Research Journal of Agricultural Science, 54 (4), 2022; ISSN: 2668-926X

STUDIES ON THE GERMINATION OF MAIZE SEEDS TREATED WITH AQUEOUS EXTRACTS BASED ON *SORGHUM HALEPENSE*

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Abstract. S*orghum halepense is an invasive weed with a high capacity to compete with both plants in agroecosystems and those present in ecosystems, often becoming dominant. This species manages to be present on extensive surfaces due to its high reproductive capacity, but also to the content of allelochemical substances, which inhibit the germination and growth of cultivated plants and those of the segetal flora. The present study aimed to evaluate Sorghum halepense extracts on maize seed germination. The influence of Sorghum halepense extracts on the germination of corn plants was tested at the "King Mihai I" University of Life Sciences in Timișoara, in the Phytosanitary Protection and Expertise laboratory, in 2021. Treatments included T1 control (distilled water); T2: aqueous extract of fresh Sorghum halepense 5%; T3: aqueous extract of fresh Sorghum halepense 15%; T4: aqueous extract of fresh Sorghum halepense 25%; T5: aqueous extract of dry Sorghum halepense 5%; T6: aqueous extract of dried Sorghum halepense 15%; T7: aqueous extract of dried Sorghum halepense 25%. After applying the treatments, the following were determined: germination percentage (GP), germination index (GI), mean germination time (MGT), germination speed (GS) and coefficient of velocity of germination (CVG). EASF and EASD extracts, regardless of the concentration used, managed to exert a negative influence towards all parameters studied, namely: germination percentage, germination index, germination speed and germination speed coefficient. The study carried out allowed us to observe that the influence of the extracts towards corn plants, although negative, their impact is different, depending on the formulation of the plant material and the concentration used.*

Keywords*: Sorghum halepense, aqueous extract, germination, maize*

INTRODUCTION

The presence of weeds in agroecosystems decreases the quantity as well as the quality of agricultural products, conducting to huge financial losses for farmers (SARI´C-KRSMANOVI´C et. al., 2019). Among the weeds frequently encountered in agricultural crops, with a very large distribution area, being distributed over a third of the total surface of the world (CHIRIȚĂ et al., 2008) is also the species *Sorghum halepense* (CHIRIȚĂ et al., 2004). This species strongly competes with agricultural crops for resources such as: nutrients, water, light and space, thus causing crop plant stress (MACÍAS ET AL., 2019, CHIFAN ET AL., 2019). *Sorghum halepense* decreases crop yield through plant growth disturbances (produced through allelopathy) either through competition or both (FAROOQ et al., 2020). *Sorghum halepense* is an invasive species, exerting the ability to influence biodiversity due to its allelopathic activity (LINDER, et al., 2017; SÁNCHEZ-MOREIRAS et al., 2004, AL SAKRAN et al., 2021).

Allelopathy is the direct or indirect, beneficial or harmful biochemical interaction between plant and weeds and/or plants and microorganisms through the production of chemical compounds that, once released into the rhizosphere, through a variety of mechanisms, influence the growth and development of neighboring plants (SANGEETHA and BASKAR, 2015; BRAAH OTHMAN et al., 2018).

Johnson grass is considered to be one of the plant species with a strong allelopathic potential (DAYAN, 2006; BUTNARIU et al., 2012). The roots of this species exudates sorgoleone

(HEJLI et al., 2004), a toxic substance that blocks the respiration and photosynthesis of other plants (ȘTEF et al., 2013) (figure 1).

a- dihydrosorgoleone b - sorgoleone

Figure 1. Chemical structure of sorgoleone and dihydrosorgoleone (ȘTEF et al., 2013)

Contains a wide range of allelopathic substances such as: phloroglucinol, dhurrin, taxiphylline, chlorogenic acid, 4-hydroxybenzoic acid, 4-hydroxylbenzyl alcohol, and sorgoleon (YAZLIK and UREMIS, 2019).

