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RESEARCH PAPER

The Allelopathic potential of Milk thistle (Silybum marianum) and Syrian thistle (Notobasis syriaca) on germination percentage, some growth characteristics and Allelopathy index of Wheat and Barley

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A B S T R A C T:

A completely randomized design bioassay experiment was performed to assess the allelopathic activity of ***Silybum marianum*** and ***Notobasis syriaca*** shoot and root water extracts on germination and some growth characteristics of wheat (***Triticum aestivum L***.) and barley (***Hordeum vulgare***) seeds for the aim of indicating ecofriendly herbicides alternatives. The concentration levels were (control, 20, 40, 60, 80 and 100%) of shoot and root aqueous extract of ***S. marianum*** and ***N. syriaca*** were applied to 25 seeds of each species in sterilized petri dishes were incubated for ten days at 25 °C. Results indicated that ***S. marianum*** and ***N. syriaca*** shoot and root aqueous extracts had a substantial impact on germination percentage was higher with shoot extracts 45.09% than that of root extracts 25.86% for ***S. marianum***, inhibition of germination percentage was higher with ***N. syriaca*** compared to ***S. marianum*** 45.09 % to 46.89 respectively, total dry weight 80.58 with ***S. marianum*** and with ***N.syriaca*** 83.65, total seedling length and germination velocity. The allelopathy index was higher with shoot aqueous extracts compared to root extracts, obviously for ***S. marianum*** the allelopathy index was higher than that of ***N. syriaca*** 23.99. The two bioassayed plants were significantly affected in different proportions to the aqueous extracts of both plants and the effect was concentration dependent. Determination of allelopathic substances was conducted using the Gas Chromatography-Mass Spectroscopy (GC-MASS). The GC-MASS results indicated that the shoot and root of both plants contain numerous allelochemicals which may cause an allelopathic impact on tested plants.

KEY WORDS: Allelopathy, Allelochemicals, Bioassay, Silybum marianum, Notobasis syriaca
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1.INTRODUCTION:

Allelopathy is defined by Rice as “any direct or indirect effect of one plant, including microbes, on another by the formation of chemical substances that release into the environment and influence the growth and development of neighboring plants” (VanVolkenburg et al., 2020). Various parts of a plant impose different allelopathic effects on neighbouring plants by releasing allelochemicals into the soil. Plants use four methods of allelochemical protrusion: root exudation, volatilization, breakdown of plant residues and leaching (Zimdahl, 2018).

The effects may be stimulatory or inhibitory depending on the concentration of the released compounds (Sangeetha and Baskar, 2015). Wheat and barley are two cereal crop plants from the Poaceae family. Wheat is the chief source of nutrition for more than 40% of the planet's population. Barley is primarily utilized for animal feeds and brewing, but it also serves as an important part of the diet in regions where other main crops cannot be grown (Giraldo et al., 2019). Wheat was the most widely grown crop in Iraq's Kurdistan region. In Iraqi Kurdistan, barley is the second most common crop, with the largest territory allocated to its production (Eklund et al., 2017).

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Some members of the Asteraceae family have an allelopathic effect on other plants (El-Amier et al., 2015., Baličević et al., 2016., Mushtaq et al., 2020). With over 1600 genera and 2500 species globally, the Asteraceae family is among the most prominent angiosperms families (Rolnik and Olas, 2021). ***S. marianum*** (***Cardus marianus***) is a member of Asteriaceae family. The leaves of ***S. marianum*** are glossy and light green, while the flowers are red to purple with white veins (Bahmani et al., 2015). ***S. marianum*** is a biennial plant, native to the Mediterranean and Northern Africa, although it has spread to other hot, dry areas of the United States, Australia, and Europe. (Ghafor et al., 2014, Wianowska and Wiśniewski, 2015). ***S. marianum*** grows in Iraq and the Kurdistan Region, where it completes its life cycle in the winter and spring. (Hussain, 2019). This plant's extract has medicinal qualities (Chambers et al., 2017). Milk thistle can often be used to treat a number of diseases, such as hepatic disease and inhibit the occurrence and treatment of cancer, and it's also utilized as a diet (Othman et al., 2020). Earlier researches also shown that ***S. marianum*** has a solid allelopathic capability. (Khan et al., 2011) focused on the allelopathic influence of ***S. marianum*** as a donor plant on mungbean (***Vigna radiata L.***), kidneybean (***Phaseolus vulgaris L.***), soybean (***Glycine max L.***) and chickpea (***Cicer arietinum L.***). The findings showed that milk thistle leaves extract concentration resulted in a substantial reduction in the test plant's seed germination rate, average seed germination time, seed germination index, and seed vigour index. ***N. syriaca*** is another Asteraceae family member that differs from ***S. marianum*** in its genus. (Silaev, 2018). According to (Qasem, 2015) It is possible to eat the fresh stem and leaf base of ***N. syriaca***. It is the sole species of Notobasis genus, which belongs to the family of Asteraceae. It is one of the most common plants in the Mediterranean east, with spiky, attractive blooms. ***N. syriaca*** is commonly used in traditional remedies. Also, it has been used in middle east civilizations to cure cephalalgia, the black plague caused by ***Yersinia pestis*** bacteria, aphthous ulcer, vertigo, and high level of bilirubin (jaundice), and it is occasionally utilized to boost breastfeeding (Azab et al., 2018). Therefore, the purpose of this study was to determine the allelopathic effect of various concentrations of aqueous extracts of ***S. marianum*** and ***N. syriaca*** on germination and some growth characteristics of bread wheat, barley and to indicate some allelochemical compounds in both plants.

2.Materials and method:

This study investigated the effect of ***S. marianum*** and ***N. syriaca*** shoots and root aqueous extracts with six levels of concentrations (0 considered as control, 20%, 40%, 60%, 80% and 100%) on germination and some seedling's growth characteristics of bread wheat (***Triticum aestivum)*** and barley (***Hordeum vulgare***).

2.1. **Sample collection of both donor plants: -** samples of ***S. marianum*** and ***N. syriaca*** were collected from the Soran university campus. Then the samples were identified in the herbarium lab of the college of agricultural engineering science/ salahadeen university. Samples were washed with water and cleaned from soil residues and suspended matter. Then samples were air-dried and chopped into small pieces.

2.2.**Aqueous extract preparation: -** Root and shoot plant part powders were soaked in distilled water flask with the ratio 20gm:100ml, it was placed in electric shaker with 120 rpm for 24 hours at room temperature 25℃, after that they were screened through two layers of cheesecloth and rewashed twice with distilled water and pressed or squeezed to remove any left extracts in the debris. The collecting extracts were filtered through Whatman filter paper No.1., rewashed twice and broad to the final size of 100 ml with distilled water. The collecting extracts were kept in the dark glass bottles prepared for such purposes and reserved in deepfreeze at -20 ℃ for subsequent use (Cheema, 2000., Kadioglu, 2004., Swapnal, 2010., Naby, 2020) .

