Original Article

Effect of Sorghum [*Sorghum Bicolor* (L.) Moench] Aqueous Extract on Germination and Seedling Growth of Wheat, Wild Oat, Wild Barley and Canary Grass

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ABSTRACT

Weed control is a necessary tool in crop production because of remarkable economic losses in crop yield. A bioassay experiment was conducted in order to evaluate phytotoxic activity of Sorghum bicolor shoot water extract on germination and some parameters of Triticum aestivum L., Triticum durum L., Hordeum spontaneum, Avena fatua and Phalaris minor seeds. The concentration levels were (control, 15, 30, 45, 60%) in this study, shoot aqueous extract of Sorghum bicolor were applied to 20 seeds of each species in sterilized petri dishes during the 10 days incubated period at 22 °C and the experimental units were laid out in randomized complete design. The quantification and determination of allelopathic substances were done by using high performance liquid chromatography (HPLC). Results indicated that sorghum shoot aqueous extract significantly affected germination percentage, inhibition of germination percentage, total dry weight, seedling growth inhibition, plumule and radicle dry weight, seedling length, seedling vigor index, plumule and radicle length, plumule and radicle elongation velocity. Moreover the five tested plant species were responded significantly in different ratio to sorghum aqueous extracts. In addition, all concentration levels had on germination and all growth parameters especially higher concentration levels. The germination percentage of wild barley was eliminated due to apply 45 and 60% concentrations. The HPLC results showed that the shoot of sorghum plant contained syringic acid, vanillic acid and ferulic acid. The outcomes proposed that the sorghum shoot concentrates can be recommended as a bioherbicide to inhibit weed germination.

Keywords: Allelopathy, Aqueous extract, Bioherbicide, Phenolic compounds, Sorghum

Introduction

Allelopathy is a term that expresses a natural occurrence of a plant liberated chemical inhibitors that inhibits the plant growth in vicinity. [1] Years later allelopathy was defined as inhibitory or stimulatory and effects of a plant on another including microorganisms. [2] Allelochemicals are secondary plant compounds which, releases into the environment leaching, root exudation, volatilization and plant residues in soil. [3, 4] Allelochemicals might affect plant metabolism pathways such as mineral absorption, photosynthesis, cellular respiration and water uptake.

Indicating a new biochemical compound produced by plants that potentially act as herbicides for weed control in crop fields is an ecofriendly process. [5] Previous study indicated the suppressive impact of sorghum plants extracts on some weed residues on different crop and weed plants *Chenopodium album, Convolvulus arvensis Melilotus parviflora and Rumex dentatus.* [6]

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Convolvulus arvensis, Rumexdentatus and Triticum aestivum Germination and growth were inhibited by different water extracts of sunflower (*Helianthus annuus*) sorghum (*Sorghum bicolor*), and johnson grass (*Sorghum halepense*). [7]

Sorghum (Sorghum bicolor L. Moench) from poaceae family imposed allelopathic effect on different studied plants due to release allelochemicals such as phenolic compounds. [8, 9] Almaghrabi, (2012) revealed that germination percentage of wild oat seed significantly decreased by using four synthetic phenolic compound salicylic acid, hydroxybenzoic acid ferulic acid and hydroxyphenyl acetic acid was the most effective. [10] Dry matter and growth of soybean was inhibited significantly when it treated with some phenolic acids like chlorogenic acid, caffeic acid, p- coumaric acid, gallic acid, ferulic acid, vanillic acid and p –hydroxybenzaldehyde. [11]

This study evaluated the allelopathic potential of *Sorghum bicolor* shoot extract on germination and growth characteristics of two crops bread and durum wheat (*Triticum aestivum* L., *Triticum durum* L.) and three grass weed plants (*Hordeum spontaneum, Avena fatua* and *Phalaris minor*) as a first step toward ecofriendly bio-herbicides.

Material and Methods

Seed Sources

Three Crop seeds of sorghum (*Sorghum bicolor* L. Moench) Var. Enqaz, bread wheat (*Triticum aestivum* L.) Var. Aras, durum wheat (*Triticum durum* L.) Var. Hawler 1 and three grassy weed seeds of wild oat (*Avena fatua*), wild barley (*Hordeum spontaneum*) and canary grass (*Phalaris minor*) were received from Erbil Research Center.

