sciendo

**DOI: 10.2478/cerce-2019-0003** **Original Article**
Available online: www.uaiasi.ro/CERCET_AGROMOLD/
Print ISSN 0379-5837; Electronic ISSN 2067-1865

**Cercetări Agronomice în Moldova**
**Vol. LII , No. 1 (177) / 2019: 26-33**

# BARLEY RESIDUES ALLELOPATHIC EFFECTS ON CORN SEED GERMINATION AND SEEDLINGS GROWTH

**M. KHOSHKHARAM[1], W. SUN[2,3], Q. CHENG[2,3], M.H. SHAHRAJABIAN[1,2,3*]**

*E-mail: hesamshahrajabian@gmail.com

Received: Feb. 01, 2019. Revised: June 19, 2019. Accepted: July 12, 2019. Published online: Oct. 10, 2019

**ABSTRACT.** Allelopathy is the detrimental effect of one crop on germination or development of a plant of another species. A factorial layout within completely randomized design with four replications was used to survey the influence of barley extract on corn seeds. Treatments included plant organs extract (leaf, stem, root and total), and different barley extract densities (Nosrat cultivar) includes four levels of 0%, 25%, 50% and 100%. The influence of barley extract was significant on coleoptile weight, radicle weight, radicle length and coleoptile length. Plant organs had meaningful effect on germination rate, germination percentage, coleoptile weight, radicle weight, radicle length and coleoptile length. Among all experimental characteristics, coleoptiles length was influenced by interaction between barley extract and plant organ. Although, the highest germination rate and germination percentage was related to 25% and 100% of barley extract density, the maximum coleoptile weight, radicle weight, radicle length and coleoptiles length was related to control treatment (0%). Leaf extract has obtained the higher values of germination rate, germination percentage, coleoptile weight, radicle weight, radicle length and coleoptile length. Interaction between control treatment (0% plant extract) and stem extract had obtained the highest coleoptiles weight, radicle weight, radicle length and coleoptile length. Hence, from the obtained results, it can be concluded that the extracts of barley may have allelopathic influence on germination and seedling growth of corn.

**Keywords:** maize; primarily growth; forage crop; allelochemicals.

## INTRODUCTION

Corn (*Zea mays* L.) is one of the most important grain and forage crop in Iran (Esfandiary *et al.,* 2012; Soleymani and Shahrajabian, 2012a; Soleymani *et al.,* 2012a; Soleymani *et al.,* 2012b; Soleymani *et al.,* 2012d;

[1] Department of Agronomy and Plant Breeding, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran
[2] Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing, China
[3] Nitrogen Fixation Laboratory, Qi Institute, Building C4, No.555 Chuangye, Jiaxing, Zhejiang, China

Shahrajabian *et al.,* 2017). This major and strategic crop is the at the third place of grains after wheat and rice in the world (Khoshkharam *et al.,* 2010; Soleymani *et al.,* 2011a; Esfandiary *et al.,* 2011; Soleymani *et al.,* 2012c; Soleymani *et al.,* 2016).

Barley (*Hordeum vulgare* L.) is one of the most important crop in semi-arid and arid regions, which is leaving farm lands earlier than other cereals, thus farmers have time to prepare it for the second crop planting (Shahrajabian *et al.,* 2011; Soleymani and Shahrajabian, 2011; Soleymani *et al.,* 2011b; Amini *et al.,* 2012a; Amini *et al.,* 2012b; Soleymani and Shahrajabian, 2013a; Soleymani and Shahrajabian, 2013b; Soleymani and Shahrajabian., 2017; Yong *et al.,* 2018; Shahrajabian *et al*., 2019a,b; Sharajabian *et al*., 2020; Sun *et al*., 2020).

Ben-Hammouda *et al.* (2001) reported that the response by durum wheat and bread wheat varied depending on the source of allelochemicals (plant part) and the growth stage of barley plant. Because allelopathy of barley (*Hordeum vulgare* L.), which is adapted to semi-arid conditions of center of Iran, has not been reported, the goal of this study is to study the influence of barley extracts on germination and seedling growth of corn.