2.3. **Bioassay: -** Seeds of bread Wheat and barley were surface sterilized in a 1:10(v\v) dilution of commercial hypochloride blech for 5 minutes and rinsed several times with distilled water. Petridishes, 9 cm diameter were used and laid with filter papers. Twenty-five seeds placed in a manner of equal distances in each petri-dish, then 8ml of previously prepared extracts were added to each petri-dish while the distilled water was used for control. Three replicates were actually prepared for each tested plant. Then labelled petri-dishes were randomly placed in the incubator without light at (22 – 24) ℃. Germination percentage of each petri dish was determined on the 3rd, 6^{th}

and 9th day. Ten days later, the germination percentage and root and shoot length data were recorded from each five homogenous seedlings. Generally, if the root radicle protruded totally from the seeds as observed with the naked eye, the seed will be regarded as a germinated seed. Finally, the samples were placed in an electric oven at 40℃ for 72 hours or until weight consistency to record dry seedling weight, radicle and plumule dry weight.

2.4. **Preparation of plant extracts for GC-MASS analysis**: GC-MASS analysis was performed for different parts of ***S. marianum*** and ***N. syriaca*** plants to indicate the allelochemicals within the samples. The shoot and root of both studied plants were dried and pulverized to powder in a mechanical grinder. Plant samples were weighted, transferred to a flask, treated with absolute ethanol until the powder was fully immersed, and placed in an electric shaker with 120 rpm for 24 hours at room temperature 25℃, the extract products were filtered through a filter paper to avoid excess particles. Finally, the extract producte were injected into GC-MASS analyser. GC-MS analysis of the sample were carried out using Agilent GC 6890 MS 5973 series equipped with a 7683 autosampler, and a DB5 column (0.25 μm, 30 m × 0.25 mm i.d.). Hilium was used as the carrier gas and the temperature programming was set with initial oven temperature at 40℃ and held for 3 min and the final temperature of the oven was 246℃. 4μl sample was injected for quantitative measurement of allelochemicals (Aizpurua-Olaizola, 2016).

2.5. **Recorded data**: They have consisted of germination percentage (G%), inhibition of germination percentage (I.O.G.%), radicle dry weight (RDW), plumule dry weight (PDW), total dry weight (TDW), radicle length (RL), plumule length (PL), seedling length (SL), root to shoot ratio, seedling vigor index (SVI), seed germination velocity and allelopathy index (AI). according to the equations shown below (Ali, 2011).

G. % = T.G.S. / T.T.S. * 100 …………… (1)

I.O.G. % = {(G.P.C. – G.P.T.)/ G.P.C.} *100 …………… (2)

AI = 1-(SDWt / SDWc) * 100 …………… (3)

Where TGS = total germinated seed, TTS = total tested seed, GPC = germination percentage of control, GPT = germinated seed of treatment, SDWt = seedling dry weight of treatment, SDWc = seedling dry weight of treatment and AI=allelopathy index (Ali, 2011).

2.6. **Statistical analysis:**

This experiment was designed as a factorial in completely randomized (Factorial C.R.D) with three replications. The factors were four plant species and six concentration levels of shoot and root part of ***S. marianum*** and ***N. syriaca*** aqueous and methanolic extract. The data were examined using SPSS computer analysis, and means were compared at a (1%) significant level using the Duncan test, and a standard error of the mean was discovered (Field, 2013).

3. Result and discussion:

The significant impact of ***S. marianum*** and ***N. syriaca*** shoot and root aqueous extract on germination percentage, inhibition of germination, total dry weight, total seedling length and allelopathy index on different plant species are elucidated below. The allelopathic effects of both plants were concentration-dependent and consistent with previous studies (Lehoczky., 2017., Waseem., 2018, Nyasha., 2018).

3.1 Effect of *S. marianum* and *N. syriaca* plant part extracts on germination and some growth parameters of *Triticum aestivum L.*:

According to the statistical study, there is a significant difference. (P ≥0.01) between ***S. marianum*** and ***N. syriaca*** plant parts allelopathic impact on bread wheat: ***S. marianum*** shoot and root extracts on germination percentage of wheat ranged between 50.44% for shoots and 68.11% for root parts, while inhibition of germination was higher with shoot extracts 45.09% than that of root extracts 25.86%. Also, the allelopathy index of shoot parts was higher at 33.95 than root parts at 14.02 (figure 1).

Germination percentage, inhibition of germination, total dry weight, total length and allelopathy index ranged from (48.22%, 46.49%, 61.68mg, 15.03cm, 23.99) respectively with ***N. syriaca*** shoot parts to (70.78%, 20.58%, 83.65mg, 24.94cm, -6.13) with ***N. syriaca*** root parts (figure

2). Shoot extracts of ***N. syriaca*** had a higher allelopathic potential than root portions. Most allelopathic studies evaluate plant part crude extract's effect on the germination of tested plant, meanwhile results of this study indicate that plant shoot part extracts impose a stronger effect compared with root part extracts due to allelochemics existed in higher quantities in shoot parts as compared with root extractions (Sodaeizadeh et al., 2009, Gella et al., 2013).

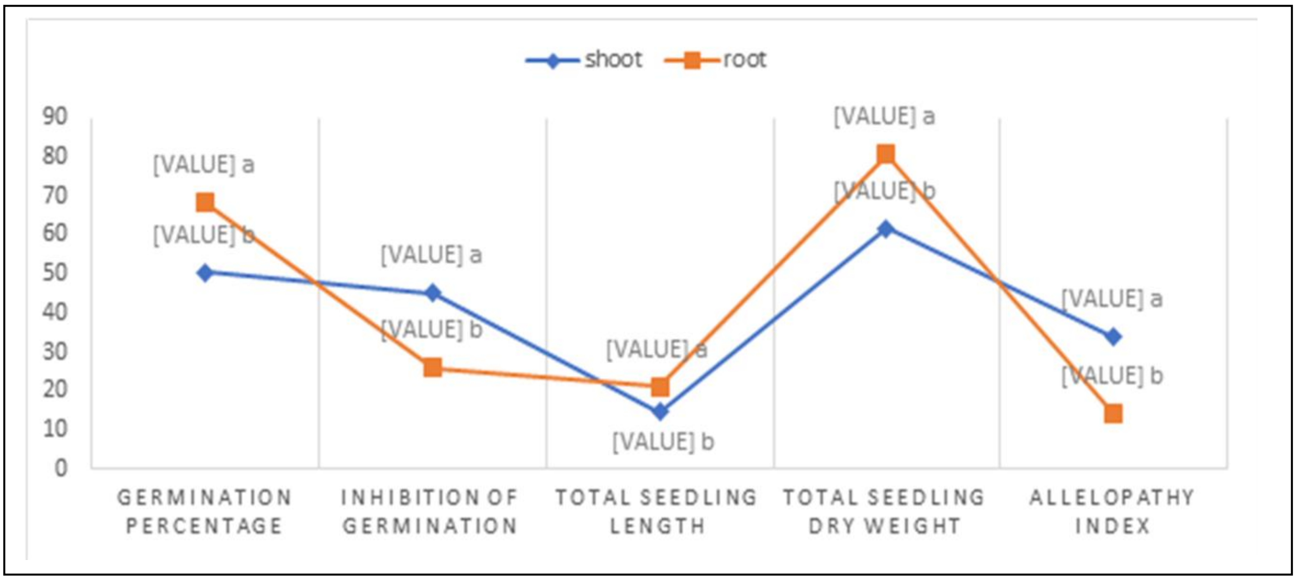


figure (1): Effect of ***S. marianum*** shoot and root aquoeus extracts on germination, growth characteristics and Allelopathy index.