Extract Preparation

Sorghum seeds were sown at Grdarasha fields/ College of Agriculture/ Salahaddin University Lat. 36.4° N, Long. 44.1° E in the 2nd of July 2016. Sorghum plant herbage harvested when plants were reached to maturity stage. Plant was cut to 2-3 cm pieces then stored under shade till dryness, next it was grind by electrical mill instrument (JFSO-100). After that, shoot extract was prepared by soaking the powder into distilled water with the ratio of (20:100 w/v) after that it was placed in a shaker (LAB SK-180-Pro) with 120 rpm for 24 hours at 25°C. Later, it was filtered through four layers of cheesecloth then by Whatman filter paper No.1. Then adding distilled in order to complete volume to 100 ml. Finally, the extract kept in dark glass bottles and stored in deepfreeze at (-20°C) till implementation of experiment. [12]

Bioassay

The experiment was conducted at Agriculture college laboratories in the October 2017. A series of sorghum aqueous extract concentrations (control, 15, 30, 45, 60%) were prepared by using distilled water. [13, 14] Twenty seeds of each species placed between pair of filter paper #1 in 9 cm petri dishes then each of them were treated with 8ml of sorghum shoot extract; then they were sealed by Para-film tape and placed in growth chamber machine under (20º- 25°C) and continued in darkness. Germination percentages of each petri dish were determined on (3rd, 5th, 7th and 10th day). Finally, data of Plumule, radicle and seedling lengths were calculated in centimeter (cm), as well as radicle, plumule and total dry weight were recorded in milligram (mg) after placing seedlings in electronic oven at (40˚C) for 72 hours or until fixed weight.

Recorded Data

They were consisted of germination percentage (G%), inhibition of germination percentage (I.O.G.%), seedling growth inhibition percentage (S.G.I%); [15, 16] seedling length (S.L.), radicle length (R.L.), radicle elongation velocity (R.E.V.), plumule length (P.L.), plumule elongation velocity (P.E.V.) [17]; radicle dry weight (R.D.W.), plumule dry weight (P.D.W.), total dry weight (T.D.W), seedling vigor index (S.V.I.) [18, 19] according to equations shown below.

$$G.\ \% = T.G.S.\ /\ T.T.S. * 100 \quad (1)$$

$$I.O.G.\ \% = \{(G.P.C. - G.P.T.)/\ G.P.C.\}*100 \quad (2)$$

$$S.V.I. = \{S.L.\ (cm)* G\ \%\}\ /\ 100 \quad (3)$$

$$P.E.V.\ (cm/\ day)\ \text{or}\ R.E.V.\ (cm/\ day) = [\{P.L.\ (cm)\ \text{or}\ R.L.\ (cm)\}\ /\ T.D.W.]* 100 \quad (4)$$

$$S.G.I.\ \% = [G.\ \% * S.\ L.\ (cm)]/\ 100 \quad (5)$$

Where T.G.S = total number germinated seeds, T.T.S. = Total number tested seeds, G.P.C. = germination percentage of control, G.P.T. = germination percentage of treatment.

Chromatography Analysis

Sorghum shoot aqueous extract were prepared as mentioned by Singh et al., (1989) and Alsaadawi et al. (2005). [20, 21] Ten grams of sorghum shoot residue were soaked in (100 ml) of distilled water for 72 hours at (25 °C) then it was filtered to separate lipids and glycosides with petroleum ether and diethyl ether respectively. Identification of some phenolic acids was used (HPLC) UV Detector L-7400 and Pump L-7100, monitoring wave length 225 nm and column (c^{18}) 0.5 mish. Mobile phase of acetonitrile was 30% and deionized water was70% and 10 ml of solution for injection were used to isocratic elution. [22] Standards were used as standard library for poly phenolic compounds were caffeic acid (3,4-Dihydroxycinnamic acid), chlorogenic acid (3-Caffeoylquinic acid), ellagic acid (Benzoaric acid), ferulic acid (4-Hydroxy-3-methoxycinnamic acid), gallic acid 0.02% (3,4,5-Trihydrobenzoic acid), P-hydroxi banzoic acid (4-hydroxybenzoic acid), protocatechuic acid (3,4-Dihydroxybenzoic acid), syringic acid (4-Hydroxy-3,5Dimethoxybenzoic acid), vanillic acid (4-Hydroxy-3-methoxybenzoic acid).

