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Phytochemical Screening and Assessment of Pesticidal Properties of Some Wild Herbaceous Plants from Bilaspur District of Chhattisgarh State

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ABSTRACT

Plant secondary metabolites emerged as the promising approach to control pests in crop fields towards sustainable agriculture. As the uncontrolled use of synthetic pesticides to control pests causes several side effects, the herbal-derived natural pesticide attracts the scientific communities to develop potent pesticides to replace commercial synthetic pest control agents. In line, the present research work was carried out to evaluate plant species viz., *Heliotropium indicum* L., *Portulaca oleracea* L., *Blumea lacera* L., *Physalis angulata* L., *Achyranthes aspera* L., and *Salvia plebeia* R. Br. were collected from Bilaspur district, for their pesticidal action against some bacteria and fungi including *Escherichia coli*, *Staphylococcus aureus*, *Aspergillus flavus*, and *Alternaria solani*. The result revealed that the maximum antibacterial action of 20.5 ±0.22 ZoI (in mm) against *E. coli* was observed with Methanol (100%) extract of *P. oleracea* L. whereas the maximum antifungal action of 17.2 ±0.18 ZoI (in mm) was accomplished with ethanol (100%) extract of *A. aspera* L. against *A. flavus*. The potent pesticides could potentially be used in sustainable agriculture practices to control pests and increase crop yield and certain pharmaceutical applications.

Keywords: Antifungal, Antibacterial, Sustainable Agriculture, Pharmaceutical Application.

INTRODUCTION

The worldwide expansion of population encouraged the extensive use of synthetic pesticides (SP) for the rapid and effective control of pests and diseases during agriculture practices (Lengai *et al.*, 2020). India was ranked in 3rd position in the Asian continent and 12th position internationally for the use of pesticides. The Food and Agriculture Organization, United Nations stated that India used around 58,160 tonnes of SP in 2018 (Piploda *et al.*, 2022). The SP is derived from the chemicals that are generally used to control pests (e.g., insects), weeds, and pathogenic microbes (i.e., bacteria and fungus). Commercially, SP are available as animal repellents, antimicrobials, fungicides, herbicides, insecticides, molluscicides, nematicides, and rodenticides (Duke, 2018). Although, the pesticides seem promising to increase crop yields, be affordable to use, able to produce high-quality food the use of SP at higher concentrations causes adverse effects on the ecosystem (Zacharia, 2011). The widespread and uncontrolled use of SP stimulates pesticide resistance biotic factors, contributes to soil pollution, leftover residual pesticides on food commodities, promotes biomagnification, induces bioaccumulation, and causes chronic toxicity to humans, and non-target organisms (Tudi *et al.*, 2021).

Plant-derived pesticides (or Botanical pesticides) are often sourced from plant extracts and their essential oils. Plant extracts have been prepared from barks, cloves (flower buds), flowers, fruits, leaves, roots, rhizomes, seeds, stems or whole plants (Lengai *et al.*, 2020). The Plant Secondary Metabolites (PSMs) are synthesized by plants during metabolism and that makes them competitive in their niche which mostly includes alkaloids, phenolics, saponins, terpenoids, and other bioactive substances (Chen *et al.,* 2022). These PSMs have been widely studied for their significant pharmaceutical and nutraceutical application in biological systems (Seca and Pinto, 2019). In contrast, the PSMs have also been reported for crop protection (Divekar *et al.,* 2022) e.g., PSMs against Herbivores (Khare *et al.,* 2020) and attract pollinators. Bhonwong *et al.* (2009) revealed that phenolics are toxins to herbivores by producing polyphenol oxidases (toxic metabolites) upon oxidation that arrest insect growth and development. Besides phenolics, alkaloids have also been divulged as toxic to herbivores by disrupting signal transduction, interfering with DNA replication, and interrupting enzyme activity (Züst and Agrawal, 2015). Terpenes have been reported for their defensive toxins and to deter herbivores (Ramírez-Gómez *et al.,* 2020).

A variety of solvents have been reported to extract bioactive phytochemicals. Koffi *et al.* (2010) revealed that ethanol and methanol were found to be effective in extracting phenolic contents. However, the effective extraction depends on the nature of the plant material, solvent, pH, temperature, and solvent-to-sample ratio (Abubakar and Haque, 2020). Polar solvents i.e., water, ethanol, and methanol are generally used to extract polar compounds (Altemimi *et al.*, 2017; Pandey and Tripathi, 2014). Further, water has been reported as the most polar solvent for the extraction of a variety of polar compounds due to its high polarity (Das *et al.*, 2010).