The mode of action of allelopathic products includes multiple mechanisms such as reduction of germination percentage and germination rate along with reduction of root and shoot growth (HUSSAIN et al., 2008). In addition, they inhibit the evolution of chloroplast oxygen, with a strong effect on mitochondrial function, alter the absorption of nutrients, chlorophyll pigments, or the efficiency of water use (HUSSAIN and REIGOSA, 2017; HUSSAIN et al., 2021).

Up to date studies have shown that allelopathic substances secreted by *Sorghum halepense* can have inhibitory or stimulatory effects on crop plants or other weed species, or have no influence on other species. Inhibitory effects of Sorghum halepense extract on different weed species such as: *Chenopodium album, Phalaris minor, Cyperus rotundus, Senebiera didyma and Rumex dentatus Avena fatua, Lolium temulentum. Lathyrus sativa* and *Cephalaria syriaca* (THAHIR and GHAFOOR, 2011; NOURI and TAVASSOLI, 2012) were observed. The bibliographic study shows that allelopathic extracts from *Sorghum halepense* have also been tested on crop plants, such as: maize, wheat, rice, sugar beet, sunflower, soybean, etc. (ȘTEF et al., 2015; YANG et.al., 2004, CHUN et al., 2011).

The aim of this study was to evaluate the allelopathic effects of the aqueous extract from the vegetative biomass of *Sorghum halepense*, on several germination parameters (*GP*, *GI*, *MGT*, *GS*, *CVG*) of maize seeds.

MATERIAL AND METHODS

The experiment was carried out under laboratory conditions (the Phytosanitary Expertise Laboratory of the University of Life Sciences "King Mihai I" Timișoara). The experiment aimed the germination of maize seeds, as it is a critical stage in the development of a plant (AHMAD et al., 2014). The experience was placed on 26.05.2021.

Plant material

The plant used in the preparation of the allelopathic extract was *Sorghum halepense*. At the very beginning of the experiment, the Johnson grass plants were harvested at the growth stage BBCH 14-16. The samples were washed to remove soil and dust. For the preparation of dry material extracts, the plants were cut into pieces (a few centimeters) and subjected to drying for 14 days at a constant temperature of 25.0°C (ȘTEF et al., 205, VÎRTEIU et al., 2015; ȘTEF et al., 2017; ȘTEF et al., 2018; KINCEL et al., 2019). For extracts based on fresh material (rhizomes, adventive roots, stem, leaves), the plants were harvested and crushed.

Extracts preparations

Each extract contained 50 g of dry or fresh material to which 600 ml of distilled water was added, placed in the magnetic stirrer for 24 hours, following that a filtration was performed. The extracts used in the study differ in the concentrations used and, in the material, used. The three concentrations were prepared as follows: 5% (5 ml of extract was used in addition to 95 ml of water), 15% (15 ml of extract were used in addition to 85 ml of water) and 25% (25 ml of extract was used in addition to 75 ml of water).

Trial setup

The period of observations and application of the treatments was 10 days. Maize seeds were placed on a layer of filter paper in a Petri dish (10 seeds/Petri dish) (figure 1) and covered with sterilized (boiled) sand, each variant was watered with 100 ml extract.

There were 7 experimental variants (treatments): V1 = untreated = distilled water; V2 = concentration 5% EASF (aquos extract of fresh *Sorghum halepense*); V3 = concentration 15% EASF (aquos extract of fresh *Sorghum halepense*); V4 = concentration 25% EASF (aquos extract of fresh *Sorghum halepense*); V5 = concentration 5% EASD (aquos extract of fresh *Sorghum halepense*); V6 = concentration 15% EASD (aquos extract of dried *Sorghum halepense*); V7 = concentration 25% EASD (aquos extract of dried din *Sorghum halepense*).

