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Allelopathic effect of two invasive weeds on growth performance of *Sorghum vulgare* Pers

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Abstract
The present study reveals allelopathic potential of aqueous leaf extracts of two invasive weeds *Euphorbia hirta* L. and *Parthenium hysterophorus* L. on seed germination, growth performance and protein content of jowar (*Sorghum vulgare* Pers.) seedlings. Laboratory experiments were conducted to check the allelopathic potential of aqueous extract of selected weeds on germination and seedling growth of jowar. Enfluence of aqueous extrats (25, 50, 75 and 100 % concentrations) of two weed plants were studied on seed germination, growth performance, biomass and protein content of jowar seedlings. The observations of experiments revealed a significant stimulatory allelopathic potential of both the weeds on root and shoot growth. Similar results were obtained in case of performed bioassays. Among all concentrations, 25 % concentration of both the weed extracts shows maximum stimulation in biomass and protein content in jowar seedlings.

Keywords: Allelopathy**,** *Euphorbia hirta* L, *Parthenium hysterophorus* L., Sorghum, aqueous extracts

Introduction
Plant physiologist, Hans Molish of University of Vienna, Austria defined allelopathy as effect(s) of one plant on other plants through the release of chemical compounds in the environment (Rice, 1984) [1]. Almost all allelochemicals are categorized as secondary metabolites of the plant (Kruse *et al*., 2000) [2] and depending on the concentration of the compounds, they have stimulatory and inhibitory effects on other plants (Bhowmik and Inderjit, 2003) [3]. The presence of allelochemicals has been reported throughout the plant body, however, their concentration varies from part to part. The synthesis of allelochemicals is broadly regulated by environmental factors as well as genetics at different growing stages (Yu *et al*., 2003) [4].

Plants release these allelochemicals in surrounding by four major methods which could be summarize as leaching, volatilization, decomposition and exudation. In leaching type, allelochemicals could be synthesized by dead or alive plant parts. In case of volatilization, terpenes components are released from the leaves of some plant species. Decomposition involves release of allelochemicals from dead plant residue while in exudation method, large amount of biocompounds release from roots of plants which may acts as an inhibitor for the growth of other plants (Gill *et al*., 1993) [5].

Sorghum is considered as one of the most important cereal crop and serves as a staple for millions of people living in the semi-arid and subtropical regions of Africa and Asia (Kumar *et al*, 2011) [6]. The crop is considered to be dual-purpose in agroecology, as the grains and stalks have significant consumption value for humans and cattles, respectively (Hariprasanna *et al*. 2016) [7]. Sorghum is also cultivated as a fuel crop (Bergtold *et al*., 2017) [8].

All crops have considerable amount of threat from weeds as they compete for light , water and nutrients (Rani *et al*., 2011) [9]. A great loss in the yields or complete crop failure caused due to severe uncontrolled weed infestations in Sorghum fields (Pannacci *et al*., 2010) [10]. For better yield of crop plants, use of chemical fertilizers, pesticides and weedicides has increased. Although, growing use of weedicides has improved agricultural profitability, but it also harms the earth's ecosystem (Raj *et al*. 2018) [11]. Several perilous effects in plant growth like stunted growth, foliar chlorosis, albinism and necrosis can be caused by usage of high volumes of herbicide (Rao and Madhulety, 2005) [12].

Aqueous weed extracts of many weeds has been reported to have stimulatory effects on growth various crop plants (Dhole *et al*. 2011 [13], Ghodake *et al*. 2012 [14]**,** Mali *et al*. 2014 [15]). Therefore, the objectives of the work is to use allelochemicals of weed as a biostimulants which can also support the theme of sustainable agriculture. The proposed study was plotted to investigate the allelopathic potential of two weed plants *E. hirta* L. and *P. hysterophorus* L. on germination and seedling growth characteristics of Sorghum.