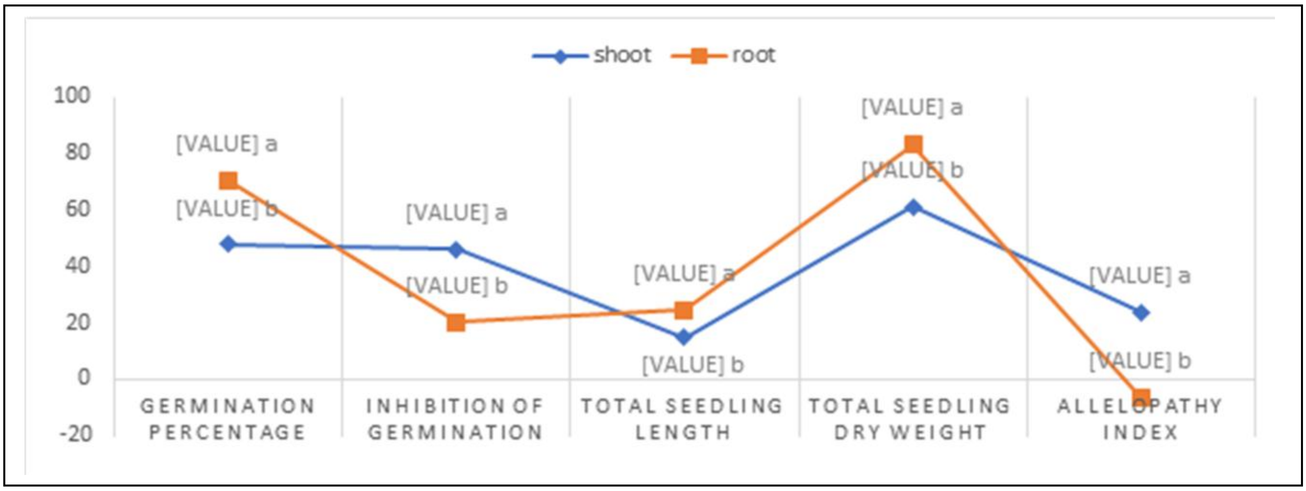


Figure (2): Effect of ***N. syriaca*** shoot and root aquoeus extracts on germination, growth characteristics and Allelopathy index

3.2 Effect of *S. marianum* and *N. syriaca* plant part extracts on germination and some growth parameters of *Hordeum vulgare* L.:

The effects of ***S. marianum*** plant parts on the germination and growth parameters of barley were determined (figure 3). Recorded data of germination percentage, inhibition of germination, dry seedling weight, seedling length and allelopathy index ranged from (47.67%, 46.84%, 49.08mg, 12.98cm, 48.15) with shoot extracts to (67.67%, 29.28%, 76.06mg, 21.18cm, 19.46) respectively with root extracts.

The allelopathic impact of ***N. syriaca*** on barley plant parts has a significant ($P \geq 0.01$) difference except for dry seedling weight as shown in (figure 4); the previous characteristics were (61.33%, 78.79mg, 25.24cm, 32.78% and 15.8) in case of shoot extracts and (70.83%, 79.81mg, 26.64cm, 20.06% and 12.48) in case of root extracts. The shoot extract of both plants has a stronger impact than root extract (Wu, 2009., Shui, 2010).

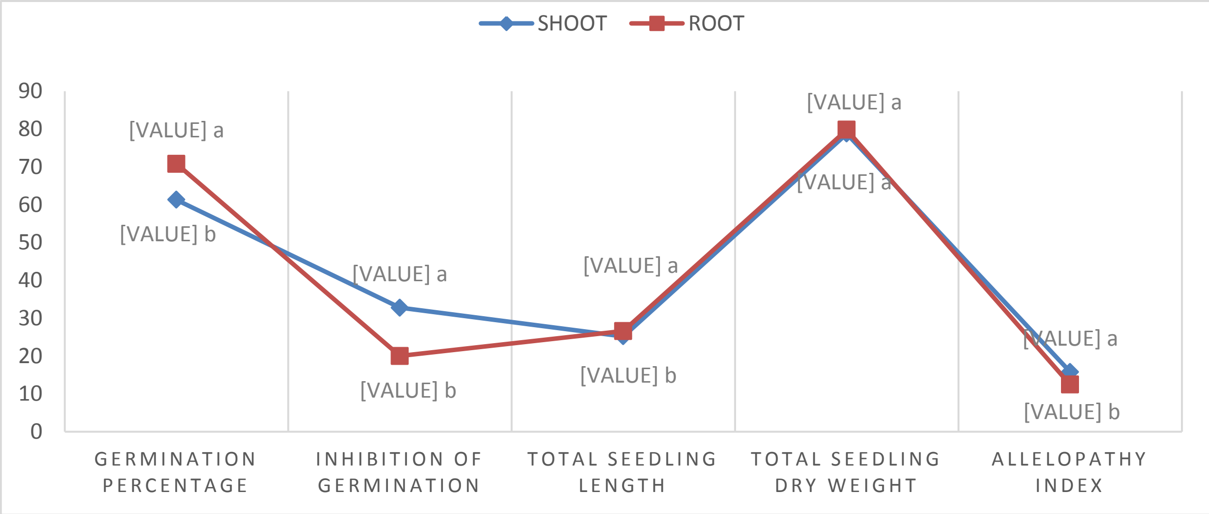


Figure (3): Effect of ***N. syriaca*** shoot and root aqueous extracts on germination, growth characteristics and Allelopathy index of barley.