Statistical Analysis

The design of this experiment was factorial in completely randomized (Factorial C.R.D) with three replications. The factors were five plant species and five concentration levels of shoot part of sorghum aqueous extract. The data were analyzed by using SPSS computer analysis that means were compared at (1%) significant level by Tukey test and standard error of mean were found. [23, 24]

Result and Discussion

Influence of sorghum shoot aqueous extract on plant species

The significant impact of *Sorghum bicolor* aqueous extract on germination percentage, inhibition of germination, total dry weight, seedling growth inhibition, plumule dry weight and radicle dry weight is elucidated in (Fig. 1). The highest value of germination percentage and plumule dry weight (56.33%, 34.97mg) respectively were recorded for durum wheat, while inhibition of germination and seedling growth inhibition maximum record (74.58%, 51.17%) respectively were observed with wild barley but the highest record of radicle and total dry weight were (32.13mg, 66.22mg) respectively at bread wheat. On the other hand lowest measurements were with germination percentage (25.33%) in wild barley, inhibition of germination (40.20%) with durum wheat, seedling growth inhibition (22.28%) at wild oat and the radicle, plumule and total dry weight (17.68 mg, 27.40 mg, 45.08 mg) respectively in wild oat. Identical results were indicated by Shahid et al., (2006), Mubeen et al., (2012) and Anwar et al., (2019). [7, 25, 26] Metabolic processes during early growth stages of plants may inhibit by allelopathic weed plant extracts because of the phenolic compounds presence. [27]

Results indicated that there were significant difference $p<0.01$ between all studied plant parameters (Fig. 1). The highest record for seedling length, seedling vigor index, plumule length and plumule elongation velocity of durum wheat were (17.35 cm, 11.30, 11.13 cm, 1.11 cm/ day) respectively and the maximum data (6.30 cm, 0.63cm/ day) of length and velocity elongation of radicle noted with bread wheat, however the minimum values of seedling length, seedling vigor index, radicle length and radicle elongation velocity were (12.14 cm, 5.66, 3.07 cm, 0.31 cm/ day) with canary grass but the lowest data for plumule length and plumule elongation velocity were (8.29 cm, 0.83 cm/day) respectively for wild barley (Fig. 1). Previous studies showed the similar when different plant species exposed to radish water extracts, [28] also various sensitivity of plant species toward allelopathic plants were found due to genetic variation properties of plant species. [29]

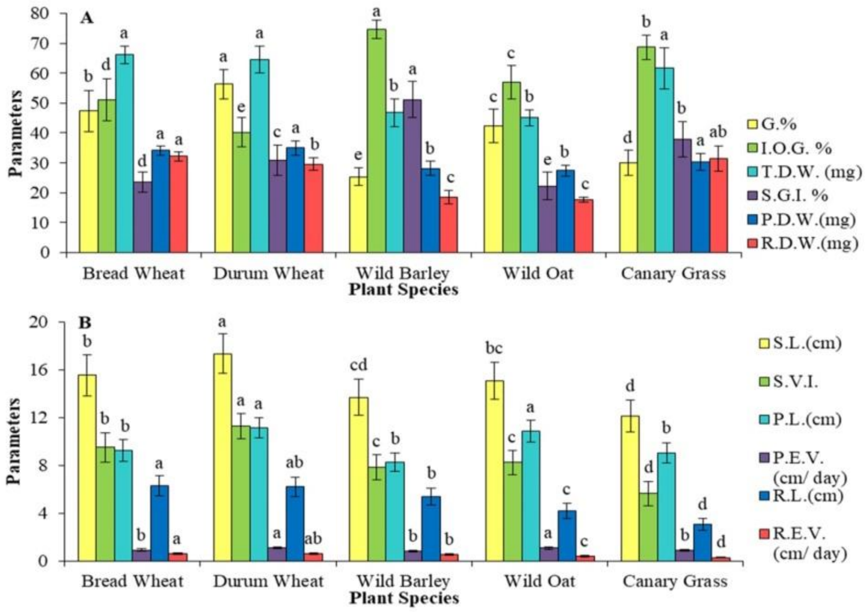

Figure 1: (A, B) The effect of sorghum shoot aqueous extract on germination and some seedling growth parameters of some plant species. Common letter means that there was non-significance difference at probability level (1%) by Tukey test.