Materials and Methods

A laboratory experiment was conducted under room temperature with three replications at Botany Department, Yashwantrao Chavan Institute of Science, Dist. Satara, Maharashtra, India. Healthy weeds *viz*. *E. hirta* L. and *P. hysterophorus* L. were collected from jowar fields in Satara. 10 g fresh leaves of these two weeds were homogenized in 10 ml distilled water. Then it was filtered through Whatman No. 1 filter paper. Using the filtrate, stock solution is prepared by making 100 ml final volume with distilled water. For treatment, 25, 50, 75 and 100 % concentration of stock solutions were prepared. Jowar seeds of uniform size were selected and were kept in sterile petri plates containing 25, 50, 75 and 100 % concentrations of weed extracts for 12 hours. Simultaneously control was made using distilled water. 12 hours treated 25 jowar seeds were kept in sterile petriplates [9 cm in diameter] over filter paper at room temperature. The filter paper was moistened with 10 ml distilled water and distilled water was provided to the seedlings uniformly, as and when required. The germination of seeds was observed upto 72 hours and root shoot length was measured upto 192 hours at an interval of 24 hours. After 192 h of germination, the biomass of seedlings was measured as well as germination seedlings were used to protein estimation by the method of Lowry *et al.* [16].

Results and Discussion

Alleopathic potential of aqueous extracts of *E. hirta* L. and *P. hysterophorus* L. on germination and seedling growth on of Jowar (*Sorghum vulgare* Pers.) are shown in Table 1. From the results, it is distinctly clear that the seed germination was stimulated in all concentrations of test weeds compared to control except 25 % concentration of *E. hitra* L. However, 75 % and 100 % concentration of extracts *E. hirta* L. showed 100 % germination in jowar. Similar to the observed data in this trial, Hanan. M. Abou El-Ghit (2016) [17] reported significant stimulation in the germination percentage of pea by treatment of aqueous extracts of concentrations of cucumber and carrot seeds. This was supported by findings of Mali and Kanade (2014) [15].

In case of root and shoot growth, 25 % extracts of both test weeds caused remarkable enhancement in jowar seedlings. The root growth was greatly stimulated by this treatment and 25 % concentration of both the weed extracts shows maximum root growth in jowar seedlings. Similar trend was observed in shoot develpoment in case of *E. hirta* L. while, 50 % and 100 % concentrations *P. hysterophorus* L. marked reduction in shoot development. However, promising shoot growth was perceived with 25 % and 75 % concentration of *P. hysterophorus* L. All the concentrations of *E. hirta* L. extracts indicated noteworthy stimulation in root and shoot length and maximum stimulation was found in 25% concentration (Table 1.). The results are similar to Ghodake *et al*., (2012) [14] who studied allelopathic effect of three *Euphorbia* species on seed germination and seedling growth of wheat and observed that extracts of various concentrations greatly stimulated root as well as shoot length.

Effect of *P. hysterophorus* L. on root growth of jowar indicated stimulatory effects with respect to concerned concentration of extracts while in case of shoot growth, 50 % and 100 % concentrations lower plumule lengths and 25 % and 75 % concentrations marked stimulation in shoot growth with maximum growth by 25 % treatment. Twenty five % extracts of both test weeds caused remarkable root, shoot growth and biomass enhancement, while other concentrations do not caused significant change in biomass of jowar seedlings. The 192h old jowar seedlings were used for protein estimation. Both weed extracts caused significant stimulation in protein content of jowar seedlings than control and maximum stimulation caused by 25% concentration (Figure 1).

On the other hand, Dessalegne Gella *et al*., (2013) [18] found highest reduction in wheat seed germiantion by treatment of aqueous extract of *P. hysterophorous* L. Similar trend was reported by Malatu *et al.*, (2009) [19] who found inhibitory effect of *P. hysterophorous* L. on seed germination and growth of lettuce. Many other workers also reported negative effect of allelopathic chemicals on seed germination and seedling growth. According to Fandah *et al.*, 2020 [20], treatment of aqueous extracts of different concentrations of the vegetative parts of *Euphorbia heterophylla* L. shows reduction in germination percentage of wheat and mustard and maximum inhibition was marked by 20% concentration, while the effect of 5% concentration was stimulatory in case of cucumber germination. Allelopathic potential of *Euphorbia helioscopia* Linn. was investigated by Tanveer *et al.*, 2010 [21] against wheat, chickpea and lentil. They reported that root, stem, leaf and fruit extracts triggered a decline in seedling vigour index, root and shoot length, root dry weight and total dry weight of wheat, chickpea and lentil seedlings. Parthasarathi *et al*., (2012) [22] marked significant reduction in germination and seedling growth of greengram, blackgram and groundnut by increase in concentration of *Parthenium* leaf extract. The inhibitory effect of extracts of different plants on seed germination and seedling growth of other plants is may be because of occurrence of growth inhibitors in the extract.

