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A Weed diversity and Comparative Allelopathic effects of Extracts of *Trianthema portulacastrum* L., *Portulaca oleracea* L. and *Boerhavia diffusa* L. on seed germination and seedling growth of *Hibiscus cannabinus* L.

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Abstract

This study examines the diversity of weeds and the allelopathic impact of selected weed extracts on the seed germination and seedling development of *Hibiscus cannabinus* L., a leafy vegetable from the Malvaceae family. Field observations were conducted from March to June 2023 in B. Thandrapadu, a village in Andhra Pradesh's Kurnool district. We identified 34 weed species belonging to 16 families with varied important value index (IVI). *Trianthema portulacastrum* exhibited the highest IVI at 27.11%, followed by *Portulaca oleracea* 15.59%, *Boerhavia diffusa* 15.54%, *Cynodon dactylon* 14.54% and *Parthenium hysterophorus* 14.52%. Allelopathy effect of aqueous extracts of the top three weeds at varying concentrations on seed germination and seedling performance of *H. cannabinus* was assessed. All three weed species demonstrated the strong allelopathic effect on seed germination and seedling growth at 100% concentration and the weakest at 25%. Comparatively, *T. portulacastrum* showed a more pronounced effect than the other two weed species. Therefore, environmentally sustainable and appropriate weed management strategies are necessary for the agricultural sector during the initial stages or prior to crop planting.

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Allelopathic effect;
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Important Value Index;
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Seedling Growth;
Weed Diversity.

Introduction

The complexity of weed diversity in agricultural environments has far-reaching consequences for crop productivity, ecological benefits and long-term farming methods. Research findings suggest a complex relationship between weed diversity and crop output, with both advantageous and detrimental effects observed. These outcomes are influenced by a range of variables, including the type of crop cultivated, environmental conditions, and agricultural management techniques.[1,2 &3]

Allelopathy is a biological phenomenon where organisms produce biochemical's, known as

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allelochemicals that influence the growth, survival, development, and reproduction of other organisms.[4] These allelochemicals, often secondary metabolites, can have both inhibitory and stimulatory effects on target organisms and play a significant role in plant interactions within various ecosystems, including natural communities and agricultural systems.[5&6] Allelopathy is a complex interaction with diverse ecological implications. It is a critical factor in plant community dynamics, agricultural management, and environmental sustainability. The dual nature of allelopathy, as both a beneficial and detrimental force, underscores the importance of understanding its mechanisms and effects to harness its potential in sustainable agriculture and ecosystem management. For effective management, it is important to monitor the weed species present, their growth patterns, and the timing of crop planting to mitigate any negative allelopathic effects.

This research aims to test the hypothesis one way ANOVA followed by Dunnett's test that certain weed species exhibit allelopathic effects that negatively impact the growth, yield, and health of economically important crops. Specifically, we propose that the chemical compounds released by these weeds inhibit seed germination, root development, and overall crop productivity, thereby affecting agricultural output.

Material & Methods

Study Area

B. Thandrapadu is a village in Kurnool Mandal of Kurnool district in Andhra Pradesh state. It is situated within the Rayalaseema region. The village is located 7 km south of the district headquarters, Kurnool (Figure 1).The local climate is characterized by a temperature of 29° C, wind speed of 16 mph (26 km/h), and 70% relative humidity in the month of august 2023. We studied a *Hibiscus cannabinus* L. crop grown by a local farmer in B. Thandrapadu village. From June to September 2023, we observed and recorded the weeds growing with the main crop. Other crop fields adjacent to the one selected for the study were cropped with *Capsicum annuum* (Chilli), *Citrus limon* (Lemon), *Gossypium hirsutum* (Cotton) and *Solanum melongena* (Brinjal) with red soil.