Influence of different concentration levels of sorghum aqueous extract

Increasing sorghum water extract concentration levels caused significant effect on all studied criteria (Fig. 2). The highest record for germination percentage, radicle, plumule and total dry weight were (94.33%, 40.37 mg, 46.33 mg, 86.70mg) respectively with control treatment but the minor values for mentioned parameters were (10.33%, 14.82 mg, 17.38 mg, 32.21 mg) with 60% concentration level that means by increasing concentration levels lead to decreasing the mentioned parameters but in contrast with increasing concentration levels induced to increasing inhibition of germination and seedling growth inhibition from (5.67%, 0.00%) to (84.94%,60.98%) respectively (Fig. 2). These results are in agreement with the other results where they were revealed that growth and germination of *Lactuca sativa* seedling were significantly inhibited by *C. papaya* extract. [30] Another study has reported that small doses of secondary compounds may stimulate growth but the large doses have to be toxic impacts. [31] As well as seed germination of *Vigna radiata* were inhibited by different concentration of *Lantana camara* and *Chromolaena odorata* leaf extracts. [32] All tested plant criteria significantly affected by different concentration levels of sorghum aqueous extract indicated in (Fig. 2). It was obvious a reverse relationship between all tested plant parameters and concentration levels which decreased the data of seedling length, seedling vigor index plumule length, plumule elongation velocity, radicle length and radicle elongation velocity from (26.48 cm, 25.05, 15.49 cm, 1.55 cm/ day, 10.99 cm, 1.10 cm/ day) to (5.40 cm, 0.72, 4.42 cm, 0.44 cm/ day, 0.98 cm, 0.10 cm/ day) respectively. Javaid et al. (2006) named this phenomenon as concentration dependent effect which may lead to a new bioherbicide. [33] As well as, Mustafa *et al*., (2019) showed the same reduction in percentage of germination, root and shoot growth of some plants due to rising concentration levels of some allelopathic weed plant aqueous extract. [34]

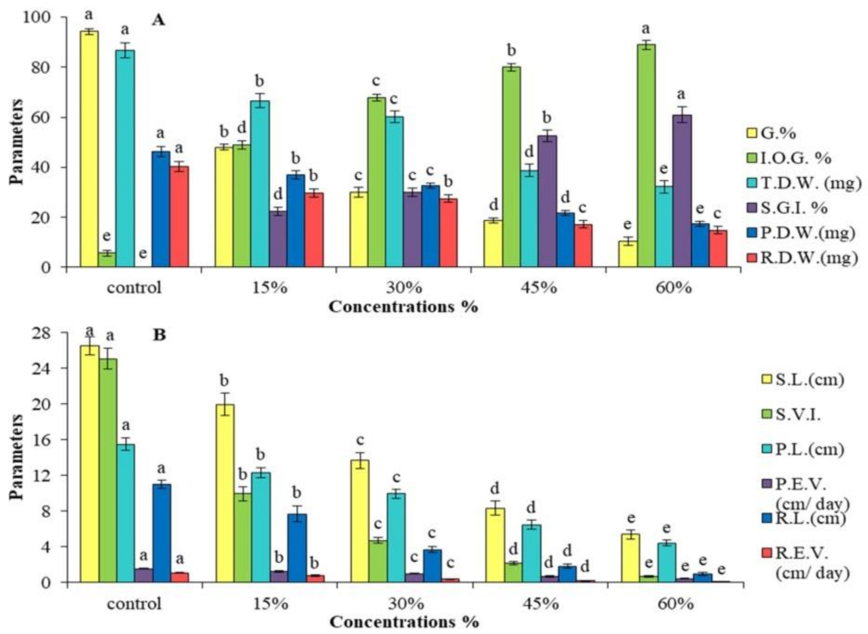

Figure 2: (A and B) The effect of concentration levels of sorghum shoot aqueous extract on germination and some seedling growth parameters of some plant species. Common letter means that there was non-significance difference at probability level (1%) by Tukey test.