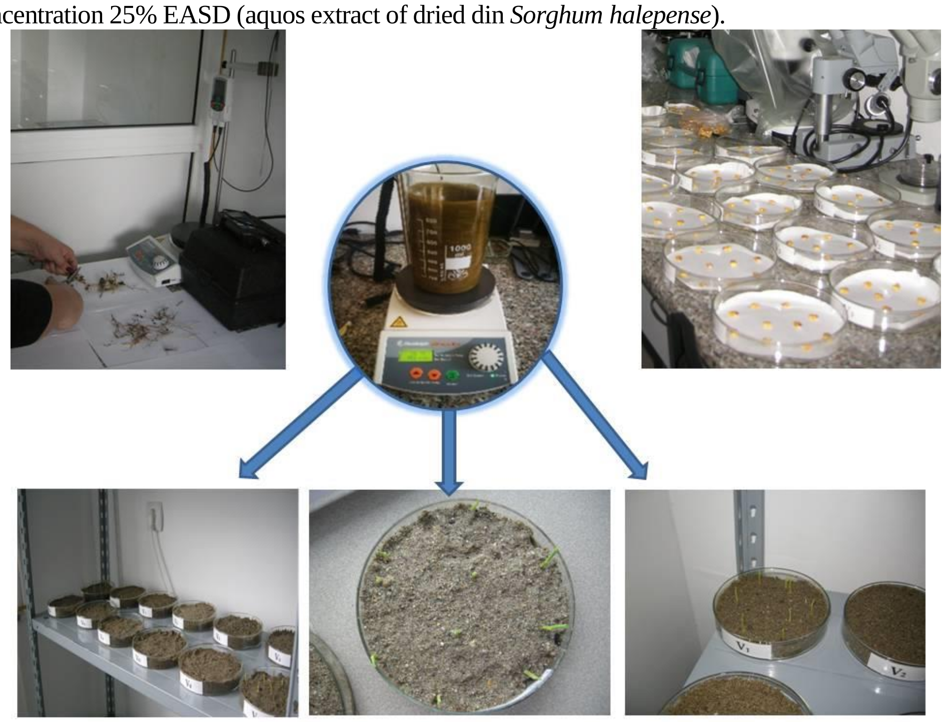

Figure 1. Pictures during the trial (Source: original photo by ȘTEF R., 2021).

Data analysis

The measured variables related to the germination of corn seeds, after the application of the extracts, were: germination percentage, germination index, average germination time, germination speed, germination speed coefficient.

The seed germination percentage was determined according to the formula**:**

GP = (germinated seed /seeds total) x 100

Germination index (GI) calculated as:

GI = (10xn1) + (9 x n2) + (8 x n3) + (7 x n4) + (6 x n5) + (5 x n6) + (4 x n7) + (3 x n8) + (2 x n9) + (1 x n10) (ARNOLD et al., 1991)

- where n1, n2, n3….n10 represents the number of germinated seeds at 1, la 2 and so on until 10th day

The average germination time was calculated according to the formula (ORCHARD, 1997):

TMG = Σ f *x/Σf

- where f is the number of seeds germinated on day x

Germination rate (VG) was obtained by the formula given by (CZABATOR, 1962):

VG = n1/d1 + n2/d2+……nx/dx

- where n – the number of germinated seeds while "d" the number of days

The germination rate coefficient was calculated according to the formula: **CVG%**

CVG = 100 × Total germinated seeds /$\sum(N_1/1 + N_2/2 + N_3/3 \ldots N_7/7)$

- where N1 = seeds germinated on day 1, N2 = seeds germinated on day 2, N7 = the seeds that germinated in 7 days.

RESULTS AND DISCUSSIONS

Seed germination is considered the most important stage to have a successful growth and development of plants. Percent of germination (GP) was calculated according to the formula presented by Jones and Sanders, 1987, where "n" is the number of seeds germinated in "d" days. The data, shown in figure 2, highlight the fact that by applying EASD and EASF there was a substantial suppression of maize germination.