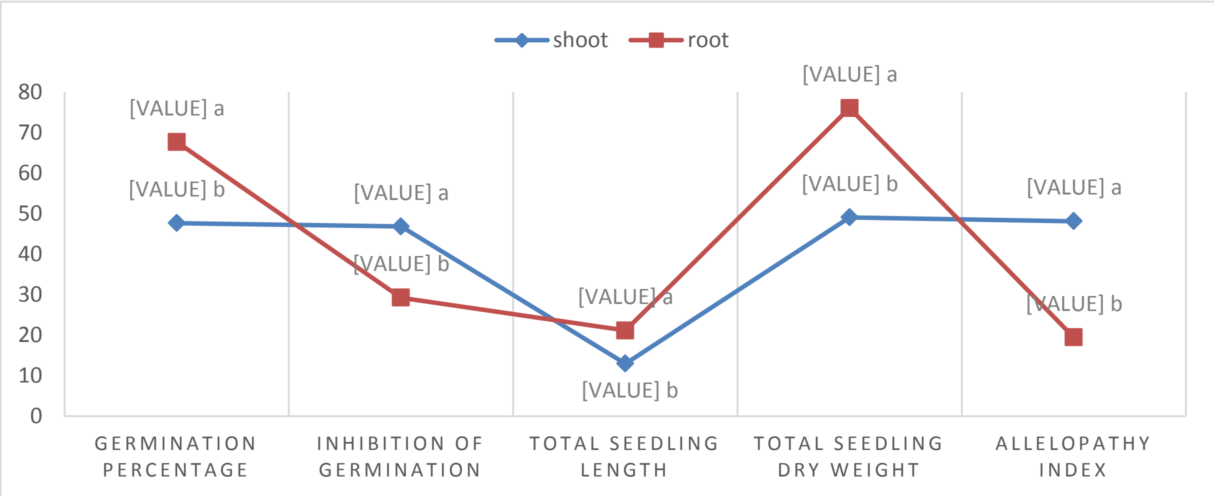


Figure (4): Effect of ***N. syriaca*** plant parts aqueous extracts on germination, growth characteristics and Allelopathy index of barley.

3.3 Effect of different concentrations of *S. marianum* and *N. syriaca* extraction on seed germination and some growth parameters of bread wheat:

Wheat is shown to be adversely affected by higher extract concentrations of ***S. marianum***. with the control treatment, the maximum records for germination percentage, total dry weight and total seedling length were (92%, 93.68 mg, and 31.23 cm) respectively. With the highest concentration, the maximum records for germination inhibition and allelopathy index were (73.77%, 50.9). However, the minimum values for the aforementioned parameters were (24%, 45.71 mg, and 7.14 cm) with the highest concentration levels (table 1). This indicates that increasing concentration levels caused to decrease in the aformementioned parameters, but increased concentration levels elevated the inhibition of germination and the allelopathy index (Mishra, 2015, Mangal et al., 2014).

N. syriaca concentration levels significantly affect bread wheat germination and other growth parameters. The inhibitory activity of ***N. syriaca*** extracts was concentration dependent. Control data for germination percentage, inhibition of germination, total dry weight, seedling length and allelopathy index were (89.67%, 80.18mg, 29.47cm, 0 %, and 0%) respectively the highest concentration of previously mentioned parameters were (30.33%, 50.84mg, 11.63cm, 66.32%, 35.13) (table 2). These findings are consistent with previous findings, which demonstrated that the growth and germination of ***C. tora*** were significantly inhibited by higher extract concentrations of ***N. plumbaginifolia*** (Mushtaq et al., 2019). Another research showed that lower concentrations of secondary metabolites might boost growth, but higher concentrations have to be toxic effects (Pelinganga and Mashela, 2012)

Table 1: Effect of different extract concentrations of **S. marianum** germination, growth characteristic and Allelopathy index of bread wheat

Concentrations& parameters	Germination percentage (%)	inhibition of germination (%)	total seedling dry weight (mg)	total seedling length (cm)	allelopathy index (%)
control	**92 a**	**0 f**	**93.68 a**	**31.23 a**	**0 f**
20%	**76 b**	**17.41 e**	**86.62 b**	**22.55 b**	**7.71 e**
40%	**68.33 c**	**25.58 d**	**81.61 c**	**19.36 c**	**12.91 d**
60%	**52.33 d**	**42.93 c**	**67.88 d**	**15.48 d**	**27.42 c**
80%	**43 e**	**53.16 b**	**51.32 e**	**11.48 e**	**44.98 b**
100%	**24 f**	**73.77 a**	**7.14 f**	**45.71 f**	**50.1 a**

Table 2: Effect of different concentration levels of ***N, syriaca*** on germination, growth characteristics and Allelopathy index of bread wheat

Parameters& concentrations	germination percentage (%)	inhibition of germination (%)	Total seedling length (cm)	total dry weight (mg)	allelopathy index (%)
Control	89.67 a	0 e	29.47 a	80.18 b	0 d
20%	81 b	9.5 d	25 b	86.42 a	-8.09 e
40%	62.33 c	30.19 c	21.62 c	81.95 b	-0.64 d
60%	48.67 d	45.5 b	17.75 d	72.6 c	8.75 c
80%	45 d	49.69 b	14.44 e	64 d	18.44 b
100%	30.33 e	66.32 a	11.63 f	50.84 e	35.13 a

3.4 Effect of different concentrations of *S. marianum* and *N. syriaca* extraction on seed germination and some growth parameters of barley:

S. marianum extracts significantly affected seed germination and growth parameters of barley. The maximum records of germination percentage, inhibition of germination, total seedling dry weight, total seedling length and allelopathy index were (96%, 94.58mg, 30.81cm, 0%, 0) respectively with control, minimum records were (19.67%, 16.2mg, 3.36cm, 79.27% and 82.87) (table 3). It was obvious from these results that allelopathic impact was concentration dependent.

N. syriaca extracts caused the previously mentioned parameters when they ranged from (90%, 0%, 91.98mg, 33.95cm, 0) respectively to (35%, 61.3%, 53.35mg, 16.62cm, 40.82) (table 4).

Table 3: Effect of different extract concentrations of ***S. marianum*** on germination, growth characteristics, and Allelopathy index of barley.

Parameters& concentrations	germination percentage (%)	inhibition of germination (%)	total seedling length (cm)	total seedling dry weight (mg)	allelopathy index (%)
Control	96 a	0 c	30.81 a	94.58 a	0 e
20%	85.67 b	10.95 c	25.88 b	94.4 a	0.26 e
40%	55.33 c	41.95 b	20.07 c	78.64 b	16.98 d
60%	55.33 c	41.86 b	12.53 d	50.08 c	46.85 c
80%	34 d	54.32 b	9.8 e	41.7 d	55.87 b
100%	19.67 e	79.27 a	3.36 f	16.02 e	82.87 a

Table 4: Effect of different concentration levels of ***N. syriaca*** on germination, growth characteristics, and Allelopathy index of barley.