## MATERIAL AND METHODS

This research accomplished in seed technology laboratory of Faculty of Agriculture, Islamic Azad University of Isfahan in 2018 (latitude $32^{o}40^{/}$N, longitude $51^{o}58^{/}$E, and 1570 m elevation). A factorial layout within completely randomized design with four replications was used. Treatments included plant organs extract (leaf, stem, root and total), and different barley extract densities (Nosrat cultivar) includes four levels of 0%, 25%, 50% and 100%. Aerial sections of the plant were separated by scissors.100 g of barley straw was powdered and suspended in 1 lit of distilled water and shacked for 24 hrs.

The extract was centrifuged (6000 rpm for 20 min in $10^{o}$C). The seeds of corn (SC 704) were put in sodium hypocoloid 5% during 10 min and then they were washed by distilled water. Seeds soaked in distilled water used as control treatment. For germination test, 20 seeds were put in 12 cm Petri dishes on two layers of filter paper and 5 ml of distilled water for control and 5 ml from levels of expected extract were added to it. The lids of containers with the temperature $2^{o}$C were prepared (12 hrs in the day and 12 hrs in the night). Every day, the germinated seeds were numbered in the certain hour. The criterion of radical exit germination has been considered 1 mm. At the end of germination test, the length of radical and coleoptiles were measured. Both radical length (root) and plumule (shoot) length was measured using a ruler in cm. For counting the length of radical and coleoptiles, 10 germinated seeds were sent out from Petri dishes and measured. For accounting germination rate, from the second day, unit when the seeds did not germinate,

the germinated seeds were counted per 24 hrs and on time. The germination rate was defined as following *(Equation 1)*:

$$GR = \Sigma \frac{N}{\Sigma(n \times g)} \quad (1)$$

where, *n* is the number of germinated seed on growth day and *g* is the number of germination seeds Analysis of variance (ANOVA) was used to determine the significant differences. The Multiple Range Test of Duncan performed the separation means ($p<0.05$). All statistics was performed with the SAS statistical software.

## RESULTS AND DISCUSSION

The influence of barley extract was significant on coleoptiles weight, radicle weight, radicle length and coleoptiles length.

Soleymani and Shahrajabian (2012b) reported the significant influence of sesame extract on germination rate, germination percentage, coleoptiles weight, radicle weight, radicle length and coleoptiles length.

Plant organs had meaningful effect on germination rate, germination percentage, coleoptiles weight, radicle weight, radicle length and coleoptiles length. Soleymani and Shahrajabian (2012b) reported the meaningful effect of plant organs on germination rate, radicle weight, radicle length and coleoptiles length.

The interaction between barley extract and plant organs just had significant effect on coleoptiles length (*Table 1*).

**Table 1 - Analysis of variance for experimental characteristics**

| S.O.V | d.f. | Germination rate | Germination percentage | Coleoptile weight | Radicle weight | Radicle length | Coleoptile length |
|---|---|---|---|---|---|---|---|
| Replication | 2 | $1.08^{ns}$ | $54.72^{ns}$ | $0.000043^{ns}$ | $0.00000002^{ns}$ | 0.16ns | 0.13 |
| Barley extract (a) | 3 | $0.22^{ns}$ | $215.63^{ns}$ | 0.000192* | $0.00001026^{*}$ | 2.77** | 2.89** |
| Plant organs (b) | 3 | 7.53* | 1317.95** | $0.000431^{**}$ | $0.0001496^{**}$ | 0.98* | 5.17** |
| a×b | 9 | $1.02^{ns}$ | $151.56^{ns}$ | $0.000059^{ns}$ | $0.000001496^{ns}$ | $0.45^{ns}$ | 1.21* |
| Error | 30 | 1.8 | 87.37 | 0.000046 | 0.00000219 | 0.25 | 0.56 |