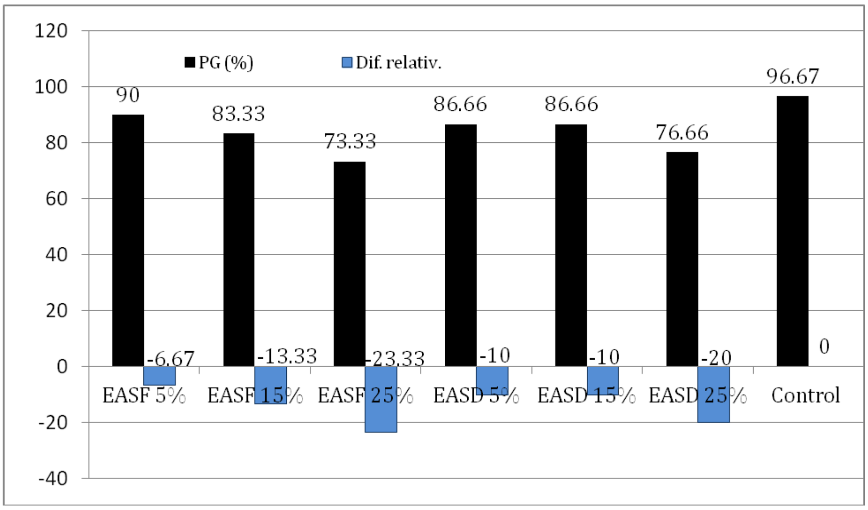

Figure 2 The effects of extracts (EASD and EASF) from Sorghum halepense on the GP of the seeds porumb

However, the germination of maize was not affected by the aqueous extract of fresh Johnson grass at dilution of 5%. The lowest germination rate (73.33% and 76.66%) was recorded in corn seeds, treated with the highest concentration (35% EASF and EASD), exerting a reduction of 23.33% and 20, respectively 0% compared to untreated seeds. By treating the seeds with EASU 5% and EASU 15% (aqueous extract of dried *Sorghum halepense*) the germination of maize seeds was reduced by 10 percent, the differences being significant. The germination index (GI) represents both the speed of seed germination and the germination time. Its value is higher for seeds that germinate earlier than those that germinate later. The highest value of the germination index was recorded in the control variant (77.33) (figure 3). In the variants, in which EASF and EASD were applied in a concentration of 5%, the value of the germination index showed a reduction of 10.0 (67.33) and 8.66 (68.66). By applying the treatments with EASF and EASD in a concentration of 15 and 25%, respectively, the germination index was reduced very significantly.

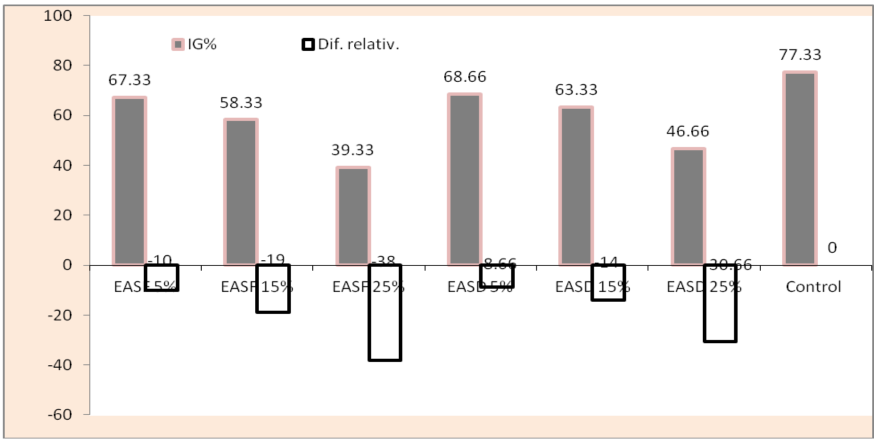

Figure 3. Corn germination index (GI) values after the application of EASD and EASF treatments

EASF and EASD caused delayed germination and decreased number of germinated maize seeds. The scab, being allelopathic in nature, negatively affected the germination of corn plant seeds. MUBEEN et al. (2012) reported that the germination index of rice was less affected by aqueous extracts of sorghum and sunflower, but that of weeds (T. *portulacastrum*, *D. egyptium* and *E. indica*) was influenced.