Parameters& concentrations	germination percentage (%)	inhibition of germination (%)	total seedling length (cm)	total seedling dry weight (mg)	allelopathy index (%)
control	90 a	0 e	33.95 a	91.98 a	0 cd
20%	81.67 b	8.88 d	30.78 b	96.4 a	-5.06 d
40%	75 b	16.31 d	29.6 b	92.64 a	3.97 c
60%	62.5 c	30.66 c	23.68 c	72.31 b	20.88 b
80%	52.33 d	41.38 b	21 d	69.14 b	24.22 b
100%	35 e	61.3 a	16.62 e	53.35 c	40.82 a

3.5 Effect of the combination between *S. marianum* plant part extracts and different concentrations on germination and growth parameters of bread wheat

Wheat is shown to be adversely affected by shoot and root aqueous extracts of ***S. marianum*** (figure 5). The maximum records for germination percentage, total dry weight, and total seedling length of ***S. marianum*** shoot water extract were (92%, 93.63 mg, and 31.23 cm) respectively, recorded with control treatment. The maximum records for germination inhibition and allelopathy index were (79.6% and 70.86) respectively with the highest tested concentration. However, the minimum values for germination percentage, total dry weight, and total seedling length were (18.67%, 26.72 mg, and 2.84 cm) with the highest concentration levels (figure 5). These results indicate that increasing concentration levels led to a decrease in the afore mentioned parameters. Still, increased concentration levels caused an increase in the inhibition of germination and the allelopathy index (figure 6). phytotoxic impact of aqueous root extract of ***S. marianum*** on wheat illustrated in (figure 5). When extract concentration was increased, the records for germination percentage, dry weight, and total length declined to (29.33%,64.52mg, and 11.45cm) with 100% concentration from (92%, 93.73 mg, 31.23cm) respectively with control. As the extract concentration was raised, germination inhibition and the allelopathy index rose (figure 6).

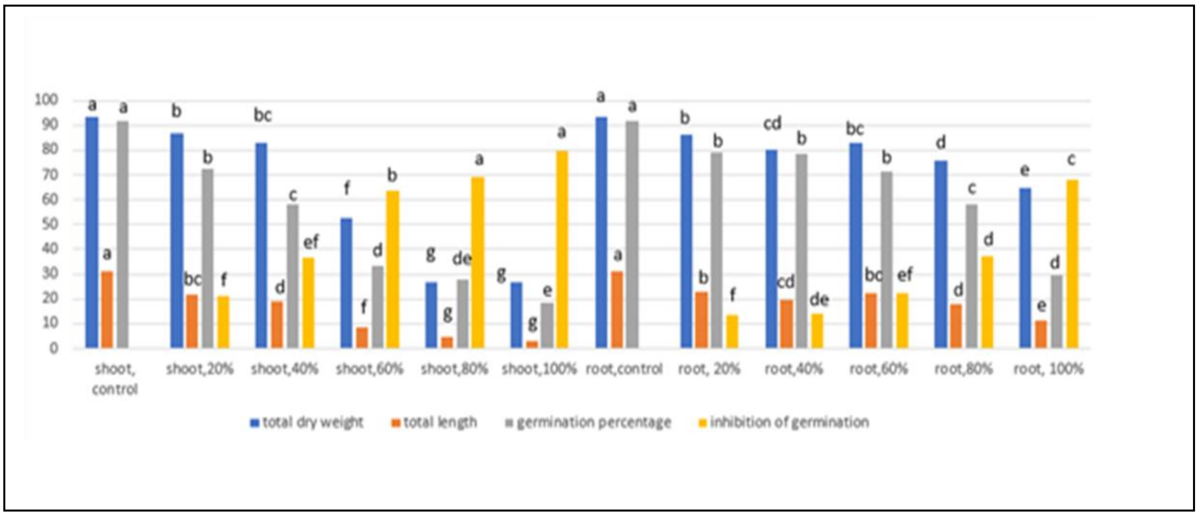


Figure (5): effect of different concentration levels of ***S. marianum*** shoot and root aqueous extracts on germination, growth characteristics and Allelopathy index of wheat.

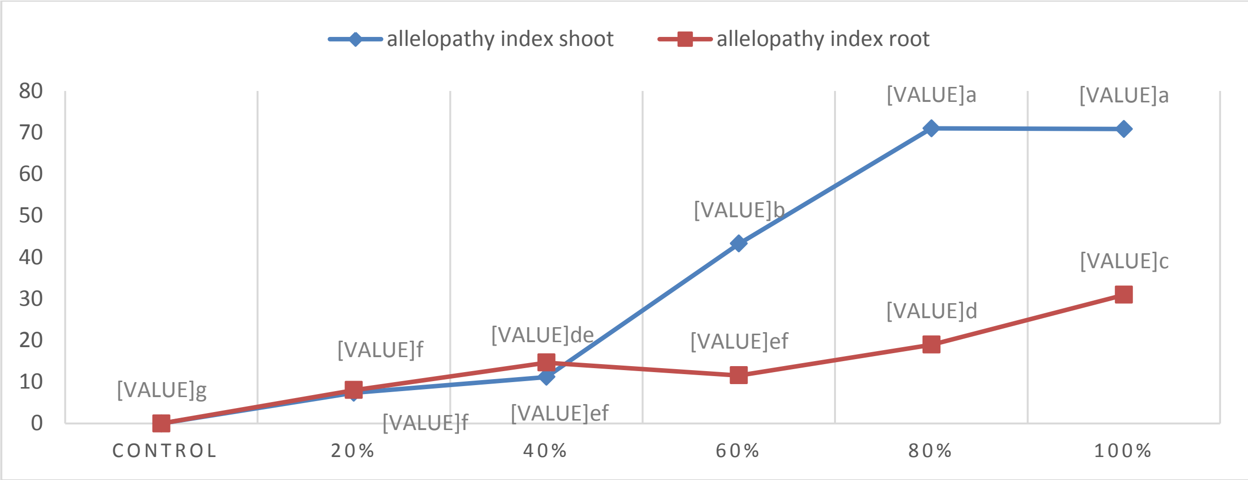
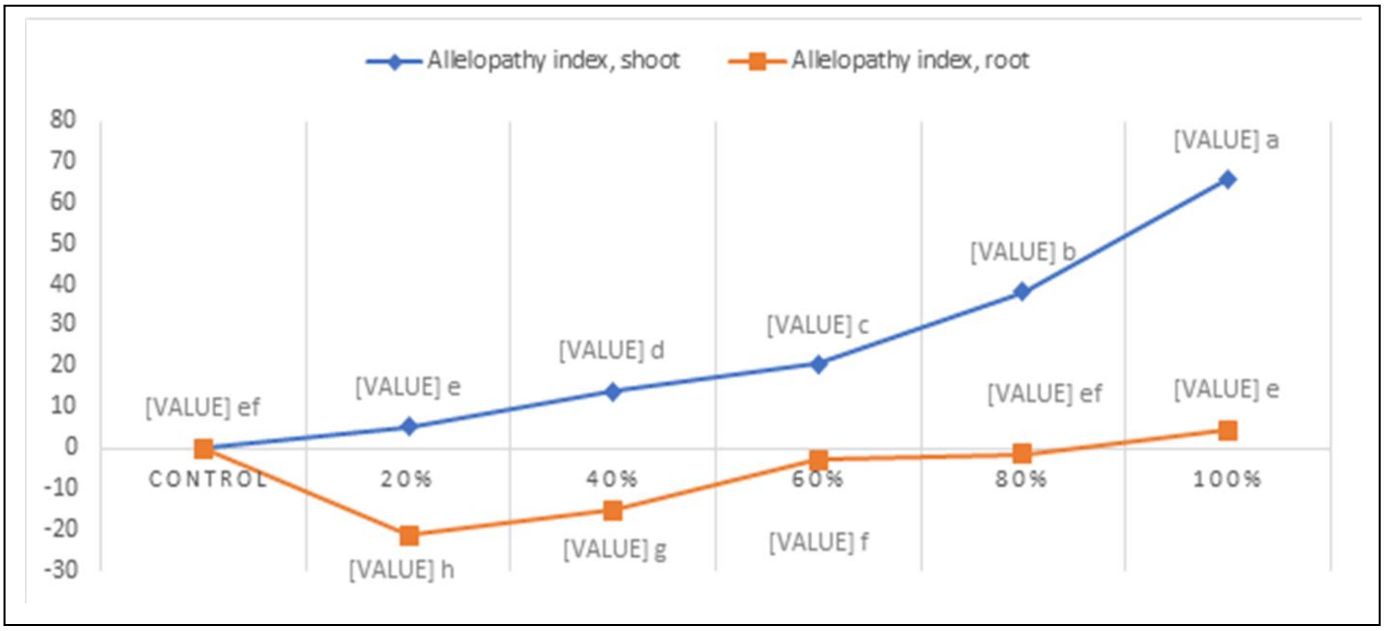