$^{ns}$ non significant, *significant at 0.05 significant in F-tests, **significant at 0.001 significant in F-test

The highest and the lowest germination rate was related to 25% (2.56%) and 50% (2.24%) of barley extract which had no significant difference with each other. The higher germination percentage was obtained for 100% (84.18%) of barley extract, followed by 25%, (81.06%), 50%

(74.14%), and 0% (78.61%). Although, application of 100% of barley extract has significant difference with 50%, but it had no meaningful differences with 0% and 25% of barley extract. Germination is the most sensitive stage in the life cycles of plant (Soleymani and Shahrajabian, 2012c; Shahrajabian and Soleymani, 2017; Shahrajabian *et al.,* 2018; Soleymani and Shahrajabian, 2018; Ogbaji *et al.,* 2018).

The maximum coleoptile weight (0.037 mg) and radicle weight (0.0100 mg) was related to 0% of barley extract, and the minimum one was achieved in 50% of barley extract.

There were significant differences in both coleoptiles weight and radicle weight between these two densities. The higher value of radicle length was related to 0% (6.13 mm), followed by 25% (5.39 mm), 100% (5.32 mm), and 50% (4.99 mm) barley extract density. There were significant differences between 0% and other barley extract densities. The maximum and the minimum coleoptiles length was related to 0% (4.60 mm), and 50% (3.63 mm), which had meaningful differences with each others. Coleoptile length in 25% and 100% of barley extract density was 3.68 mm, and 4.39 mm, respectively.

The highest and the lowest germination rate was related to leaf extract (3.34%), and total extract (1.58%), respectively, which had significant differences with each other. The higher value of germination percentage was obtained for leaf extract (89.91%), followed by root (86.43%), stem (74.20%), and total extract (67.46%), respectively. Although, there was no significant difference between leaf and root extract, both of them had meaningful differences with stem and total extract.

The maximum coleoptile weight (0.038 mg), and radicle weight (0.0141 mg) was observed in leaf extract. Furthermore, the minimum one was related to total extract. The minimum coleoptile weight and radicle weight was 0.025 mg, and 0.0065 mg, respectively.

The highest value of radicle length (5.81 mm), and coleoptiles length (4.81 mm) was achieved in leaf extract, which had significant differences with all other treatments, except root extract. The minimum radicle length and coleoptiles length was related to total plant extract, which was 5.13 mm, and 3.39 mm, respectively.

The highest germination rate and germination percentage was related to interaction between total plant extract and 50% of barley extract. The maximum coleoptile weight, radicle weight, radicle length and coleoptile length was related to interaction between total plant extract and 0% of barley extract (*Table 2*).

Ben-Hammouda *et al.* (2001) found that the allelopathic potential of barley plant parts was not stable over its life cycle for either bread or durum wheat.

**Table 2 - Mean comparison of germination rate (%), germination percentage (%), coleoptile weight (mg), radical weight (mg), radical length (mm) and coleoptile length (mm)**