Weed Dominance

We used a quadrate method assessing weed communities. Quantitative data on the density, frequency and abundance of crop and weed plants were collected using randomly distributed standard quadrats of 1 X 1 m size. Relative density, Relative frequency, Relative abundance and Importance value index are calculated as per protocols.[7&8]

Allelopathic Effect

We tested the effect of the selected weed extracts on *H. cannabinus* of local variety. The weeds selected for the study is *Tranthema portulacstrum* (*Aizoaceae*), *Portulaca oleracea* (*Portulacaceae*) and *Boerhavia diffusa* (*Nyctaginaceae*). *H. cannabinus* is an annual or biennial herbaceous plant with a woody base. It grows up to 11.5 feet tall.

The seeds were initially cleaned by washing them in running tap water. Aqueous extracts of the weeds were then prepared by cutting the whole plant into small pieces and shade-drying them for several days. The dried plant material was ground into a powder form, which was utilized to create a stock solution. This solution was filtered through Whatman No.1 filter paper prior to use. The resulting pure aqueous extract served as the stock solution and is further diluted to concentrations of 25%, 50%, 75%, and 100% using distilled water. For the control group, three sets of 10 seeds each were soaked in distilled water and placed in petri dishes. The whole plant extracts were utilized as the stock solution, from which four different concentrations 25%, 50%, 75% and 100% were prepared using distilled water. Ten seeds were placed at equal spacing on filter paper in petri dishes and treated with the required amount of solution. The experiment was conducted with three replicates. The petri dishes were maintained at room temperature, and germination observed after 3-4 days. Seed germination is determined by the emergence of the radicle. The parameters selected for the present study are

Germination studies of *H. cannabinus*

Germination Percentage (GP) -The number of seeds germinated was counted daily and the germination percentage was calculated by using the formula.[9]

GP = Number of seeds Germinated / Total number of seeds used X 100

Vigour Index (VI)

Vigour Index was calculated by the formula.[10]

VI = Germination Percentage x Seedling length (cm)

Growth Index (GI) -Growth Index is calculated using the following formula.[11]

Growth Index = Growth in cm/day in presence of solution/Growth in cm/day in control

Radicle length -It was determined by considering the growth of seedling with different concentrations of leaf extracts.

Hypocotyl length -It was determined by considering the growth of seedling with different concentration of leaf extracts.

Morphological Studies

Leaf Area

Leaf area is calculated by taking the mean value of length of basal region, middle region and tip region of leaf.

Fresh Weight and Dry Weight

The germinated seeds were collected and their fresh weights were taken.

Statistical Analysis

All the data are expressed as mean ± SEM (*p ≤ 0.05 & **p ≤ 0.01). Compared with control group one way ANOVA followed by Dunnett's test.

Results

Weed Dominance

The highest IVI was observed in *T. portulacastrum* (IVI 27.11%) was the most dominant weed followed by *P. oleracea* (IVI 15.59%), *B. diffusa* (IVI 15.54%), *C. dactylon* (IVI 14.54%) and *P. hysterophorus* (IVI 14.52%). A total of 34 weed species belonging to 16 families were enumerated in the present study. *Martynia annua* (IVI 3.25%) was the least dominant weed species during the study period (Table1 & Figure 1). The family Poaceae exhibited the highest species richness (5), followed by Euphorbiaceae (4), Amaranthaceae (4) and Fabaceae (3).

Table: 1 List of weeds with their IVI (%)

S. No	Scientific Name of the weed	Family	IVI %
1	*Portulaca oleracea* L.	Portulaceae	15.59
2	*Trianthema portulacastrum* L.	Aizoaceae	27.11
3	*Parthenium hysterophorus* L.	Asteraceae	14.52
4	*Abutilon indicum* (L.) Sweet	Malvaceae	5.25
5	*Datura metel* L.	Solanaceae	7.33
6	*Crotalaria juncea* L.	Fabaceae	4.36
7	*Euphorbia heterophylla* L.	Euphorbiaceae	7.49
8	*Digera muricata* (L.) Mart.	Amaranthaceae	4.97
9	*Cassia uniflora* (Mill.) H.S.Irwin	Fabaceae	4.97
10	*Cleome viscosa* L.	Cleomeaceae	4.36
11	*Martynia annua* L.	Martyniaceae	3.25
12	*Phyllanthus maderaspatensis* L.	Phyllanthaceae	4.88
13	*Echinochloa colona* (L.) Link	Poaceae	13.04
14	*Boerhavia diffusa* L.	Nyctaginaceae	15.54
15	*Cynodon dactylon* (L.) Pers.	Poaceae	14.54
16	*Aclypha indica* L.	Euphorbiaceae	5.97
17	*Alternanthera tenella* (L.) Sm	Amaranthaceae	8.18
18	*Cyperus rotundus* L.	Cyperaceae	10.08
19	*Setaria viridis* L.	Poaceae	10.58
20	*Trichosanthes dioica Roxb*.	Cucurbitaceae	4.36
21	*Physalis angulata* L.	Solanaceae	6.28
22	*Corchorus capsularis* L.	Malvaceae	5.7