Isolation and Identification of poly-phenols from sorghum shoot part

Results indicated that the sorghum shoot extract has three peaks syringic acid, vanillic acid and ferulic acid form studied standard curves (Fig. 3). The quantities of each phenolic acid compounds of sorghum shoot part were (0.06%, 0.06% and 0.064%) for Syringic acid, Vanillic acid and Ferulic acid respectively (Fig. 4). Syringic acid is a natural phenolic acid found in Barley (*Hordeum vulgare*) and rice. It was reported that syringic acid is shown to have auto toxicity and act as allelochemical compound and affect growth of wheat. [35, 36] Vanillic acid is a natural hydroxycinnamic acid. It was noticed that vanillic acid inhibited the growth of rice, bluegrass and wheat, also inhibited the germination and seedling growth of lettuce. [37, 38] Ferulic acid is also hydroxycinnamic acid which is distributed in the plant kingdom. It was showed that ferulic acid acts as chemical inhibitor on soybean germination and growth because it has inhibitory impact on synthesis of protein. The exact behavior was noticed on lettuce and cucumber plant. [39, 40]

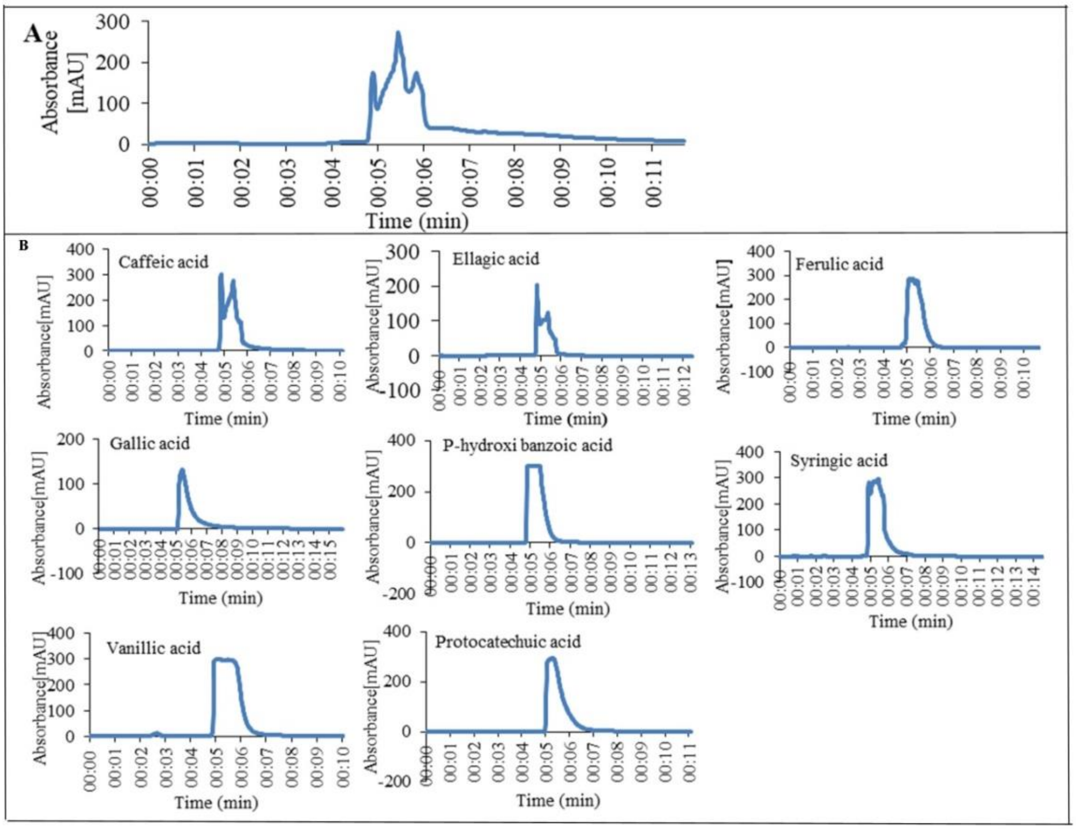

Figure 3: HPLC chromatogram of (A) sorghum shoot aqueous extract (B) standards of phenolic acids expected in sorghum shoot aqueous extract.

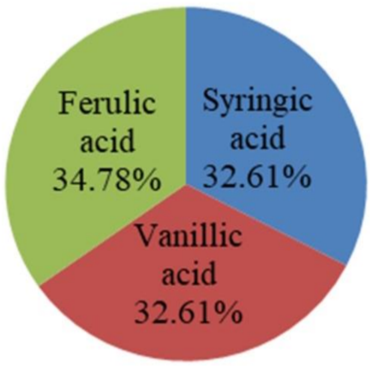

Figure 4: The amount phenolic acid in sorghum shoot aqueous extract.