Figure 4 shows the data for mean germination time (MGT) of maize under the influence of aqueous extracts of *Sorghum halepense.*

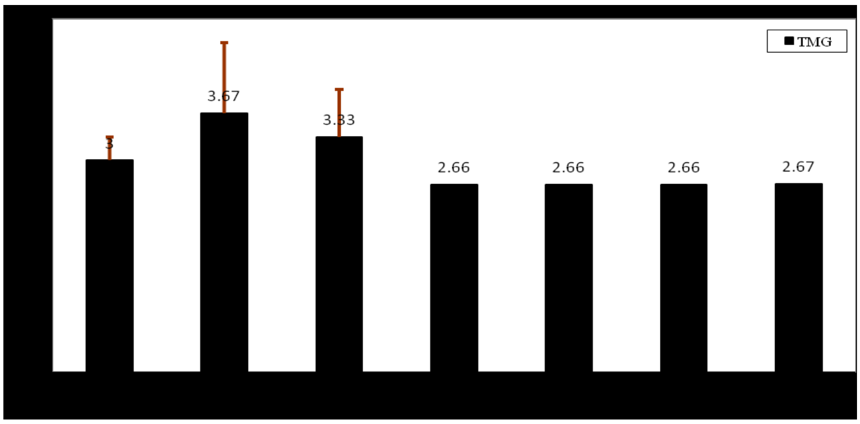

Figure 4. Mean germination time (MGT) of maize under the influence of EASD and EASF

Treatments with EASD and EASF did not determined a significant impact on the MGT of the corn grains, the only exception was registered in the variant in which the corn seeds were treated with EASF dilution 15%. Maize seeds showed an average germination time of 2.66 -3.66 days. The impact of EASD and EASF, insignificant on the mean germination time (MGT) of maize seeds could be attributed to the rapid metabolic capacity of the crop seeds, to convert allelochemicals into inactive forms (YAR et al., 2020). The results of this study are consistent with those recorded by MUBEEN et al. (2012), KANDRO et al. (2015), YAR et al. (2020).

The highest value of the germination speed was obtained in the variant treated with distilled water (3.93) (figure 5).

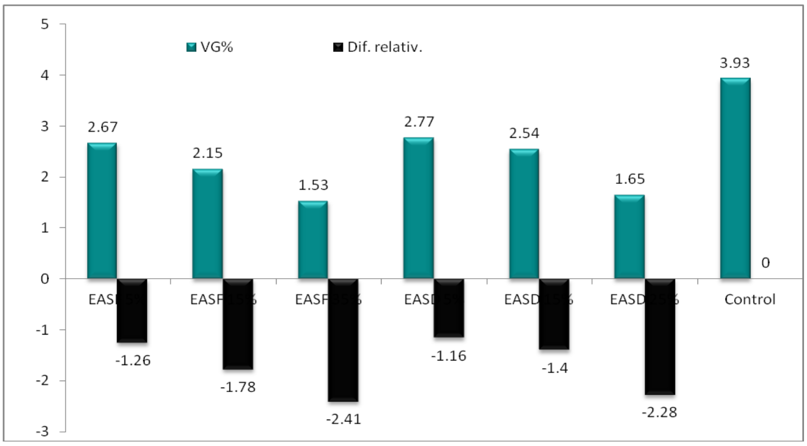

Figure 5. Germination rate (VG) of maize seeds treated with EASD and EASF

Germination rate was very significantly reduced by all applied products. The maximum reduction in the germination rate (1.53 and 1.65) was obtained in EASF and EASD 25% treated variants, similarly, following the treatment with highest concentration of Johnson grass extract, the concentration of 15% exerted a reduction of germination rate.