23	*Amaranthus retroflexus* L.	Amaranthaceae	7.08
24	*Amaranthus viridis* L.	Amaranthaceae	11.00
25	*Tephrosia purpurea* (L.) Pers	Fabaceae	5.57
26	*Dinera retroflexa* (vahl)Panz	Poaceae	10.59
27	*Erichloa distachya kunth*	Poaceae	6.58
28	*Euphorbia hirta* L.	Euphorbiaceae	8.18
29	*Euphorbia serpens kunth*	Euphorbiaceae	8.18
30	*Senna occidentalis* (L.) Link	Fabaceae	6.58
31	*Cyperus esculentus* L.	Cyperaceae	10.58
32	*Aristolochia bracteolata* Lam.	Aristolochiaceae	4.97
33	*Lantana camara*	Verbanaceae	4.07
34	*Tridax procumbens L.*	Asteraceae	5.57

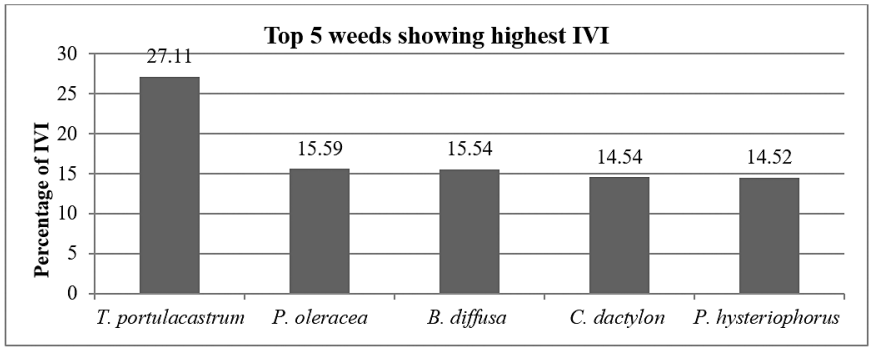

Fig. 1: Top 5 weed species showing highest IVI at study area

Table 2: Effect of weed extracts on Seed germination, Vigour and Growth Index of *H. cannabinus*

Con. of weed extracts	*T. portulacastrum*			*P. oleracea*			*B. diffusa*		
	GM (%)	VI (%)	GI (cm)	GM (%)	VI (%)	GI (cm)	GM (%)	VI (%)	GI (cm)
Control	100 ± 0.25	900 ± 0.46	-	100 ± 0.25	950 ± 0.46	-	100 ± 0.54	1200± 0.24	-
25%	93 ± 0.25	744 ± 0.70*	0.81 ± 0.25	90 ± 0.25	765 ± 0.66	0.83 ± 0.56	90± 0.70**	810 ± 0.25	0.75 ± 0.48
50%	80 ± 0.94*	640 ± 0.40	0.62 ± 0.25	83 ± 0.25	622 ± 0.24	0. 77± 0.29	63 ± 1.77	504 ± 0.25	0.66 ± 0.54
75%	56 ± 0.24	408 ± 0.40	0.53 ± 0.44	53 ± 0.50	312 ± 0.56	0.65 ± 0.44	53 ± 0. 25 ± 0.47	371± 0.25	0.33 ± 0.46*
100%	6 ± 0 .25*	80 ± 0.47*	0.37 ± 0.94*	20 ± 0.46	40 ± 0.25	0.44 ± 0.48	36 ± 0.25	216 ± 0.40	0.5 ± 0.52