Allelochemicals released by plants can reforme interactions among organisms, community dynamics into the soil environment and also regulate the growth of plants in the soil (Meiners *et al*., 2017) [23]. Cellular structure, metabolism, photosynthesis, enzyme activity, nutrient absorption and hormonal regulation of target plant can be affected by allelochemicals (Rehman *et al*., 2019) [24]. The outcomes of this study revealed that *Euphorbia* and *Parthenium* weeds has allelopathic effect on sorghum as indicated by its stimulatory and inhibitory effect on germination rate and seedling growth with response to specific concentrations. The difference in the effect of the aqueous extracts is due to the physical and chemical properties of allelopathic compounds that are soluble in water, which affects adversely or positively in test plant.

Table 1: Effect of aqueous leaf extracts of *Euphorbia hirta* L. and *Parthenium hysterophorus* L. on seed germination, seedling growth, biomass and protein content of jowar

Time [after germination]	Plant species	Germination percentage				
		Treatments				
		Control	25 %	50 %	75 %	100 %
24 h	E	55	43	48	50	56
	P	47	56	53	49	46
48 h	E	86	79	89	90	86

	P	68	86	87	76	74
72 h	E	94	87	98	100	100
	P	88	94	100	94	97
Root length in cm (Mean + SD)						
48 h	E	1.76 ± 0.28	2.66 ± 0.44	2.0 ± 0.43	2.26 ± 0.42	2.0 ± 0.23
	P	1.81 ± 0.68	2.77 ± 0.51	2.32 ± 0.74	1.49 ± 0.52	1.95 ± 0.50
72 h	E	3.47 ± 0.22	4.93 ± 0.80	4.35± 0.32	4.70 ± 0.49	4.87 ± 0.38
	P	3.05 ± 0.85	4.65 ± 0.48	3.55 ± 0.95	3.42 ± 0.51	4.01 ± 0.55
96 h	E	4.55 ± 0.34	5.83 ± 0.55	4.66 ± 0.14	5.56 ± 0.55	5.74 ± 0.31
	P	3.78 ± 0.85	6.07 ± 0.91	3.69 ± 1.76	4.90 ± 0.81	5.06 ± 0.48
120 h	E	4.09 ± 0.18	6.85 ± 1.15	5.14 ± 0.81	5.57 ± 0.98	6.38 ± 0.12
	P	4.15 ± 0.67	6.25 ± 0.90	3.68 ± 1.65	4.66 ± 0.70	5.44 ± 0.68
144 h	E	4.32 ± 0.08	6.92 ± 0.92	5.40 ± 0.61	6.35 ± 0.80	6.79 ± 0.79
	P	4.07 ± 0.72	6.17 ± 0.90	3.96 ± 1.15	5.11 ± 0.84	5.51 ± 0.69
168 h	E	4.76 ± 0.40	7.12 ± 1.26	5.29 ± 1.02	6.47 ± 1.01	6.97 ± 0.82
	P	4.31 ± 1.13	6.26 ± 0.49	4.23 ± 1.79	5.56 ± 0.98	5.68 ± 0.80
192 h	E	4.88 ± 0.64	7.24 ± 1.63	5.87 ± 0.84	6.79 ± 1.39	6.87 ± 0.52
	P	4.77 ± 0.78	6.66 ± 0.04	5.01 ± 2.33	5.38 ± 1.49	5.89 ± 0.59
Shoot length in cm (Mean + SD)						
48 h	E	0.42 ± 0.36	0.96 ± 0.1	0.75 ± 0.35	0.83 ± 0.45	0.67 ± 0.16
	P	0.68 ± 0.10	0.93 ± 0.16	0.69 ± 0.36	0.70 ± 0.26	0.36 ± 0.16
72 h	E	2.48 ± 0.22	3.94 ± 0.41	3.11 ± 0.51	5.61 ± 3.17	3.16 ± 0.02
	P	2.52 ± 0.25	3.16 ± 0.57	2.57 ± 0.62	2.84 ± 0.42	2.22 ± 0.36
96 h	E	4.26 ± 0.81	5.66 ± 0.74	5.88 ± 0.96	6.04 ± 0.87	5.95 ± 1.28
	P	5.17 ± 0.63	5.85 ± 0.44	4.06 ± 1.66	4.68 ± 0.44	4.23 ± 1.30
120 h	E	5.89 ± 0.47	7.54 ± 1.02	7.09 ± 0.19	7.95 ± 0.73	7.04 ± 0.49
	P	6.42 ± 0.83	7.08 ± 0.37	4.26 ± 1.65	5.78 ± 0.72	5.66 ± 0.52
144 h	E	7.24 ± 0.89	9.04 ± 0.91	7.84 ± 1.73	8.72 ± 1.02	8.41 ± 0.90
	P	7.43 ± 0.90	8.16 ± 0.69	5.70 ± 1.70	7.24 ± 0.19	6.29 ± 0.71
168 h	E	8.49 ± 1.53	10.92 ± 0.97	9.43 ± 0.17	9.94 ± 1.10	9.49 ± 0.59
	P	8.88 ± 1.23	9.72 ± 1.38	6.87 ± 1.77	8.65 ± 0.29	7.55 ± 0.85
192 h	E	9.31 ± 1.58	12.26 ± 0.85	11.24 ± 0.45	11.92 ± 0.28	10.26 ± 0.15
	P	9.86 ± 0.78	10.51 ± 0.84	7.74 ± 1.87	10.53 ± 0.23	8.97 ± 0.84
Biomass [g]						
192 h	E	0.907	1.075	0.981	0.984	1.011
	P	0.933	1.223	0.789	1.074	0.807
Protein content [mg/g]						
192 h	E	32	50.3	35.1	40	38.7
	P	23	37	26.7	28.3	35