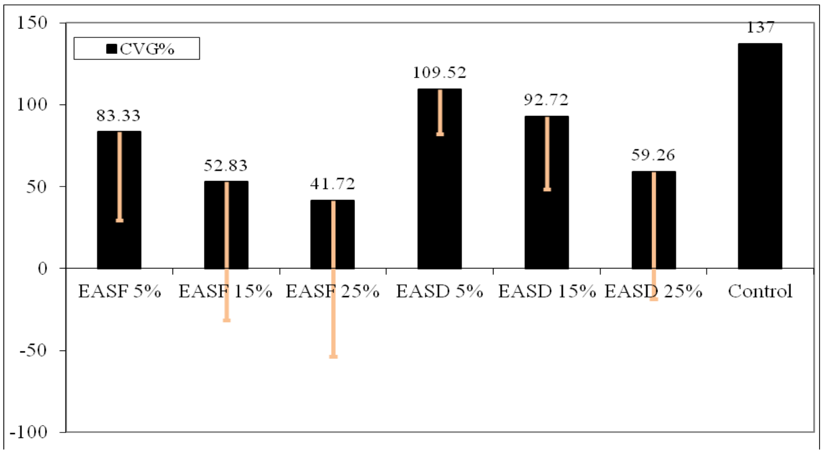

Figure 6. Coefficient of germination speed of corn seeds following application of EASD and EASF

The more seeds germinate in a shorter time frame, the higher the germination rate coefficient (GVG) will be. The values of the germination speed coefficient were in the range of 41.72% - 137.00%. The aqueous extract from fresh Johnson Grass plants, 25% dilution, was the only treatment that significantly reduced CVG (41.72%) compared to the control (137.0%).

The aqueous extract, from fresh Johnson Grass plants, 35% dilution, was the only treatment that significantly reduced CVG (41.72%) compared to the control (137.0%). On the other hand, CVG was significantly affected by the application of EASP 5%, EASU 5%, EASU 15% extracts, showing differences of 27.48 - 53.67 compared to the control.

Maize showed considerable sensitivity to all treatments in terms of CVG, being influenced by all extracts.

Phytotoxicity of sorghum differs according to plant organ, age, environmental factors, genotype and target weed species (HUSSAIN et al., 2021)

Allelopathic substances secreted by Johnson grass plants directly influenced the germination and growth of cultivated plants (such as rice and maize) in laboratory, greenhouse and field experiments (FAROOQ et al., 2017; FAROOQ et al., 2020), these results being consistent with that obtained in this study. The effect of sorghum extracts on alfalfa plants was studied by GOLUBOVINA and ILIEVA (2014) among many target legume species.

CONCLUSIONS

Aqueous extracts of fresh and dried *Sorghum halepense* negatively influenced maize seed germination. The studied parameters: germination percentage, germination index, germination speed, germination speed coefficient, were negatively influenced, the differences shown being determined by the concentration of the extract and the type of plant material used.

The average germination time of corn seeds was the only parameter that was not influenced by the extracts used in the experiment.

BIBLIOGRAPHY

AHMAD W., M. AKBAR, U. FAROOQ, A. ALIA, F. KHAN, 2014, Allelopathic effects of aqueous extracts of *Avena fatua* on seed germination and seedling growth of *Triticum aestivum* (variety GW-273). Journal of Environmental Science, Toxicology And Food Technology, vol. 8:2:38-42

AL SAKRAN MUHAMMAD, KAMAL ALMHEMED, TAMER USTUNER, SENA DAL, 2021, Effect of aqueous extract of *Sorghum halepense* (L.) Pers. on germination and growth of some weed species, International Journal of Scientific and Research Publications, 11:1

BRAAH OTHMAN, DINA HADDAD, SAMIR TABBACHE, 2018, Allelopathic effects of *Sorghum halepense* (L.) Pers. and *Avena sterilis* L. water extracts on early seedling growth of *Portulacca oleracea* L. and *Medicago Sativa* L," SSRG international Journal of Medical Science, 5:10:7-12

BUTNARIU, M., 2012, An analysis of *Sorghum halepense's* behavior in presence of tropane alkaloids from *Datura stramonium* extracts. Chemistry Central Journal, 6, 75.