Figure 6: Allelopathy index according to **S. marianum** shoot and root aquous extract impact on bread wheat.

3.6 effect of the combination between *N. syriaca* plant part extracts and different concentrations on germination and growth parameters of bread wheat

The germination percentage, total dry weight, and total seedling length reduced in the high concentrations of ***N. syriaca*** shoot aqueous extract from (90%, 81.12 mg, 29.27 cm) to (15.33%, 26.82 mg, 4.04 cm) in 100% concentration and allelopathy index increased with the increase of extract concentration, while in case of root extracts allelopathy index decreased in lower concentrations, it means triggering growth parameters but in high concentrations of root extracts the inhibitory impact appeared (table 5). This indicates a significant allelopathic influence on the recorded parameters. Increasing extract concentration resulted in more significant germination inhibition and elevated allelopathy index. In lower concentrations, ***N. syriaca*** root aqueous extract promotes the aforementioned parameters. Nevertheless, in larger doses, it can suppress germination percentage, allelopathy index, and other parameters (figure 7). (Chon, 2010., Zohaib, 2016) already mentioned our outcome.



Figure(7): Allelopathy index according to ***N. syriaca*** shoot and root different concentration level aquous extract on bread wheat.

Table 5: The impact of ***N. syriaca*** shoot and root aqueous extract in different concentration levels on germination, growth characteristics and Allelopathy index of bread wheat.

Parameters& Plant parts, concentrations	germination percentage (%)	inhibition of germination (%)	Total seedling length (cm)	total dry weight (mg)	allelopathy index (%)
shoot, control	90 [a]	0 [g]	29.27 [ab]	81.12 [b]	0 [ef]
shoot,20%	76.67 [b]	14.72 [f]	18.93 [de]	76.87 [bcd]	5.25 [e]
shoot,40%	50 [e]	44.27 [c]	16.13 [e]	72.8 [d]	14 [d]
shoot,60%	30 [f]	66.69 [b]	12.81 [f]	63.85 [e]	20.53 [c]
shoot,80%	27.33 [f]	69.73 [b]	8.96 [g]	48.63 [f]	38.28 [b]
shoot,100%	15.33 [g]	83.54 [a]	4.04 [h]	26.82 [g]	65.86 [a]
Root, control	89.33 [a]	0 [g]	29.67 [ab]	79.25 [bc]	0 [ef]
root, 20%	85.33 [a]	4.28 [g]	31.07 [a]	95.97 [a]	-21.43 [h]
root,40%	74.67 [bc]	16.11 [ef]	27.11 [b]	91.1 [a]	-15.28 [g]
root,60%	67.33 [cd]	24.31 [de]	22.68 [c]	81.35 [b]	-3.03 [f]
root,80%	62.67 [d]	29.65 [d]	19.92 [cd]	79.37 [bc]	-1.4 [ef]
root, 100%	45.33 [e]	49.1 [c]	19.21 [de]	74.87 [cd]	4.4 [e]

3.7 effect of the combination between *N. syriaca* plant part extracts and different concentrations on germination and growth parameters of bread wheat

As shown in (table 6), ***S. marianum*** shoot and aqueous root extract impose an allelopathic effect on barley. The control treatment had the highest germination percentage, total dry weight, and total seedling length (96%, 94.67 mg, 30.81 cm) respectively, but the 100% concentration had the minimum values (2%, 1.58 mg, and 0.3 cm). Also, the allelopathy index raised with extract concentrations (figure 8). There may be two causes for the slightly diminished effects of ***S. marianum*** root aqueous extract on all parameters. First, the position of the shoot section in a free environment susceptible to photosynthesis and chemical accumulation, and the positioning of the root section under the earth. Second, given that fruit growth results from the transmission of nutrients and dietary energy from the shoot, it may also be connected to the functions and metabolite-related cell specializations of both shoot and root cells. (Ubazi et al., 2020, Ali, 2021).

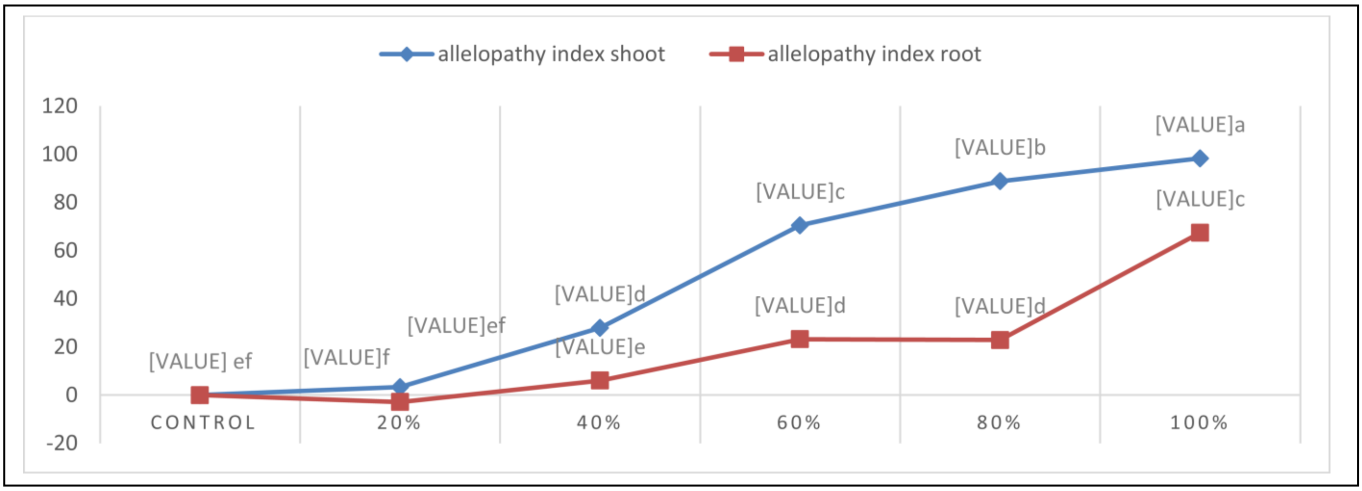


Figure 8: Allelopathy index according to **S. marianum** shoot and root aquous extract impact on barley

Table 6: Effect of ***S. marianum*** shoot and root different concentration aqueous extract on germination, growth characteristics and Allelopathy index of barley.