| Treatment | Germination rate | Germination percentage | Coleoptile weight | Radicle weight | Radicle length | Coleoptile length |
|---|---|---|---|---|---|---|
| **Barley extract density (E)** | | | | | | |
| 0% (E1) | 2.43a | 78.61ab | 0.037a | 0.0100a | 6.13a | 4.60a |
| 25% (E2) | 2.56a | 81.06a | 0.029b | 0.0092a | 5.39b | 3.68b |
| 50% (E3) | 2.24a | 74.14b | 0.028b | 0.0078b | 4.99b | 3.63b |
| 100% (E4) | 2.36a | 84.18a | 0.032a | 0.0088a | 5.32b | 4.39a |
| **Plant organs (O)** | | | | | | |
| Leaf (O1) | 3.34a | 89.91a | 0.038a | 0.0141a | 5.81a | 4.81a |
| Root (O2) | 2.73a | 86.43a | 0.035a | 0.0082b | 5.52a | 4.42a |
| Stem (O3) | 1.94b | 74.20b | 0.028b | 0.0069c | 5.36b | 3.68b |
| Total (O4) | 1.58b | 67.46b | 0.025b | 0.0065c | 5.13b | 3.39b |
| **E×O** | | | | | | |
| E1O1 | 1.9ab | 75.39cd | 0.034abc | 0.0079cd | 5.93ab | 3.99cde |
| E1O2 | 2.3ab | 79.39bcd | 0.037 | 0.0083c | 5.84abc | 5.15abc |
| E1O3 | 3.25ab | 86.56abc | 0.043a | 0.0156a | 6.41a | 5.57a |
| E1O4 | 2.26ab | 73.1cd | 0.034abc | 0.0083c | 6.34a | 3.69de |
| E2O1 | 2.59ab | 70.01d | 0.021de | 0.0065cde | 5.18bcdef | 2.79ef |
| E2O2 | 2.95ab | 94.78ab | 0.035ab | 0.0088c | 5.82abcd | 4.3bde |
| E2O3 | 3.21ab | 94.72ab | 0.042a | 0.014a | 5.87abc | 5.39ab |
| E2O4 | 1.5b | 64.74d | 0.017e | 0.0065cde | 4.68ef | 2.25f |
| E3O1 | 2.21ab | 74.04cd | 0.028bcd | 0.0067cde | 5.05cdef | 3.61de |
| E3O2 | 2.46ab | 77.54cd | 0.031bcd | 0.0071cde | 4.95ef | 3.8de |
| E3O3 | 2.85ab | 76.96cd | 0.031bcd | 0.012b | 4.97ef | 3.86de |
| E3O4 | 1.44b | 68.02d | 0.023cde | 0.0054e | 5def | 3.27def |
| E4O1 | 1.05b | 77.35cd | 0.029bcd | 0.0067cde | 5.29bcdef | 4.35abcd |
| E4O2 | 3.21ab | 94.01ab | 0.035ab | 0.0086c | 5.48bcde | 4.42abcd |
| E4O3 | 4.05a | 101.39a | 0.036ab | 0.0139ab | 5.98ab | 4.45abcd |
| E4O4 | 1.12b | 63.98d | 0.028bcde | 0.0059de | 4.51f | 4.34abcd |

Common letters within each column do not differ significantly; E= tobacco extract, O= plant organ

## CONCLUSION

Allelopathy refers to the effect of one plant species on another through the release of chemical compounds into the environment. Although, the highest germination rate and germination percentage was related to 25% and 100% of barley extract density, the maximum coleoptile weight, radicle weight, radicle length and coleoptiles length was related to control treatment (0%). Leaf extract has obtained the higher values of germination rate, germination percentage, coleoptile weight, radicle weight, radicle length and coleoptile length. Interaction between control treatment (0% plant extract) and stem extract had obtained the highest coleoptiles

weight, radicle weight, radicle length and coleoptile length. Given the fact that environmental conditions in the field, can be different from results in laboratory and greenhouse, so additional researches are required to evaluate the allelopathic influence under different field conditions. All in all, in conclusion, it is important to consider the multiple effects of ecology, chemistry and physiology in assessing allelopathic effects.

## REFERENCES

**Amini, A.R., Soleymani, A. & Shahrajabian, M.H. (2012a).** Assess the usefulness of various indices and yield potential in identifying cultivars of barley adapted to water stress. *Intl.J.Agri. Crop Sci.*, 4(7): 364-367.

**Amini, A.R., Soleymani, A. & Shahrajabian, M.H. (2012b).** Changes in morphological traits, leaf and soil RWC and length of growth and development stages of four cultivars of barley in restricted irrigation. *Intl.J.Agri. Crop Sci.*,, 4(7): 368-371.