Note - GM:Germination %, VI:Vigour Index, GI: Growth Index

Allelopathic Effect

Germination %

In the control, *H. cannabinus* seed germination was 100%, with a vigour index of 900% for *T. portulacastrum* and no growth index. When treated with 25%, 50%, 75% and 100% weed extracts, germination drops to 93-6%, vigour index to 744-80% and growth index to 0.81-0.37 cm. *P. oleracea* weed extract maintains 100% seed germination and a vigour index of 950%, with no growth index.

Treated seeds show germination percentages of 90-20%, vigour index of 765-40% and growth indices of 0.83-0.44 cm. *B. diffusa* weed extract results in 100% seed germination, a vigour index of 1200% and no growth index (Table 2).

Radicle Length & Hypocotyl Length

The radicle length of control group seeds measures 4.5 cm for *T. portulacastrum* and *B. diffusa*, and 5 cm for *P. oleracea*. *T. portulacastrum* extract reduces radicle lengths to 3.0, 2.6, 2.2, and 1.0 cm at 25%, 50%, 75%, and 100% concentrations, respectively. Seeds treated with *P. oleracea* and *B. diffusa* extracts show radicle lengths ranging from 5 to 1.1 cm across various concentrations. Seeds exposed to weed extract exhibit radicle lengths of 4, 2.5, 2.5, and 1.5 cm at the same concentrations. In the control group, all weed seeds have hypocotyl lengths between 9 and 12 cm. *T. portulacastrum* weed extract results in hypocotyl lengths of 8.0, 7.3, 6.5, and 4.0 cm at 25%, 50%, 75%, and 100% concentrations, respectively. *P. oleracea* weed extracts yield hypocotyl lengths of 8.5, 7.5, 5.9, and 2 cm at the corresponding concentrations. *B. diffusa* weed extract treatment results in hypocotyl lengths of 9, 8, 7, and 6 cm (Table 3).

Table: 3 Effect of weed extracts on Radical length and Hypocotyl length of *H. cannabinus*

Con. of weed extracts	*T. portulacastrum*		*P. oleracea*		*B. diffusa*	
	RI (cm)	HI (cm)	RI (cm)	HI (cm)	RI (cm)	HI (cm)
Control	4.5± 0.25	9± 0.44*	5± 0.44	9.5± 0.23	4.5± 1.95	12± 0.25
25%	3.0± 0.66	8± 0.24	4± 0.24	8.5± 0.28	4± 0.44	9± 0.57
50%	2.6± 0.25	7.3± 0.24	3± 0.26*	7.5± 0.56	2.5± 0.66	8± 0.55
75%	2.2± 0.54	6.5± 0.57	2.5± 0.44	5.9± 0.25	2.5± 0.24	7± 0.25
100%	1.0± 0.25	4.0± 0.66**	1.1± 0.25	2± 0.25	1.5± 0.99*	6± 0.25

Note - RI: Radical Length, HI: Hypocotyl Length

Number of leaves and Leaf Area

Seedlings in both the control group and those exposed to various concentrations of selected weed extracts consistently displayed two leaves. The leaf area of control seedlings ranged from 2.5 to 2.3 cm. In contrast, plants treated with weed extracts exhibited leaf areas between 2 and 0.5 cm, depending on the concentration (Table 4).