Parameters& plant parts, concentrations	germination percentage (%)	inhibition of germination (%)	total length (cm)	total dry weight (mg)	allelopathy index (%)
shoot, 0%	96 a	0 g	30.81 a	94.67 ab	0 ef
shoot,20%	90 ab	6.28 g	23.97 c	91.57 ab	3.36 ef
shoot,40%	49.33 e	48.19 cd	16.43 e	68.48 c	27.93 d
shoot,60%	39.33 f	58.51 bc	5.53 f	27.73 d	70.49 c
shoot,80%	9.33 g	70.13 b	0.81 g	10.47 e	88.84 b
shoot,100%	2 g	97.92 a	0.3 g	1.58 f	98.3 a
root, 0%	96 a	0 g	30.81 a	94.48 ab	0 ef
root, 20%	81.33 b	15.62 fg	27.8 b	97.23 a	-2.83 f
root,40%	61.33 d	35.71 de	23.72 c	88.8 b	6.03 e
root,60%	71.33 c	25.21 ef	19.53 d	72.43 c	23.21 d
root,80%	58.67 d	38.51 de	18.78 d	72.93 c	22.91 d
root, 100%	37.33 f	60.62 bc	6.42 f	30.45 d	67.45 c

3.8 Effect of the combination between *N. syriaca* plant part extracts and different concentrations on germination and growth parameters of barley

N. syriaca's shoot and aqueous root extracts significantly reduced the germination percentage, total dry weight, and seedling length of barley, which reduced from (91.33%, 92.05mg, and 34.61cm) respectively in the control treatment to (19.33%, 41.9mg, and 10.69cm) at 100% concentration due to the shoot aqueous extract and the root aqueous extract of such a plant had an inhibitory effect, causing the parameters to decline from (88.67%, 91.9mg, 33.29cm) to (50.67%, 64.8mg, 22.54cm) in highest concentration (figure.9). Additionally, when extract concentrations in shoot and root aqueous extract increased, germination inhibition and the allelopathy index rose (figure 10). These findings are similar to previous results, which showed that ***C. papaya*** extract significantly decreased the development and germination of ***Lactuca sativa*** seedlings (Wabo, 2011). According to other research, tiny amounts of secondary chemicals may promote development, However, excessive concentrations must have detrimental effects (Pelinganga, 2012)

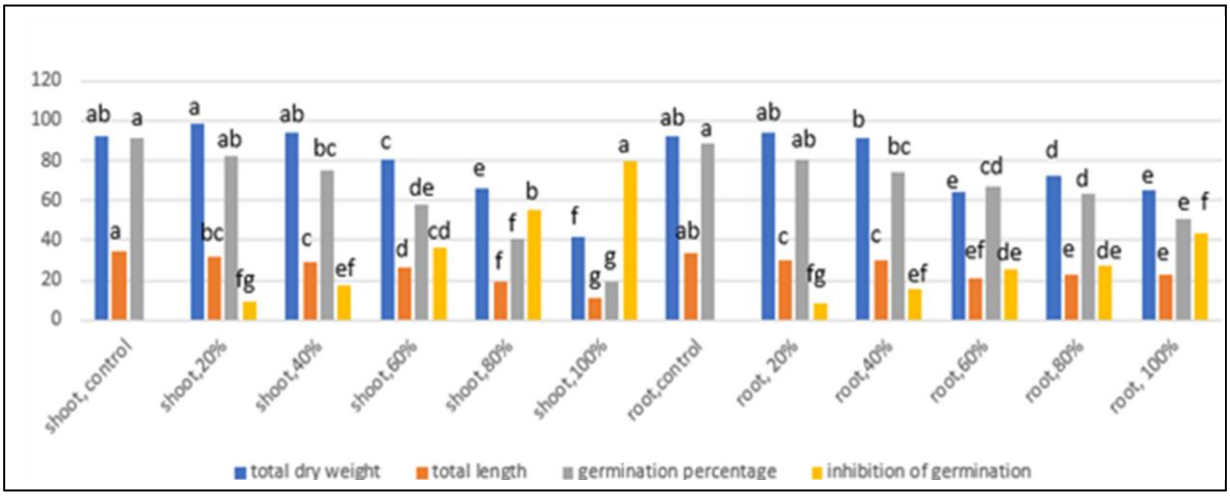


Figure (9): Effect of different concentration levels of **N. syriaca** shoot and root aquous extract on germination, growth characteristic and Allelopathy index of barley

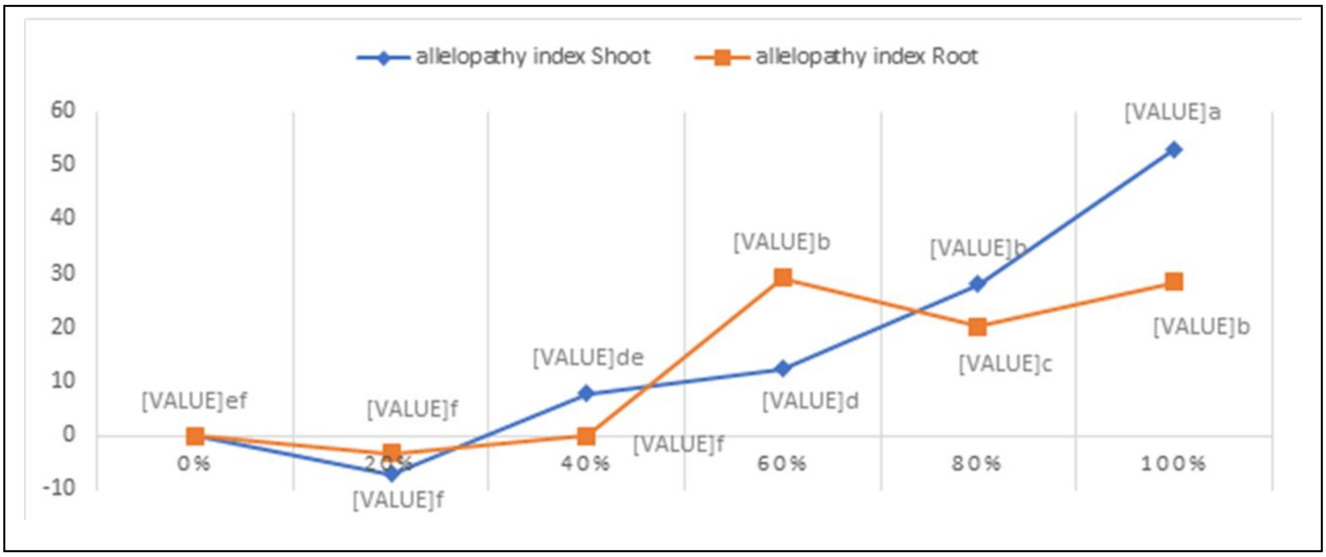


Figure 10: Allelopathy index according to diffrtrnt concentration levels of ***N. syriaca*** shoot and root aquous extract impact on barley