**Ben-Hammouda, M., Ghorbal, H., Kremer, R.J. & Oueslati, O. (2001).** Allelopathic effects of barley extracts on germination and seedlings growth of bread and durum wheats. *Agronomie*, 21(1): 65-71, DOI: 10.1051/agro:2001109

**Esfandiary, M., Soleymani, A., Shahrajabian, M.H. & Darkhal, H. (2011)**. Effect of planting methods on grain yield and leaf orientation at different stages of corn cultivars. *Research on Crops*, 12(2): 336-340.

**Esfandiary, M., Soleymani, A. & Shahrajabian, M.H. (2012)**. Evaluation of yield and yield components of corn cultivars in different planting methods under semi-arid condition of Iran. *J.Food, Agric. Environ.*, 10(2): 664-667.

**Khoshkharam, M., Rezaei, A., Soleymani, A. & Shahrajabian, M.H. (2010).** Effects of tillage and residue management on yield components and yield of maize in second cropping after barley. *Research on Crops*, 11(3): 659-666.

**Ogbaji, P.O., Li, J., Xue, X., Shahrajabian, M.H. & Egrinua, E.A. (2018).** Impact of bio-fertilizer or nutrient solution on spinach (*Spinacea oleracea*) growth and yield in some province soils of P.R. China. *Cercet.Agron.Mold.*, 2(174): 43-52, DOI: 10.2478/cerce-2018-0015

**Shahrajabian, M.H., Soleymani, A. & Naranjani, L. (2011).** Grain yield and forage characteristics of forage sorghum under different plant densities and nitrogen levels in second cropping after barley in Isfahan, Iran. *Research on Crops*, 12(1): 68-78.

**Shahrajabian, M.H. & Soleymani, A. (2017).** Responses of physiological indices of forage sorghum under different populations in various nitrogen fertilizer treatments. *Int.J. Plant Soil Sci.*, 15(2): 1-8.

**Shahrajabian, M.H., Soleymani, A. & Khoshkharam, M. (2017).** Influence of green manuring from different cover crops and farm yard manures on quantitative and qualitative characteristics of forage corn in low input farming. *Research on Crop Ecophys.*, 12(2): 62-68.

**Shahrajabian, M.H., Wenli, S. & Qi, C. (2018).** A review of goji berry (*Lycium barbarum*) in traditional Chinese medicine as a promising organic superfood and superfruit in modern industry. *Acad.J.Med.Plants*, 6(12): 437-445, DOI: 10.15413/ajmp.2018.0186

**Shahrajabian, M.H., Khoshkharam, M., Sun, W. & Cheng, Q. (2019a).** The effect of pretreatment factors on

seed germination and seedling growth of anise (*Pimpinella anisum* L.). *Middle East Journal of Science*, 5(1): 86-93. DOI: 10.23884/mejs. 2019.5.1.09

**Shahrajabian, M.H., Khoshkharam, M., Sun, W. & Cheng, Q. (2019b).** Germination and seedlings growth of corn (*Zea mays* L.) to allelopathic effects of rice (*Oryza sativa* L.). *Tropical Plant Research*, 6(1): 152-156, DOI: 10.22271/tpr.2019.v6.i1. 022

**Shahrajabian, M.H., Khoshkharam, M., Zandi, P., Sun, W. & Cheng, Q. (2020).** The influence of temperatures on germination and seedling growth of pyrethrum (*Tanacetum Cineraiifolium*) under drought stress. *IJABBR*, 8(1): 29-39, DOI: 10.33945/SAMI/IJABBR.2020. 1.4

**Soleymani, A. & Shahrajabian, M.H. (2011).** Influence of planting date and plant density on grain and biological yields of barley. *Research on Crops*, 12(3): 698-700.

**Soleymani, A., Khajedin, A.A. & Shahrajabian, M.H. (2011a).** Grain yield and yield components of corn (*Zea mays* L.) hybrids in response to planting dates in semi-arid region in Isfahan. *Research on Crops*, 12(1): 45-52.