The PSMs have numerous advantages over SP that include effectiveness against a wide range of agricultural pests, cost-effective, biodegradable, eco-friendly, least toxicity, having several alternate mechanisms of action based on target cells, readily available in the ecosystem, often acting on target organisms and so forth (Verma *et al.*, 2023). The biologically active PSMs have been examined for different pests including bacteria, fungi, insects, nematodes, and virus-infected host plants (Lengai *et al.*, 2020). Therefore, the present course of investigation was done to evaluate the phytochemical examination and assessment of pesticidal Properties of some wild herbaceous plants collected from Bilaspur District of Chhattisgarh State.

MATERIALS AND METHODS

As per the objective of the present research work the phytochemical examination and assessment of pesticidal properties of some wild herbaceous plants were evaluated using qualitative and quantitative methods. The plant species viz., *Heliotropium indicum* L., *Portulaca oleracea* L., *Blumea lacera* L., *Physalis angulata* L., *Achyranthes aspera* L., and *Salvia plebeia* R. Br. were collected from Bilaspur district. The Voucher specimens were authenticated and deposited at the Department of Botany, Govt. E.R.R. P.G. Science College, Bilaspur (C.G.). A brief description of the samples is mentioned in Table 1.

The pesticidal action of selected wild herbaceous plants was evaluated against *Escherichia coli* (ATCC10536), *Staphylococcus aureus* (ATCC25923), *Aspergillus flavus* (ATCC 9643), and *Alternaria solani* (ATCC 6663).

Table 1: A brief description of the selected wild herbaceous plants

Sl. No.	Name of Plants	Local Name	Family	Brief Description	Part used	Photograph
1	***Heliotropium indicum* L.**	Hatisundha	Boraginaceae	Annual herb, erect, branched, hairy stem, alternating ovate to oblong-ovate leaves, small white or purple flowers with a green calyx, scorpioid cyme inflorescence.	Leaf and Stem	

2	***Portulaca oleracea* L.**	Nonia Bhaji	Portulacaceae	Annual herbs, stem erect or prostrate, branched, sometimes rooting at nodes, trichomes on nodes, Leaves simple, opposite, alternate and with trichomes, Inflorescence axillary	Whole Plant	
3	***Blumea lacera* L.**	Kukurmuta	Asteraceae	Erect, annual plant with branched stems, smells like turpentine, a whole plant is pubescent, ash grey coloured, leaves are alternate, ovate, sharply serrate, obtuse, base tapered. The flowers are bright yellow.	Whole Plant	
4	***Physalis angulata* L.**	Chirpoti	Solanaceae	Annual herbaceous plant, branched erect, angled and hollow stems, the flowers are borne on stalks, balloon-like calyx, the fruit is an orange-coloured round berry.	Leaf and Stem	
5	***Achyranthes aspera* L.**	Chirchira	Amaranthaceae	Perennial, erect herb. Leaves -Ramal and cauline, simple, exstipulate, opposite decussate, petiolate, ovate or obovate. Inflorescence - A spike with reflexed flowers arranged on long peduncle. Flowers - Bracteate, bracteolate.	Whole Plant	
6	***Salvia plebeia* R. Br.**	Bhui-tulsi	Lamiaceae	Annual or biennial herb. Inflorescences are 6-flowered verticillasters in racemes or panicles, with a distinctly small corolla that comes in a wide variety of colours: reddish, purplish, purple, blue-purple, to blue, rarely white.	Leaf and Stem	

Research Methodology

The extracts of selected herbaceous plants were prepared and evaluated for phytochemical content and pesticidal action in terms of antifungal and antibacterial assay. All the experiments were carried out in triplicates.

Preparation of plant extract

Methanol, ethanol, and aqueous (25%, 50%, 75%, and 100%) extract of *H. indicum* L. (Leaf and Stem), *P. oleracea* L. (Whole Plant), *B. lacera* L. (Whole Plant), *P. angulata* L. (Leaf and Stem), *A. aspera* L. (Whole Plant), and *S. plebeia* R. Br. (Leaf and Stem) were prepared as mentioned by Das *et al.* (2010). The dried samples were ground to make fine particles. The ground samples were mixed with solvents (Methanol, Ethanol, and Double distilled water) at a ratio of 10:1 (v/w) (Green, 2004) and left for 24 h. The solvent-soaked samples were then subjected to filtration using double-layer Whatman Filter Paper. The filtered samples were then centrifuged at 20,000 xg for 30 minutes to clarify the extract (Taylor *et al.*, 1996).