Table 4: Effect of weed extracts on no. of leaf and leaf area

Con. of weed extracts	Number of leaves and leaf area (cm)					
	T. portulacastrum		*P. oleracea*		*B. diffusa*	
	RI (cm)	HI (cm)	RI (cm)	HI (cm)	RI (cm)	HI (cm)
Control	4.5± 0.25	9± 0.44*	5± 0.44	9.5± 0.23	4.5± 1.95	12± 0.25
25%	3.0± 0.66	8± 0.24	4± 0.24	8.5± 0.28	4± 0.44	9± 0.57
50%	2.6± 0.25	7.3± 0.24	3± 0.26*	7.5± 0.56	2.5± 0.66	8± 0.55
75%	2.2± 0.54	6.5± 0.57	2.5± 0.44	5.9± 0.25	2.5± 0.24	7± 0.25
100%	1.0± 0.25	4.0± 0.66**	1.1± 0.25	2± 0.25	1.5± 0.99*	6± 0.25

Note - RI: Radical Length, HI: Hypocotyl Length

Morphological Studies

Height of the Plant

Control plants reached heights of 10 to 12 cm. Plants treated with selected weed extracts ranged from 3.5 to 9 cm in height across different concentrations. At 100% concentration, *P. oleracea* exhibited the most significant allelopathic effect, resulting in a plant height of 3.5 cm. *T. portulacastrum* and *B. diffusa* showed less pronounced effects, with heights of 4 cm and 5 cm respectively, indicating lower allelopathic impact compared to *P. oleracea* (Figure 2).

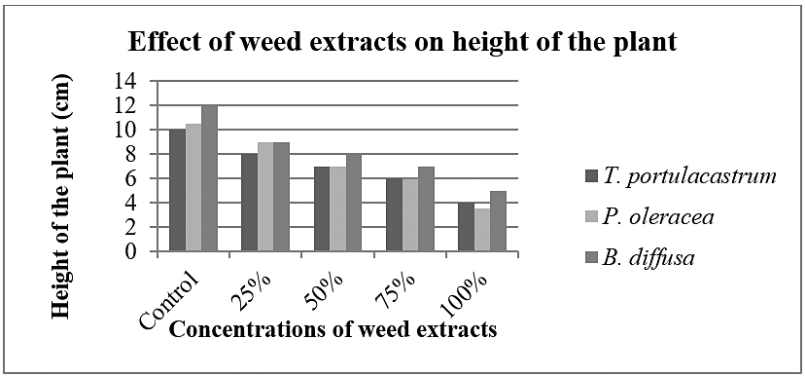

Fig. 2: Effect of weed extracts on height of the plant of *H. cannabinus*

Length of the Root

In the control group, seedling root length ranges from 7 to 9 cm. Seedlings treated with various weed extracts exhibit root lengths between 1.5 and 6 cm, depending on the concentration. At 100% concentration, *P. oleracea* produces the shortest roots (1.5 cm), followed by *T. portulacastrum* (2.0 cm) and *B. diffusa* (5 cm) (Figure 3).

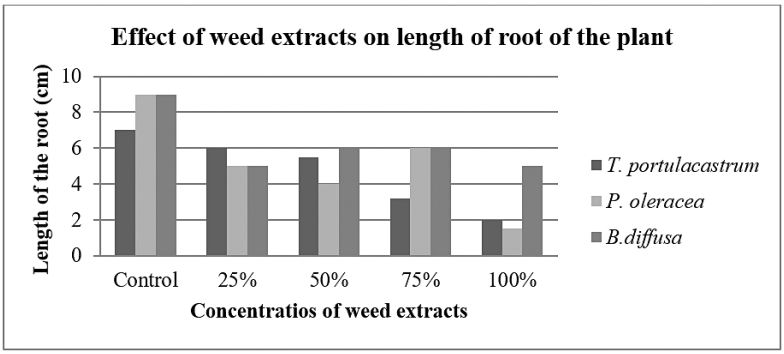

Fig. 3: Effect of weed extracts on length of the root of *H. cannabinus*

Fresh and Dry Weights

Control seedlings have fresh weights of 5.39 to 6.35 g and dry weights of 0.560 to 0.730 mg. Treated seedlings show fresh weights from 0.6 to 5.02 g and dry weights from 0.089 to 0.724 mg. At 100% concentration, *T. portulacastrum* demonstrates the strongest allelopathic effect with the lowest dry weight (0.089 mg), followed by *P. oleracea* (0.106 mg) and *B. diffusa* (0.239 mg). *T. portulacastrum* exhibits the most potent allelopathic impact on seed germination at 100% concentration, with diminishing effects at lower concentrations. *P. oleracea* follows a similar pattern, inhibiting *H. cannabinus* germination more effectively at higher concentrations. *B. diffusa* shows the weakest allelopathic effect at 100% concentration (Table 5).