4. Allelochemical identification

Certain metabolic pathways are involved in creating various types of secondary metabolites. The acetate route is where a variety of inhibitors that were derived from amino acids and the shikimic acid pathway were used to create the majority of chemicals that induce allelopathy from amino acids. (Chon and Nelson, 2010, Waseem and Badruzzaman, 2018, Krumsri et al., 2020). The primary location for the creation of various regulatory substances, such as secondary metabolites, and inhibitory and stimulatory biochemicals, is still thought to be the leaves, according to the physiological activities of different plant sections (Taiz and Zeiger, 2006., Lambers et al., 2008). The allelochemicals composition of ***N. syriaca*** and ***S. marianum*** root and shoot extracts and the retention time of identified compounds are summarized (Table 7). Different compounds were identified in root and shoot ethanolic extracts of both plants. Some allelochemicals were commonly identified in both parts of these two plants such as (benzene, ethane,1,1-diethoxy, ethylbenzene, p-xylene benzene,1,3-dimethyl, 2-butoxy-ethanol, benzene,1-ethyl-3-methyl, benzene,1-ethyl-2-methyl, benzene,1,2,4-trimethyl, mesitylene, n-hexadecanoic acid, oleic acid, 9-octadecanoic acid, 6-octadecenoic acid) most of them are benzene and benzene derivatives and some of them are organic acids, according to (Liu et al., 2009, Elqahtani et al., 2017) organic acid, benzene and benzene derivatives have a strong allelopathic impact.

5. Discussion

The allelopathic effects of the plants' aqueous extracts reduced wheat and barley seed germination and other growth parameters. Each plant's shoot aqueous extracts imposed a higher allelopathic effect than its root sections because the shoot component contains more allelochemicals due to the position of the shoot section in a free environment where it is susceptible to photosynthesis and chemical accumulation (Ubazi et al., 2020). The allelopathic effect was concentration-dependent, meaning that at larger concentrations, seed germination and other growth parameters can be inhibited, but at lower concentrations, the inhibition rate is lowered and growth parameters are occasionally stimulated (AYEB, 2013).

6. Conclusion:

The results of this study demonstrated that the application of shoot and root extract from ***S. marianum*** and ***N. syriaca*** reduced several growth parameters and seed germination due to numerous active allelochemicals that serve as biochemical herbicides. On all examined parameters, increasing the concentration of ***S. marianum*** and ***N. syriaca*** water extract had a substantial impact. Higher concentrations such as 80 and 100% of the aqueous extracts from the shoot and root of ***S. marianum*** and ***N. syriaca*** caused the greatest reduction in germination. Our findings could make it easier to create particular bioherbicides for integrated weed management in climate-smart agriculture.

Table (7): secondary metabolites from ethanolic extract of ***S. marianum*** and ***N. syriaca*** root and shoot.

Compounds	Retention time	N. syriaca shoot	N. syriaca root	S. marianum shoot	S. marianum root
Benzene	5.339	√	√	√	√
1,3benzenediol,2methyl	5.339	o	o	o	√
acetone, ethylemethyl acetal	6.116	√	o	√	o
silane, ethyle trimethyl	6.116	√	o	√	o
ethane, 1,1-diethoxy	6.391	√	√	√	√
acetone, diethyl acetal	7.253	√	o	√	o
propane,2,2-diethoxy	7.253	√	o	√	o
acetic acid,2-methyl-propyl ester	7.431	o	√	o	√
isobutyl acetate	7.431	o	√	o	√
Ethylbenzene	10.334	√	√	√	√
Xylene	10.683	√	√	√	√
p-xylene	10.683	√	√	√	√
benzene,1,3-dimethyl	10.683	√	√	√	√
o-xyline	11.58	o	o	o	√
2-butoxy-ethanol	11.94	√	√	√	√
benzene, propyl	14.146	o	√	√	√
benzene,1-ethyl-3-methyl	14.478	√	√	√	√
benzene,1-ethyl-2-methyl	14.478	√	√	√	√
unidentifiedC3benzene	14.478	√	√	o	o
benzene,1,2,4-trimethyl	14.478	√	√	√	√
Mesitylene	14.478	√	√	√	√
9,12,15-octadecatrioneic acid	45.723	o	√	o	o
bicyclo [4.3.1] dec-1(9)-ene	45.723	o	√	o	o
9,12,15-octadecatrien-1-ol	45.723	o	√	o	o
6-tetradecyne	51.793	o	√	o	o
3,4-octadiene,7-methyl	51.793	o	√	o	o
Neophytadiene	51.81	√	o	√	o
2-hexadecen-1-ol,3,7,11,15-tetramethyl	51.81	√	o	o	o
n-hexadecanoic acid	56.102	√	√	√	√
myristic acid	56.097	o	√	o	o
octadecanoic acid	57	√	o	√	√
tetradecanoic acid, ethyl ester	57	√	√	o	o
9-octadecenal	56.8	o	o	√	o
2-methyl-z, z-3,13 octadecadienol	56.8	o	o	√	o
heptadecanoic acid, ethyl ester	57.005	o	√	o	o
9-octadecenoeicacid,2,3 dihydroxypropyl ester	57.474	o	o	o	√
cyclohexanepropanoeic acid	57.474	o	o	o	√
cis-2,3-epoxycyclohexan-1-methanol	57.48	√	o	o	o
Sulforous acid, cyclohexylmethyl, heptadecyl ester	57.48	√	o	o	o
cyclohexane,1-(1,5-dimethylhexyl)-4-(4-methylpentyl)	57.48	√	o	o	o
2-bromocyclohexanone	57.485	o	o	√	o
cyclopentanecarboxylic acid,2,2 dimethylpropyl ester	57.485	o	o	√	o
3-butene-1,2-diol,1-(2-furanyl-2-methyl	57.485	o	o	√	o
oleic acid	59.091	√	√	√	√
thiosulfuric acid, s(2-aminoethyl) ester	59.091	√	o	o	√
benzyl (dideuterated) methyl ether	60.737	√	o	√	o
oxirane, tetradecyl	60.737	√	o	o	o
oxirane, decyl	60.737	√	o	o	o
octadecane,1-(ethenyloxy)	60.737	o	o	√	o
piperidinone, N-[4-bromo-n-butyl]	60.737	o	o	√	o
9-octadecanoic acid	61	√	√	√	√
6-octadecenoic acid	61	√	√	√	√
cis-vaccenic acid	61.646	√	o	o	o
1-ethoxy-r-1-phenyl-c-2-fluorobenzocycloheptane	62.355	√	o	o	o

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