Test for Phytochemicals

The Phytochemicals viz., Alkaloids (Mayer’s test), Saponins (Frothing test), Terpenoids (Salkowski’s test), Steroids (Libermann Burchard’s test), Glycosides (Modified Bontrager’s test), Flavonoids (Shinoda’s test), Tannins (Gold Beater’s skin test) were qualitatively estimated using the method described by Pandey and Tripathi (2014), Auwal *et al.* (2014), and Beena *et al.* (2016).

Pesticidal Activities

It was determined by well agar diffusion bioassay (Toit and Rautenbach, 2000; Rojas *et al.*, 2006; Belewa *et al.,* 2011; Baskaran *et al.,* 2012; Gupta *et al.*, 2016) of different solvent extract of selected plants against pathogenic microorganism (Tembo *et al.,* 2018; Geraldin *et al.*, 2020).

Antifungal activity

The antifungal activity of plant extracts was screened and compared with standard Fungicides Mancozeb (1 ppm) and Carbendazim (1ppm) by well diffusion method (Toit and Rautenbach, 2000; Baskaran *et al.,* 2012). Lawn culture of *A. flavus* and *A. solani* was prepared in potato dextrose broth. The inoculated culture plates were kept aside for a few minutes. In those plates 3 wells were made using sterilized cork borer at the required distance, using sterilized micropipettes 20µL of different solvents with selected plant extracts were added into the well. The plates with fungi were incubated at room temperature for 48 hrs. The antifungal activity of the plant extracts was determined by measuring the diameters of the Zone of Inhibition (in mm.). For each fungal strain, the positive controls were Mancozeb (1 ppm) and Carbendazim (1 ppm) and maintained negative controls with pure solvents were used (Baskaran *et al.*, 2012).

Antibacterial activity

The antibacterial test was performed using agar well diffusion (Das *et al, 2010*). MH agar plates were punched using a sterile cork-borer (6.0 mm) and inoculated with test bacterial organisms (*E. coli* and *S. aureus*) at McFarland 0.5 turbidity standard). The punched 6.0 mm holes were filled with plant extracts as per the experimental design. The inoculated MH agar plates were incubated for 24 h at 37°C then observed for the ZoI (in mm). The positive controls were Gentamycin (10µg/ml) and Kanamycin (30µg/ml).

Data analysis

The observed data were tabulated and statistically analyzed using MS Excel 2021. The Standard deviation of quantitative experimental observations was calculated. The experimental observations were summarized using a graphical representation with error bars.

RESULTS AND DISCUSSION

Methanol, ethanol, and aqueous (25%, 50%, 75%, and 100%) extract of *H. indicum* L. (Leaf and Stem), *P. oleracea* L. (Whole Plant), *B. lacera* L. (Whole Plant), *P. angulata* L. (Leaf and Stem), *A. aspera* L. (Whole Plant), and *S. plebeia* R. Br. (Leaf and Stem) were evaluated for their pesticidal potency in terms of antibacterial and antifungal action. The secondary metabolite profile of selected plants is systematically brought up in Table 2.

Table 2: Secondary metabolite profile of selected Herbaceous Plants

Name of Herbaceous Plants	Extract	Alkaloids	Saponins	Terpenoids	Steroids	Glycosides	Flavonoids	Tannins
***Heliotropium indicum* L.**	Methanol	+	+	+	+	-	+	+
	Ethanol	+	+	+	-	-	-	-
	Aqueous	+	+	+	+	-	+	+
***Portulaca oleracea* L.**	Methanol	+	+	+	-	+	+	-
	Ethanol	+	-	+	-	+	+	-
	Aqueous	+	+	+	-	-	+	-
***Blumea lacera* L.**	Methanol	+	+	+	+	-	+	+
	Ethanol	-	+	-	+	-	+	+
	Aqueous	+	-	+	-	+	-	+
***Physalis angulata* L.**	Methanol	+	-	+	-	+	+	+
	Ethanol	-	-	+	-	+	+	-
	Aqueous	+	-	+	-	-	+	+
***Achyranthes aspera* L.**	Methanol	+	+	-	+	+	+	+
	Ethanol	+	-	+	+	+	+	+
	Aqueous	+	+	-	+	-	+	+
***Salvia plebeia* R. Br.**	Methanol	+	+	+	+	+	+	+
	Ethanol	+	+	-	+	-	+	-
	Aqueous	+	+	+	-	+	-	-

+:Present; -:Absent

The methanol (100%) extract of all selected plants was found to be effective against both bacterial and fungal strains. However, it was noted that the methanol (100%) extracts of selected plants exhibited effective action against fungal strains (Figure 3 and Figure 4). Methanol (100%) extract of *H. indicum* L., *P. oleracea* L., and *S. plebeia* R. Br. were indicated significant antibacterial action of 19.5 ±0.31, 20.5 ±0.22, 19.3 ±0.18 ZoI (in mm) against *E. coli* (Figure 1) whereas the methanol (100 %) extract of *P. oleracea* L. and *S. plebeia* R. Br. were remarkably shown 16.0 ±0.30 and 20.1 ±0.35 ZoI (in mm) against *S. aureus* (Figure 2).