Table 5: Effect of weed extracts of fresh and dry weights of *H. cannabinus*

Con. of weed extracts	Fresh and Dry weights (g)					
	T. portulacastrum		***P. oleracea***		***B. diffusa***	
	FW	**DW**	**FW**	**DW**	**FW**	**DW**
Control	5.39± 0.44	0.560± 0.36*	6.35± 0.25	0.600± 0.55	6.25± 0.25	0.730± 0.44
25%	5.02± 0.55	0.528± 0.25	4.67± 0.25	0.550± 0.22	5.150± 0.56**	0.724± 0.66
50%	4.8± 0.25	0.451± 0.25	4.44± 0.44	0.460± 0.28	4.931± 0.25	0.687± 0.66*
75%	3.7± 0.75	0.314± 0.46	2.68± 0.25	0.340± 0.25	3.377± 0.25*	0.411± 0.24
100%	0.6± 0.95	0.089± 0.56	0.83± 0.55	0.106± 0.66*	2.237± 0.25	0.239± 0.46

Note - FW: Fresh weight, DW: Dry weight

Discussion

The study of weeds in the crop field of *H. cannabinus* revealed that the number of weeds increases concurrently with the crop, and weed presence is common in any crop field. More than thirty weed species were identified in the *H. cannabinus* crop. Certain weed species occupied more space and were present in higher numbers. This study focused on weeds exhibiting high Importance Value Index (IVI) and occurring in greater numbers to examine their allelopathic effect on the crop. Three dominant weed species were selected for this study: *T. portulacastrum*, *P. oleracea* and *B. diffusa*. Treated seeds exhibit germination percentages of 90-36%, vigour index of 810-216% and growth indices of 0.75-0.5 cm. Among the extracts, *T. portulacastrum* shows the highest growth effect, followed by *P. oleracea* and *B. diffusa* at 100% concentration. *T. portulacastrum*-treated seeds at 100% concentration show the strongest allelopathic effect with a radicle length of 1.0 cm, compared to *P. oleracea* (1.1 cm) and *B. diffusa* (1.5 cm). At 100% concentration *P. oleracea* produces the shortest hypocotyl length (2 cm), followed by *T. portulacastrum* (4 cm), while *B. diffusa* exhibits the longest radicle length among the three weeds. At 100% concentration, *P. oleracea* demonstrated the strongest impact on leaf area (0.5 cm), while *T. portulacastrum* (1.0 cm) and *B. diffusa* (1.5 cm) showed less pronounced allelopathic effects compared to *P. oleracea*. Seedling growth is generally better at lower concentrations for all weed extracts, except at 100% concentration. Similar results were reported regarding the allelopathic effect of *Sorghum vulgare, Phaseolus vulgaris* and *Allium cepa* extracts on the germination and growth of *T. portulacastrum*; *Datura stromonium* extracts on *P. oleracea* expressed more allelopathic effect on seed and seedling growth of crop species.[12,13,&14]

Conclusion

A study on weed diversity in *H. cannabinus* fields in B. Thandrapadu village using the quadrate method identified 34 distinct weed species, with *T. portulacastrum*, *B. diffusa*, *P. oleracea*, *C. dactylon* and *D. retroflexa* being prevalent. Consequently, *T. portulacastrum*, *P. oleracea* and *B. diffusa* were selected for allelopathic research. Allelopathy involves organisms producing biochemicals that affect others' growth, survival, development, and reproduction. The study examined the allelopathic effects of *T. portulacastrum*, *P. oleracea*, and *B. diffusa*, which thrive in various habitats and disturbed areas. Results showed that weed extracts inhibit *H. cannabinus* seed germination at higher concentrations and cause delays at lower concentrations. Increased extract concentration led to decreased germination percentage, vigor index, growth index, and radicle and hypocotyl length. Weed extracts adversely affected seedling growth, reducing plant height and root length with increasing concentration while the number of seedling leaves remained constant. Fresh and dry weights also varied with concentration. *T. portulacastrum* had the strongest allelopathic effect on *H. cannabinus*, significantly impacting germination and seedling growth, whereas *B. diffusa* had the least effect.