CHIFAN RAUL, ȘTEF RAMONA, GROZEA IOANA, 2019, The cyclohexanediones effect on the *Sorghum halepense* control in the sunflower agroecosystem, Research Journal of Agricultural Science, 51 (4):262-272

CHIRIȚĂ RAMONA, IOANA GROZEA, NICOLAE SARPE, KARL FRITZ LAUER, 2008, Control of *Sorghum halepense* (L.) species in western part of Romania, Communications in agricultural and applied biological sciences 73 (4): 959-964

CHIRITA RAMONA, K.F. LAUER, N. SARPE, 2004, Control of Johnson grass in maize with new broad-spectrum herbicides in Western Romania, Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz- -Journal of plant diseases and protection, Verlang Eugen Ulmer Stuttgart, 725-731

CHUN MM, GOLOMB J D, TURK-BROWNE NB (2011). A taxonomy of external and internal attention. Annu. Rev. Psychol. 62:73–101

DAYAN FE, HOWELL J, WEIDENHAMER JD, 2009, Dynamic root exudation of sorgoleone and it's in planta mechanism of action. J Exp Bot 60:2107–2117

Farooq M., Nawaz A., Ahmad E., Nadeem F., Hussain M, Siddique K.H.,2017, Using sorghum to suppress weeds in dry seeded aerobic and puddled transplanted rice. Field Crop. Res., 214, 211–218.

FAROOQ N., ABBAS T., TANVEER A., JABRAN K., 2020, Allelopathy for weed management. In Coevolution of Secondary Metabolites; Springer: Berlin/Heidleberg, Germany, 505–519

FAROOQ, M.; KHAN, I.; NAWAZ, A.; CHEEMA, M.A.; SIDDIQUE, K.H., 2020, Using sorghum to suppress weeds in autumn planted maize. Crop. Prot. 133, 105162.

GOLUBINOVA I., A, I. ILIEVA; 2014, Allelopathic effects of waterextracts of *Sorghum halepense* (L.) Pers., *Convolvulus arvensis* L. and *Cirsium arvense* Scop. on early seedlinggrowth of some leguminous crops. Pesticides and Phytomedicine, vol. 29(1):35-43

HEJLI AM, KOSTER KL.,2004, The allelochemical sorgoleone inhibits root H+ –ATPase and water uptake. J Chem Ecol. 30(11):2181–91.

HUSSAIN M.I., DANISH S., SÁNCHEZ-MOREIRAS A.M., VICENTE Ó., JABRAN K., CHAUDHRY U.K., BRANCA F., REIGOSA M.J., 2021, Unraveling Sorghum Allelopathy in Agriculture: Concepts and Implications. Plants, 10:1795.

HUSSAIN M.I., REIGOSA M.J., 2017, Evaluation of photosynthetic performance and carbon isotope discrimination in perennial ryegrass (*Lolium perenne* L.) under allelochemicals stress. Ecotoxicology, 26:613–624

HUSSAIN, M.I.; GONZÁLEZ, L.; REIGOSA, M.J., 2008, Germination and growth response of four plant species towards different allelochemicals and herbicides. Allelop. J. 22, 101–110.

KANDHRO MN, ANSARI MA, NAQI A, IBRAHIM M, MEMON HUR., 2015, Laboratory studies on the allelopathic potential of sorghum and sunflower water extract and powder against narrow-leaf summer weeds. Gomal Univ. J. Res.21(2): 9-17.

KINCEL KLAUDIA, ȘTEF RAMONA**,** CĂRĂBEȚ ALIN, 2019, Influence of *Ambrosia artemisiifolia* extract on germination and growth of *Amaranthus retroflexus* and *Zea mays*, Research Journal of Agricultural Science, 51 (2)

LINDER H. P., C.E.R. LEHMANN, S. ARCHIBALD, C.P. OSBORNE, D. M. RICHARDSON, 2017, Global grass (Poaceae) success underpinned by traits facilitating colonization, persistence and habitat transformation. Biological Reviews, Cambridge Philosophical Society

MACÍAS A.F., MEJÍAS F.J.R., MOLINILLO J.M.G., 2019, Recent advances in allelopathy for weed control: From knowledge to applications Pest. Manag. Sci. 2019, 75, 2413–2436.