Table 3: Antibacterial activities of different solvent extracts of some wild herbaceous plants

Plant Extracts & Standard antibiotics	Conc.	Zone of inhibition (mm.) (Mean ± SD)					
		E. coli ATCC10536			*Staphylococcus aureus* ATCC25923		
		Methanol	Ethanol	Hot Water	Methanol	Ethanol	Hot Water
Control	0%	00	00	00	00	00	00
***Heliotropium indicum* L.**	25%	9.5 ±0.17	7.6 ±0.11	4.2 ±0.25	6.4 ±0.17	4.8 ±0.13	4.0 ±0.26
	50%	14.2 ±0.38	13.1±0.44	7.5 ±0.30	8.9 ±0.21	7.2 ±0.41	6.3 ±0.17
	75%	16.6 ±0.25	15.3 ±0.28	10.4 ±0.42	11.7 ±0.27	10.1 ±0.18	9.1 ±0.42
	100%	19.5 ±0.31	18.0 ±0.52	12.1 ±0.34	13.0 ±0.15	12.5 ±0.25	11.0 ±0.20
***Portulaca oleracea* L.**	25%	9.3 ±0.37	8.6 ±0.16	5.2 ±0.22	7.1 ±0.32	7.2 ±0.13	3.5 ±0.13
	50%	14.4 ±0.22	12.1 ±0.25	8.4 ±0.31	11.6 ±0.42	9.0 ±0.27	5.4 ±0.18
	75%	16.8 ±0.30	16.0 ±0.17	12.3 ±0.28	14.2 ±0.38	11.8 ±0.36	7.1 ±0.25
	100%	20.5 ±0.22	19.5 ±0.43	15.3 ±0.21	16.0 ±0.30	14.5 ±0.23	10.3 ±0.46
***Blumea lacera* L.**	25%	10.7 ±0.31	9.8 ±0.45	4.0 ±0.26	5.2 ±0.22	6.3 ±0.18	3.8 ±0.11
	50%	13.3 ±0.26	13.0 ±0.21	6.5 ±0.41	8.1 ±0.26	9.6 ±0.13	5.1 ±0.27
	75%	14.5 ±0.38	15.3 ±0.18	8.8 ±0.28	11.7 ±0.44	12.8 ±0.38	7.6 ±0.13
	100%	16.7 ±0.42	17.9 ±0.36	11.3 ±0.24	13.4 ±0.27	14.3 ±0.19	9.3 ±0.11
***Physalis angulata* L.**	25%	8.1 ±0.35	4.9 ±0.13	3.4 ±0.15	6.7 ±0.20	4.6 ±0.13	3.1 ±0.18
	50%	11.6 ±0.16	8.7 ±0.24	5.9 ±0.35	9.2 ±0.17	7.7 ±0.25	5.0 ±0.41
	75%	14.9 ±0.25	11.3 ±0.18	8.5 ±0.27	12.0 ±0.38	10.1 ±0.42	6.2 ±0.30
	100%	16.5 ±0.18	14.4 ±0.29	10.7 ±0.18	14.6 ±0.24	13.1 ±0.32	8.0 ±0.23
***Achyranthes aspera* L.**	25%	4.1 ±0.20	5.5 ±0.35	3.8 ±0.14	3.8 ±0.18	4.6 ±0.27	4.5 ±0.15
	50%	6.9 ±0.29	7.6 ±0.18	4.5 ±0.20	5.9 ±0.26	7.0 ±0.17	5.8 ±0.18
	75%	9.5 ±0.41	10.3 ±0.39	5.3 ±0.12	8.2 ±0.42	9.4 ±0.26	7.5 ±0.26
	100%	12.1 ±0.26	13.6 ±0.20	8.1 ±0.18	10.2 ±0.21	11.6 ±0.12	9.6 ±0.17
***Salvia plebeia* R. Br.**	25%	10.1 ±0.19	9.2 ±0.17	4.4 ±0.15	11.6 ±0.38	10.4 ±0.18	5.9 ±0.13
	50%	13.3 ±0.14	12.6 ±0.37	6.1 ±0.22	14.1±0.25	13.2 ±0.41	8.3 ±0.25
	75%	17.5 ±0.21	15.0 ±0.24	8.7 ±0.37	17.4 ±0.13	16.8 ±0.30	11.2 ±0.43
	100%	19.3 ±0.18	17.2 ±0.47	11.6 ±0.21	20.1 ±0.35	19.2 ±0.28	13.3 ±0.23
Gentamycin	10µg / ml	23.6 ±0.51			25.3 ±0.32		
Kanamycin	30µg / ml	26.5 ±0.29			24.1 ±0.36		