Conclusion

Results of this study revealed that application the sorghum shoot extract suppressed germination and some seedling growth parameters due to three effective phenolic acid compounds syringic acid, vanillic acid and ferulic acid which they acts as biochemical herbicide. Higher concentration levels 45 and 60% of sorghum aqueous extract imposed maximum reduction for germination. In addition the three studied grass weeds were more sensitive comparing bread and durum wheat. Therefore, these results may allow the evolution of selective biosynthesized herbicides to control weeds in sustainable crop production.

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References

1. Rice EL. Allelopathy—an update. The Botanical Review. 1979 Jan 1;45(1):15-09.

2. Rice EL. Allelopathy. 2nd (ed.) Acad. Press. Inc. Orlando. Florida, USA. 1984.
3. Rice EL. Biological control of weeds and plant diseases: advances in applied allelopathy. University of Oklahoma Press; 1995.
4. Cutler HG, Cutler SJ. Biologically active natural products: pharmaceuticals. CRC Press; 1999 Jul 27.
5. Jones RE, Medd RW. A methodology for evaluating risk and efficacy of weed management technologies. Weed Science. 2005 Aug;53(4):505-14.
6. Cheema ZA, Iqbal M, Ahmad R. Response of wheat varieties and some rabi weeds to allelopathic effects of sorghum water extract. International Journal of Agriculture and Biology. 2002;4(1):52-5.
7. Shahid M, Ahmad B, Khattak RA, Hassan G, Khan H. Response of wheat and its weeds to different allelopathic plant water extract. Pak. J. Weed Sci. Res. 2006;12(1-2):61-8.
8. Sène M, Doré T, Pellissier F. Effect of phenolic acids in soil under and between rows of a prior sorghum (Sorghum bicolor) crop on germination, emergence, and seedling growth of peanut (Arachis hypogea). Journal of chemical ecology. 2000 Mar 1;26(3):625-37.
9. Won OJ, Uddin MR, Park KW, Pyon JY, Park SU. Phenolic compounds in sorghum leaf extracts and their effects on weed control. Allelopathy Journal. 2013;31(1):147.
10. Almaghrabi OA. Control of wild oat (Avena fatua) using some phenolic compounds I–Germination and some growth parameters. Saudi journal of biological sciences. 2012 Jan 1;19(1):17-24.
11. Patterson DT. Effects of allelopathic chemicals on growth and physiological responses of soybean (Glycine max). Weed Science. 1981 Jan;29(1):53-9.
12. Cheema ZA, Khaliq A. Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi arid region of Punjab. Agriculture, Ecosystems & Environment. 2000 Jul 1;79(2-3):105-12.
13. Doğan A, Uygur FN. Antep turpu (Raphanus sativus L.)'nun mısır bitkisine ve yabancı ot türlerine olan allelopatik etkisinin araştırılması. Türkiye Herboloji Dergisi. 2005;8(2):10-25.
14. Panahyan-e-Kivi M, Tobeh A, Shahverdik MA, JAMAATI-ESOMARIN S. Inhibitory impact of some crop plants extracts on germination and growth of wheat. American-Eurasian Journal of Agriculture and Environmental Sciences. 2010;9(1):47-51.
15. Ali KA, Aziz FH. Studying the effect of root and shoot extracts of syrian cephalaria (Cephalaria syriaca) extract on wheat seeds (Triticum aestivum) germination properties. Zanco) journal of pure and applied science.(2002) Vol. 2002;14:15-24.
16. Norsworthy JK. Allelopathic Potential of Wild Radish (Raphanus raphanistrum) 1. Weed Technology. 2003 Jun;17(2):307-13.
17. Jiang W, Lafitte R. Ascertain the effect of PEG and exogenous ABA on rice growth at germination stage and their contribution to selecting drought tolerant genotypes. Asian J. Plant Sci. 2007;6(4):684-7.
18. Abdul-Baki AA, Anderson JD. Physiological and biochemical deterioration of seeds. Seed biology. 1972 Jan 1;2:283-316.
19. Oliveira AK, Ribeiro JW, Pereira KC, Silva CA. Effects of temperature on the germination of Diptychandra aurantiaca (Fabaceae) seeds. Acta Scientiarum. Agronomy. 2013 Jun;35(2):203-8.
20. Singh M, Tamma RV, Nigg HN. HPLC identification of allelopathic compounds fromLantana camara. Journal of chemical ecology. 1989 Jan 1;15(1):81-9.
21. Alsaadawi IS, Majid HS, Ekelle A, Mageed KA. Allelopathic potential of Sorghum bicolor L.(Moench) genotypes against weeds. InProceedings of the Fourth World Congress on Allelopathy 2005 Aug (Vol. 2126).
22. Sakakibara H, Honda Y, Nakagawa S, Ashida H, Kanazawa K. Simultaneous determination of all polyphenols in vegetables, fruits, and teas. Journal of agricultural and food chemistry. 2003 Jan 29;51(3):571-81.
23. Weinberg SL, Abramowitz SK. Statistics using SPSS: An integrative approach. Cambridge University Press; 2008 Mar 3.
24. Field A. Discovering statistics using IBM SPSS statistics. sage; 2013 Feb 20.
25. Mubeen K, Nadeem MA, Tanveer A, Zahir ZA. Allelopathic effects of sorghum and sunflower water extracts on germination and seedling growth of rice (Oryza sativa L.) and three weed species. The Journal of Animal and Plant Sciences. 2012 Jan 1;22(3):738-46.
26. Anwar TA, Ilyas N, Qureshi R, Malik MA. Allelopathic potential of Carica papaya against selected weeds of wheat crop. Pakistan Journal of Botany. 2019 Feb 1;51(1).
27. Muzaffar S, Ali B, Wani NA. Effect of catechol, gallic acid and pyrogallic acid on the germination, seedling growth and the level of endogenous phenolics in cucumber (Cucumis sativus L.). International Journal of Life Science Biotechnology and Pharma Research. 2012;1(3):50-5.
28. Ali K A. Allelopathic potential of radish (Raphanus sativus L.) germination and growth of some crop and weed plants. International Journal of Biosciences I.J.B. 2016; 9: 394-403.
29. Acciaresi HA, Asenjo CA. Efecto alelopático de Sorghum halepense (L.) Pers. sobre el crecimiento de la plántula y la biomasa aérea y radical de Triticum aestivum (L.). Ecología austral. 2003 Jun;13(1):49-61.
30. Wabo Poné J, Ngankam Ntemah JD. Bilong Bilong, CF; Mbida, M. A comparative study of the ovicidal and larvicidal activities of aqueous and ethanolic extracts of pawpaw seeds Carica papaya (Caricaceae) on