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Conflict of Interest
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Data AvailabilityStatement
This statement does not apply to this article.

Ethics Statement
This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions
- **Bommana Kavitha:** Reviewed thoroughly the manuscript, offered valuable insights and suggestions to improve it.
- **Shaik Basha:** Conducted field study and prepared initial draft of manuscript.

References

1. Adeux G., Cordeau S., Bàrberi P., Vieren E., Carlesi S., Munier-Jolain N. Mitigating crop yield losses through weed diversity. *Nature Sustainability.* 2019; 2(11): 1018–1026.
2. Clements D. R., Swanton, C. J., Weise, S. F. Integrated weed management and weed species diversity. *Phytoprotection*. 2005; 75(1): 1–18.
3. Ferrero R., Gonzalez-Andujar J. L., Davis A. S., Lima M. Weed Diversity Affects Soybean and Maize Yield in a Long Term Experiment in Michigan, USA. *Frontiers in Plant Science*. 2017; 8: (236).
4. Cheng F., Cheng Z. Research Progress on the use of Plant Allelopathy in Agriculture and the Physiological and Ecological Mechanisms of Allelopathy. *Frontiers in Plant Science,* 2015; 17(6):1020.
5. Kumar N., Singh R., Giri K., Kumar A., Yadav S., Bisht S., Mishra G., Singh H., Khairakpam R., Kumari R., Joshi A., Jeena, N. Physiological and molecular insights into the allelopathic effects on agroecosystems under changing environmental conditions. *Physiology and Molecular Biology of Plants.* 2024; 30(3): 417–433.
6. Pavlović P., Mitrović M., Muscolo A., Sidari M. Non-trophic Interactions: Allelopathy 2014; (pp. 139–162). springernetherlands.
7. Curtis J.T. and Mcintosh, R.P., The interrelations of certain analytic and synthetic phytosociological characters. *Ecol*. 1950; 31: 434-455.
8. Odum E. P., *Fundamentals of ecology*, 3rd edition, Saunders, Philadelphla. 1971; 574 pp.
9. Linders T.E.W., Schaffner U., Eschen R., Abebe A., Choge S.K., Nigatu L., Mbaabu P.R., Shiferaw H., Allan E. Direct and indirect effects of invasive species: Biodiversity loss is a major mechanism by which an invasive tree affects ecosystem functioning. *J. Ecol.* 2019; 107: 2660–2672.
10. Bhattacharya A.K., Lahiri A.K., and Basu R.N. Improvement of germinability of Eucalyptus species by pre-germination treatments. *Indian Forester.* 1991; 117: 661–663.
11. Li J, Ye Y, Huang H, Dong L. Kaempferol-3-O-β-D-glucoside, a potential allelochemical isolated from Solidago Canadensis. *Allelopath J*. 2011; 28: 259–266.
12. Randhawa M. A., Cheema Z. A., & Ali M. A. Allelopathic effect of sorghum water extract on the germination and seedling growth of *Trianthema portulacastrum*. *International Journal of Agriculture and Biology.* 2002; 4(3): 383-384.
13. Rashidi S., Reza Yousefi A., Goicoechea N., Pouryousef M., Moradi P., Vitalini S., Iriti M. Allelopathic interactions between seeds of *Portulaca oleracea* L. and crop species. *Applied Sciences.* 2021; 11(8): 3539.
14. Yassen S.E., Mutwali E.M., Ismail W.H. Allelopathic effect of Datura stramonium on germination and some growth characters of purslane (*Portulaca oleracea* L.). *GSC Advanced Research and Reviews*. 2022; 10(1): 090-5.