Heliotropium indicum L., *Portulaca oleracea* L., *Blumea lacera* L., *Physalis angulata* L., *Achyranthes aspera* L., *Salvia plebeia* R. Br. exhibited maximum antibacterial activitiy of 19.5 ±0.31 (100 % methanol), 20.5 ±0.22 (100 % methanol), 17.9 ±0.36 (100% ethanol), 16.5 ±0.18 (100 % methanol), 13.6 ±0.20 (100% ethanol), 19.3 ±0.18 (100 % methanol) against *E. coli* ATCC10536 while comperatively little low against *Staphylococcus aureus* ATCC25923 (Table 3).

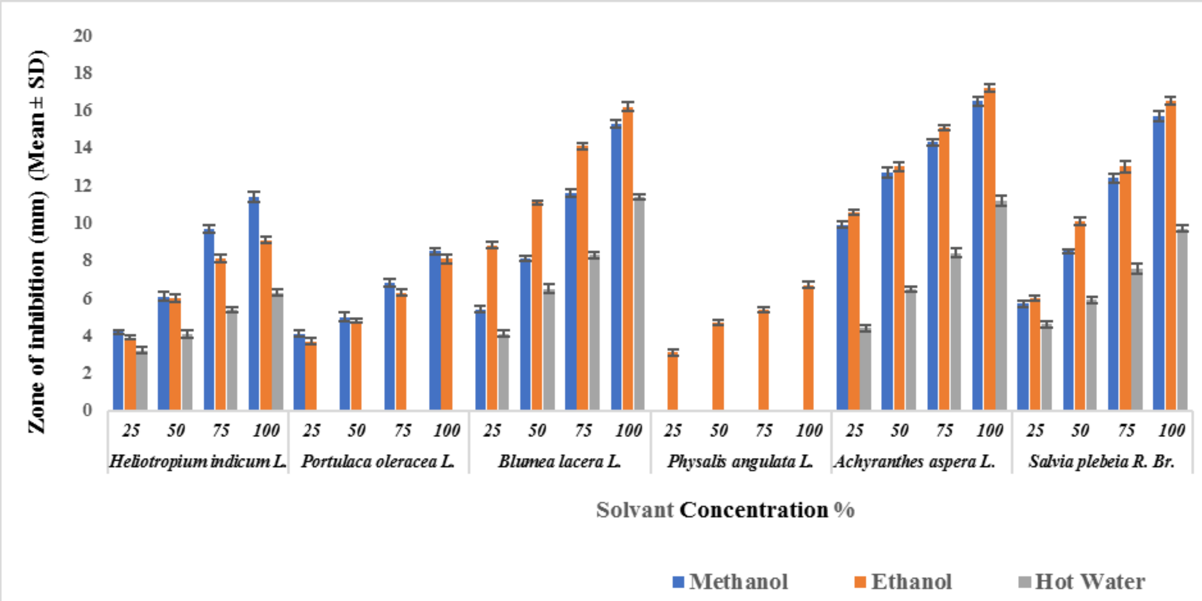

Figure 1. Antibacterial activities of different solvent extracts of some wild herbaceous plants against *E. coli* (ATCC10536)