E: *Euphorbia hirta* L. **P**: *Parthenium hysterophorus* L.

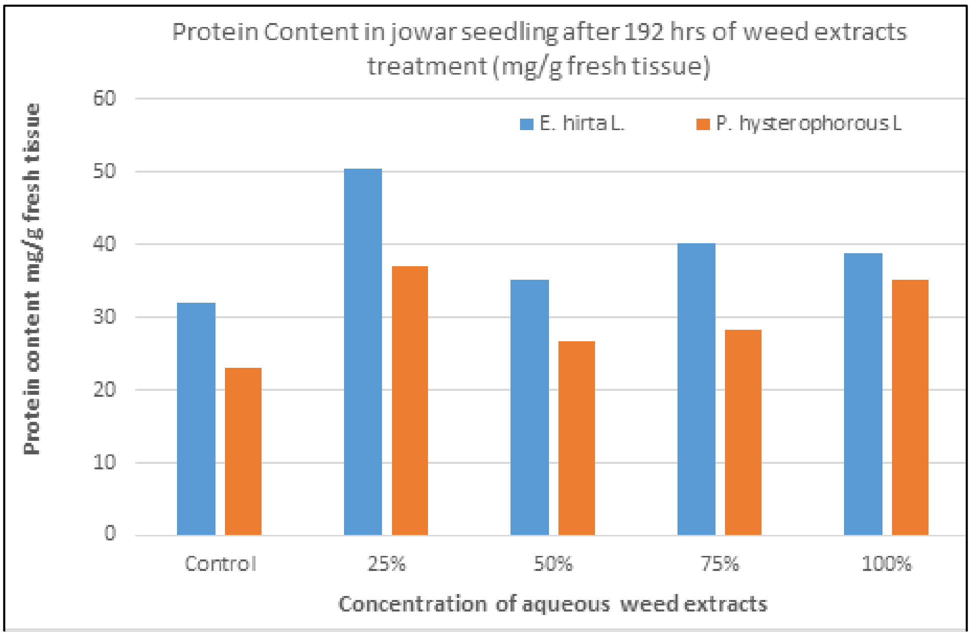

Fig 1: Effect of aqueous leaf extracts of *Euphorbia hirta* L. and *Parthenium hysterophorus* L. on protein content of jowar seedlings

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