MUBEEN K, NADEEM MA, TANVEER A, ZAHIR ZA.,2012, Allelopathic effects of sorghum and sunflower water extracts on germination and seedling growth of rice (*Oryza sativa* L.) and three weed species J Anim Plant Sci. 22(3):738-46.

NOURI H, TALAB ZA, TAVASSOLI A., 2012, Effect of weed allelopathic of sorghum (*Sorghum halepense*) on germination and seedling growth of wheat, Alvand cultivar. Ann Biol Res 3:1283–1293

SÁNCHEZ-MOREIRAS A. M.; O. A. WEISS; M. J.REIGOSA-ROGER, 2004, Allelopathic evidence in the Poaceae, The Botanical Review, Spain, Vol. 69, (3) , pp. 300-319.

SANGEETHA C., P. BASKAR, 2015, Allelopathy in weed management: A critical review, African Journal of Agricultural Research, vol.10:9:1004 -1015

SARI´C-KRSMANOVI´C, M., GAJI´C UMILJENDI´C J., RADIVOJEVI´C L., ŠANTRI´C L., POTOˇCNIK I., ĐUROVI´C-PEJˇCEV R., 2019, Bio-herbicidal effects of five essential oils on germination and early seedling growth of velvetleaf (*Abutilon theophrasti* Medik.). J. Environ. Sci. Health B 54:247–251.

ȘTEF RAMONA, CĂRĂBEȚ ALIN, GROZEA IOANA, RADULOV ISIDORA, MANEA DAN, BERBECEA ADINA, 2015, Allelopathic effects produced by johnson grass extracts over germination and growth of crop plants. Bulletin USAMV series Agriculture 72(1):239-245

ȘTEF RAMONA, CRISTIAN BOSTAN, ALINA BUTU, ALINA ORTAN, STELIANA RODINO, MARIAN BUTU, 2013, Comparative characteristics of *Lupinus perennis* L. under allelochemical sorgoleone stress, Romanian Biotechnological Letters, Vol. 18, No.3:8327-8332

ȘTEF RAMONA, IAMANDEI MARIA, CĂRĂBEȚ A., GROZEA IOANA, VÎRTEIU ANA MARIA, MANEA D., 2018, Allelopathic influence of *Datura stramonium* extracts on the germination and growing of soy plants, Journal of Horticulture, Forestry and Biotechnology, Volume 22:2:30- 33

ȘTEF RAMONA, VÎRTEIU ANA-MARIA, GROZEA IOANA, MANEA DAN, CĂRĂBEȚ ALIN, 2017, Assessment of allelopathic potential of extracts from *Colvovulus arvensis* on plant germination and growth of wheat, 17th International Multidisciplinary Scientific GeoConference SGEM:493-498

THAHIR I. M., GHAFOORA. O., 2011, The allelopathic potential of johnsongrass *Sorghum halepense* (L.) Pers. to control some weed species. Mesopotamia J. of Agric, Vol. 40: 2

YANG X, SCHEFFLER B, WESTON LA., 2004, Cloning of SOR 1, a gene associated with bioherbicide production in sorghum root hairs. J. Expt. Bot. 55:2251-2259.

YAR S., E.A. KHAN, I. HUSSAIN, B. RAZA, M. S. ABBAS, Z. MUNAZZA, 2020, Allelopathic influence of *Sorghum* aqueous extracts and *Sorghum* powder on germination indices and seedling vigor of hybrid corn and jungle rice, Planta Daninha vol.38 Viçosa

YAZLIK A, UREMIS, I., 2019, Interferences of Johnson grass [*Sorghum halepense* L. (Pers.)] with Some Robust Plant Species. MKU. Tar. Bil. Derg. 24(2):110-115