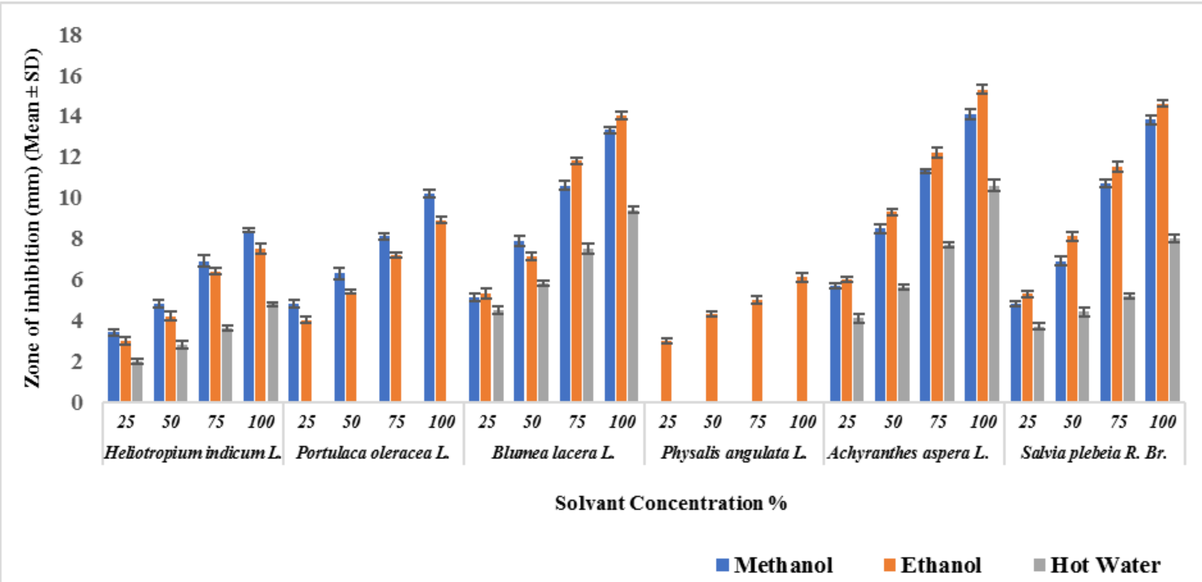

Figure 2. Antibacterial activities of different solvent extracts of some wild herbaceous plants against *Staphylococcus aureus* (ATCC25923)

Table 4: Antifungal activities of different solvent extracts of some wild herbaceous plants

Plant Extracts & Standard Fungicides	Conc.	Zone of Inhibition (mm)					
		Aspergillus flavus ATCC 9643			*Alternaria solani* ATCC 6663		
		Methanol	Ethanol	Hot Water	Methanol	Ethanol	Hot Water
Control	0%	00	00	00	00	00	00
***Heliotropium indicum* L.**	25%	4.2 ±0.12	3.9 ±0.10	3.2 ±0.17	3.4 ±0.13	3.0 ±0.19	2.0 ±0.11
	50%	6.1 ±0.24	6.0 ±0.18	4.1 ±0.21	4.8 ±0.18	4.2 ±0.21	2.8 ±0.18
	75%	9.7 ±0.20	8.1 ±0.21	5.4 ±0.12	6.9 ±0.26	6.4 ±0.15	3.6 ±0.13
	100%	11.4 ±0.26	9.1 ±0.15	6.3 ±0.18	8.4 ±0.11	7.5 ±0.27	4.8 ±0.10
***Portulaca oleracea* L.**	25%	4.1 ±0.17	3.7 ±0.18	NI	4.8 ±0.19	4.0 ±0.16	NI
	50%	5.0 ±0.24	4.8 ±0.11	NI	6.3 ±0.28	5.4 ±0.11	NI
	75%	6.8 ±0.19	6.3 ±0.16	NI	8.1 ±0.13	7.2 ±0.14	NI
	100%	8.5 ±0.16	8.1 ±0.25	NI	10.2 ±0.21	8.9 ±0.17	NI
***Blumea lacera* L.**	25%	5.4 ±0.17	8.8 ±0.17	4.1 ±0.17	5.1 ±0.18	5.3 ±0.25	4.5 ±0.20
	50%	8.1 ±0.13	11.1 ±0.10	6.5 ±0.23	7.9 ±0.25	7.1 ±0.19	5.8 ±0.13
	75%	11.6 ±0.19	14.1 ±0.15	8.3 ±0.16	10.6 ±0.22	11.8 ±0.15	7.5 ±0.24
	100%	15.3 ±0.20	16.2 ±0.24	11.4 ±0.11	13.3 ±0.17	14.0 ±0.20	9.4 ±0.14
***Physalis angulata* L.**	25%	NI	3.1±0.17	NI	NI	3.0 ±0.11	NI
	50%	NI	4.7 ±0.11	NI	NI	4.3 ±0.15	NI
	75%	NI	5.4 ±0.12	NI	NI	5.0 ±0.19	NI
	100%	NI	6.7 ±0.18	NI	NI	6.1 ±0.21	NI
***Achyranthes aspera* L.**	25%	9.9 ±0.17	10.6 ±0.14	4.4 ±0.19	5.7 ±0.14	6.0 ±0.11	4.1 ±0.21
	50%	12.7 ±0.28	13.0 ±0.22	6.5 ±0.13	8.5 ±0.22	9.3 ±0.15	5.6 ±0.12
	75%	14.3 ±0.20	15.1 ±0.13	8.4 ±0.23	11.3 ±0.10	12.2 ±0.26	7.7 ±0.14
	100%	16.5 ±0.25	17.2 ±0.18	11.2 ±0.28	14.1 ±0.24	15.3 ±0.22	10.6 ±0.28
***Salvia plebeia* R. Br.**	25%	5.7 ±0.18	6.0 ±0.15	4.6 ±0.16	4.8 ±0.14	5.3 ±0.16	3.7 ±0.15
	50%	8.5 ±0.12	10.1 ±0.21	5.9 ±0.19	6.9 ±0.23	8.1 ±0.20	4.4 ±0.21
	75%	12.4 ±0.25	13.0 ±0.29	7.6 ±0.27	10.7 ±0.17	11.5 ±0.25	5.2 ±0.13
	100%	15.7 ±0.28	16.5 ±0.20	9.7 ±0.17	13.8 ±0.22	14.6 ±0.17	8.0 ±0.19
Mancozeb	1 ppm	20.8 ±0.24			18.9 ±0.21		
Carbendazim	1 ppm	18.2 ±0.27			16.5 ±0.25		