Heligmosomoides bakeri. Asian Pac. J. Trop. Med. 2011;4:447-50.

31. Pelinganga O, Mashela P. Mean dosage stimulation range of allelochemicals from crude extracts of Cucumis africanus fruit for improving growth of tomato plant and suppressing Meloidogyne incognita numbers. Journal of Agricultural Science. 2012 Dec 1;4(12):8.
32. Julio A, Tandoc WC, Tipace HD, Vendivil YF, Yanesa Z, Tare MV, Lactaoen EJ, Clemente KJ. AJAB. Asian J Agric & Biol. 2019;7(2):190-6.
33. Javaid A, Shafique S, Bajwa R. Effect of aqueous extracts of allelopathic crops on germination and growth of Parthenium hysterophorus L. South African Journal of Botany. 2006 Nov 1;72(4):609-12.
34. Mustafa G, Ali A, Ali S, Barbanti L, Ahmad M. Evaluation of dominant allelopathic weed through examining the allelopathic effects of four weeds on germination and seedling growth of six crops. Pakistan Journal of Botany. 2019 Feb 1;51(1):269-78.
35. Oueslati O, Ben-Hammoudam H, Ghorbel M, El Gazzeh M, Kremer RJ. Role of phenolic acids in expression of barley (Hordeum vulgare) autotoxicity. Allelopathy Journal. 2009 Jan 1;23(1).
36. Abbas T, Tanveer A, Khaliq A, Safdar ME, Nadeem MA. Allelopathic effects of aquatic weeds on germination and seedling growth of wheat. Herbologia. 2014 Oct 1;14(2).
37. Einhellig FA. Mode of allelochemical action of phenolic compounds. Allelopathy. 2004:217-38.
38. Zhou YH, Yu JQ. Allelochemicals and photosynthesis. InAllelopathy 2006 (pp. 127-139). Springer, Dordrecht.
39. Blum U. Effects of microbial utilization of phenolic acids and their phenolic acid breakdown products on allelopathic interactions. Journal of Chemical Ecology. 1998 Apr 1;24(4):685-708.
40. Li ZH, Wang Q, Ruan X, Pan CD, Jiang DA. Phenolics and plant allelopathy. Molecules. 2010;15(12):8933-52.