**Soleymani, A., Shahrajabian, M.H. & Naranjani, L. (2011b).** Determination of the suitable planting date and plant density for different cultivars of barley (*Hordeum vulgare* L.) in Fars. *Afr.J.Plant Sci.*, 5(3): 284-286.

**Soleymani, A. & Shahrajabian, M.H. (2012a)**. Effect of nitrogen fertilizer on ash, nitrate, organic carbon, protein and total yield of forage maize in semi-arid region of Iran. *Research on Crops*, 13(3): 1030-1034.

**Soleymani, A. & Shahrajabian, M.H. (2012b).** Study of allelopathic effects of sesame (*Sesamum indicum*) on canola (*Brassica napus*) growth and germination. *IJACS*, 4(4): 183-186.

**Soleymani, A. & Shahrajabian, M.H. (2012c).** Study of cold stress on the germination and seedling stage and determination of recovery in rice varieties. *Int.J.Biol.*, 4(4): 23-30, DOI:10.5539/ijb.v4n4p23

**Soleymani, A., Shahrajabian, M.H. & Khoshkharam, M. (2012a).** Effect of different fertility systems on fresh forage yield and qualitative traits of forage corn. *Research on Crops*, 13(3): 861-865.

**Soleymani, A., Khosharam, M., & Shahrajabian, M.H. (2012b).** Germination rate and initial growth of silage corn grown under various fertility systems. *Research on Crops*, 13(3): 1035-1038.

**Soleymani, A., Khoshkharam, M., & Shahrajabian, M.H. (2012c).** Influence of green manures and crop residue management on yield and yield components of silage corn. *Research on Crops*, 13(3): 871-876.

**Soleymani, A., Shahrajabian, M.H. & Naranjani, L. (2012d).** Evaluation the benefits of different berseem clover cultivars and forage corn intercropping in different levels of nitrogen fertilizer. *J.Food,Agric. Environ.*, 10(1): 559-601.

**Soleymani, A. & Shahrajabian, M.H. (2013a).** Evaluation drought tolerance indices on the basis of physiological characteristics for different genotypes of barley in Esfahan region. *Int.J.Farm.Alli.Sci.*, 2(16): 533-536.

**Soleymani, A. & Shahrajabian, M.H. (2013b).** Changes in number of seed and seed yield of barley 's genotypes under drought stress and normal irrigation condition. *Int.J.Farm.Alli.Sci.*, 2(12): 325-328.

**Soleymani, A., Shahrajabian, M.H. & Khoshkharam, M. (2016).** The impact of barley residue management and tillage on forage maize. *Romanian Agric.Res.*, 33: 161-167.

**Soleymani, A. & Shahrajabian, M.H. (2017).** Assessment of ET-HS model

for estimating crop water demand and its effects on yield and yield components of barley and wheat in semi-arid region of Iran. *Cercet.Agron.Mold.*, 4(172): 37-49, DOI: 10.1515/cerce-2017-0034

**Soleymani, A., & Shahrajabian, M.H. (2018).** Changes in germination and seedling growth of different cultivars of cumin to drought stress. *Cercet.Agron.Mold.*, 1(173): 91-100, DOI: 10.2478/cerce-2018-0008

**Sun, W., Shahrajabian, M.H. & Qiman, H. (2020).** Soybean seeds treated with single walled carbon nanotubes (SwCNTs) showed enhanced drought tolerance during germination. *IJABBR*, 8(1): 9-16, DOI: 10.33945/SAMI/IJABBR.2020. 1.2

**Yong, Y., Hu, Y., Shahrajabian, M.H., Ren, C., Guo, L., Wang, C. & Zeng, Z. (2018).** Changes in dry matter, protein percentage and organic matter of soybean-oat and groundnut-oat intercropping in different growth stages in Jilin province, China *ActaAgric.Slov.*, 111(1): 1-7.