NI: No Inhibition

Heliotropium indicum L., *Portulaca oleracea* L., *Blumea lacera* L., *Physalis angulata* L., *Achyranthes aspera* L., *Salvia plebeia* R. Br. exhibited maximum antibacterial activitiy of 11.4 ±0.26 (100 % methanol), 8.5 ±0.16 (100 % methanol), 16.2 ±0.24 (100% ethanol), 6.7 ±0.18 (100 % ethanol), 17.2 ±0.18 (100% ethanol), 16.5 ±0.20 (100 % ethanol) against *Aspergillus flavus* ATCC 9643 while comperatively little low against *Staphylococcus aureus* ATCC 6663 (Table 4).

The result revealed that the vital antibacterial action of 20.5 ±0.22 ZoI (in mm) against *E. coli* was observed with Methanol (100%) extract of *P. oleracea* L. Similatly, Al-Quwaie *et al.* (2023) observed that the methanolic extract of *Portulaca oleracea* L. was significantly active against *B. subtilis*, *E. coli*, *K. pneumoniae,* and *L. monocytogenes.*

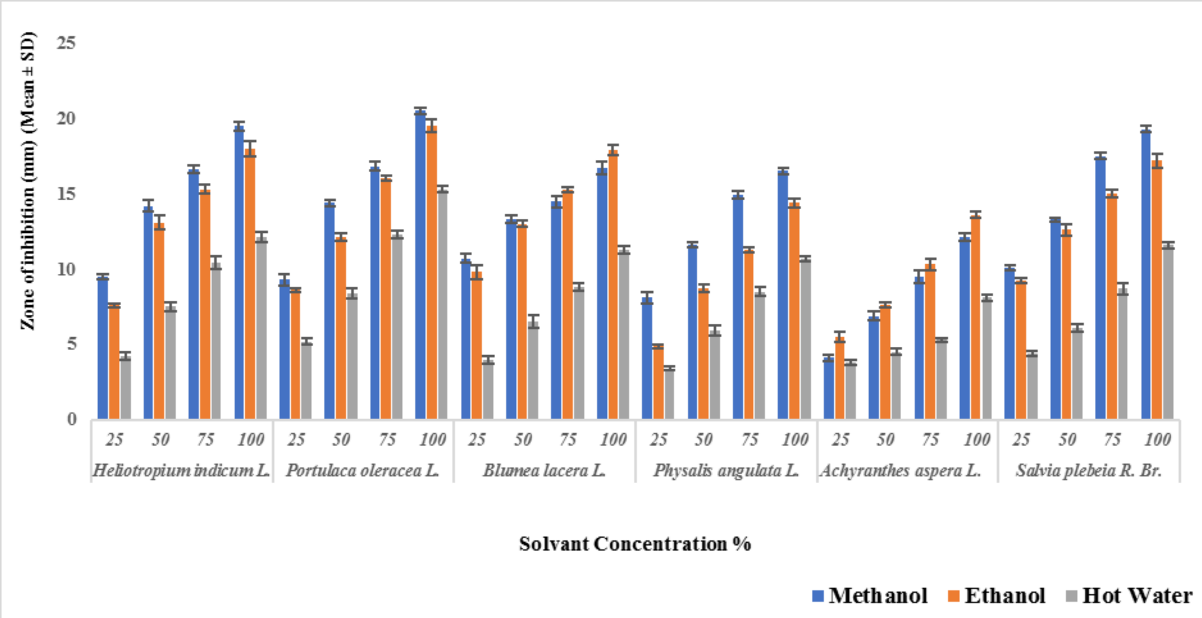

Figure 3. Antifungal activities of different solvent extracts of some wild herbaceous plants against *Aspergillus flavus* (ATCC 9643)

