullen & Dudley, *Silene thymifolia* Sm., and *Stachys maritima* Gouan is between 40 and 46 hours. The five species were within the most vulnerable group (CDT < 48 h). The CDT was shorter than floods with a maximum duration for the Bulgarian Black Sea Coast. Only the values of the parameter beginning of decomposition of the leaves were accelerated by higher water. Other parameters were unrelated to different water temperatures. The investigated species have low survival rates and low degree of sea water flood resilience and their communities will not be able to recover after floods with maximum duration within one vegetation season.

Compliance with ethical standards

Acknowledgments

A part of the scientific research, the results of which are presented in this article, was conducted at Technical University of Varna, within the framework of the scientific research, funded by the state budget.

Disclosure of conflict of interest

The authors declare the absence of a conflict of interest.

References

[1] Trifonova E, Valchev N, Keremedchiev S, Kotsev I, Eftimova P, Todorova V, Konsulova T, Doncheva V, Filipova-Marinova M, Vergiev S, Petkov J, Nikolaev R, de Vries W, Silva R, Andreeva N, Galiatsatou P, Kirilova D, Krestenitis Y, Polonsky A, Androulidakis I, Kombiadou K, Weisse R, Mendoza E, Duran G, Karambas T, Koftis T, Prinos P, Kuznetsov S, Saprykina Y. Mitigating flood and erosion risk using sediment management for a tourist city: Varna, Bulgaria. In: Zanuttigh B, Nicholls R, Vanderlinden J, Burcharth H and Thompson R (Eds), Coastal Risk Management in a Changing Climate. Elsevier, Oxford. 2014; 358-383.

[2] Vergiev S, Filipova-Marinova M, Trifonova E, Kotsev I. Vulnerability assessment of coastal plant communities from flooding caused by unusual storms: A case study of Kabakum beach, Varna (Northeastern Bulgaria) for 2018 year. GSC Biological and Pharmaceutical Sciences. 2019; 9(3):109-115.

[3] Vergiev S. Tall Wheatgrass (*Thinopyrum ponticum*): Flood Resilience, Growth Response to Sea Water Immersion, and Its Capacity for Erosion and Flooding Control of Coastal Areas. Environments. 2019; 6(9): 103.

[4] Nicholls RJ, Wong PP, Burkett VR, Codignotto JO, Hay JE, McLean RF, Ragoonaden S, Woodroffe CD. Coastal systems and low-lying areas, In: Climate Change 2007: Impacts, Adaptation and Vulnerability. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ and Hanson CE (Eds), Cambridge University Press, Cambridge. 2017; 315-356.

[5] Nicholls RJ, Cazenave A. Sea-level rise and its impact on coastal zones. Science. 2010; 328: 1517-1520.

[6] Hoggart S, Hanley M, Parker D, Simmonds D, Bilton D, Filipova-Marinova M, Franklin E, Kotsev I, Penning-Rowsell E, Rundle S, Trifonova E, Vergiev S, White A, Thompson R. The consequences of doing nothing: The effects of seawater flooding on coastal zones. Coastal Engineering. 2014; 87: 169-182.

[7] Vergiev S. The growth response of *Galilea mucronata* (L.) Parl. to sea water immersion. GSC Biological and Pharmaceutical Sciences. 2018; 5(2): 103-108.

[8] Vergiev S. GIS mapping of plant biodiversity hotspots in the Bulgarian floristic region Black Sea Coast. SocioBrains. 2018; 52: 171-178.

[9] Vergiev S, Filipova-Marinova M, Trifonova E, Kotsev I, Pavlov D. The impact of sea water immersion on the viability of psammophilous species *Leymus racemosus* subsp. *sabulosus* and *Ammophila arenaria*. Comptes Rendus de l'Academie Bulgare Des Sciences. 2013; 66(2): 211-216.

[10] Narayan S, Nicholls R, Trifonova E, Filipova-Marinova M, Kotsev I, Vergiev S, Hanson S, Clarke D. Coastal habitats within flood risk assessments: Role of the 2D SPR approach. Coastal Engineering Proceedings. 2012; 1(33) Management 12: 1-9.

[11] Bulgarian Biodiversity Act. Annex III and Annex IV, State Gazette number 77, 09.08.2002, pp. 9–42. Last amended in State Gazette number 27, 15 March 2013.

[12] Peev D. (Main ed.). Red Data Book of Republic of Bulgaria. Vol. 1. Plants and Fungi, IBER – BAS & MEW, Sofia, (in Bulgarian). 2011.

[13] Vergiev S. The impact of sea water immersion on the viability of psammophilous species *Carex colchica* and its capacity as dune stabilizer. Comptes Rendus de l'Academie Bulgare Des Sciences. 2018; 71(5): 648-654.