Ethanol (100%) extract of *B. lacera* L. and *A. aspera* L. expressed noteworthy antifungal action of 16.2 ±0.24 and 17.2 ±0.18 ZoI (in mm) against *A. flavus* (Figure 3) while Ethanol (100%) extract of *B. lacera* L., *A. aspera* L., and *S. plebeia* R. Br. gave significant antifungal potency of 14.0 ±0.20, 15.3 ±0.22, and 14.6 ±0.17 ZoI (in mm) against *A. solani* (Figure 4). Further, the maximum antifungal action of 17.2 ±0.18 ZoI (in mm) was accomplished with ethanol (100%) extract *A. aspera* L. against *A. flavus* . Sharma *et al.* (2011) noted maximum antifungal activity of 17.5 mm against *A. flavus* at 1000µg ml^{-1} concentration. Zalavadiya *et al.* (2013) reported the antifungal action of *A. aspera* L. against *A. flavus* (MTCC 418).

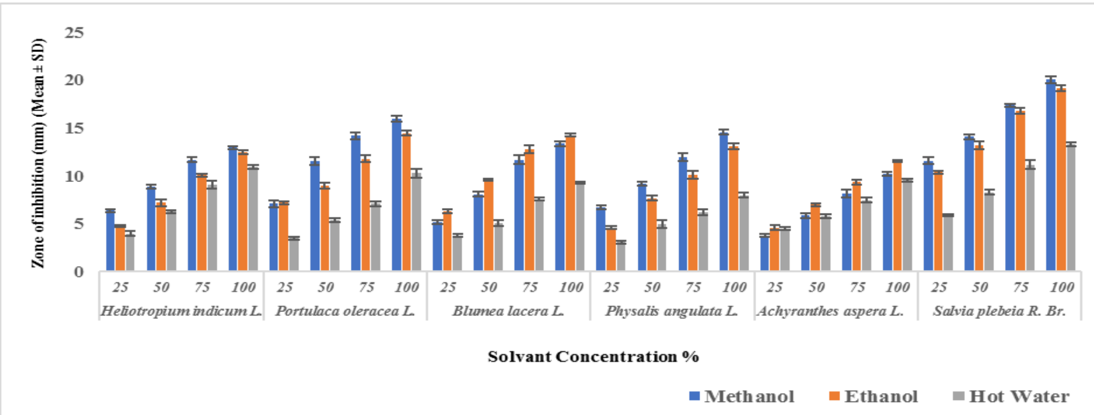

Figure 4. Antifungal activities of different solvent extracts of some wild herbaceous plants against *Alternaria solani* (ATCC 6663)

Khursheed and Jain (2021) revealed the antibacterial, antifungal, and antioxidant efficacy of *P. oleracea* L. solvent (aqueous, acetone, ethanolic, hexane, and methanolic) extracts. The results showed that *P. oleracea* has rich phytochemicals including alkaloids, anthraquinones, flavonoids, phenols, saponins, steroids, tannins, and terpenoids. The acetone extract of *P. oleracea* L. exhibited a maximum total flavonoids content of 21.75 ±0.21 mg/L while the ethanolic extract of *P. oleracea* L. showed a maximum phenolic content of 31.97 ±0.32) mg/L dry matter. Moreover, they stated that the ethanolic extract of *P. oleracea* has indicated the minimum inhibition concentration of 0.14, 0.05, 0.07, 0.62, and 0.73 mg/ml against *S. aereus*, *E. coli*, *Micrococcus luteus*, *Fusarium oxysporum*, and *A. flavus*, correspondingly. However the present study revealed that the 100% methanolic extract of *P. oleracea* was potent for antibacterial and antifungal action.

Islam *et al.* (2008) have conveyed that the maximum ZoI of 23.0 mm was noted against gram-positive *B. subtilis* with leaf extract of *B. lacera*. Nevertheless, 100% methanolic extract of *Salvia plebeia* R. Br. leaf and stem exhibited maximum antibacterial efficacy of 20.1 ±0.35 ZoI (in mm) against gram-positive *Staphylococcus aureus* and 100% methanolic extract of *B. lacera* L showed maximum antifungal potency. Moreover, Buckton *et al.* (1999) and Sarkar *et al.* (2021) reported that plant diseases, for instance, verruca vulgaris, and warts (plantar, flat, and genital) could be effectively treated by *B. lacera* extract.

CONCLUSION

Agricultural croplands and associated ecosystems including water bodies and numerous food chains, are adversely exaggerated by using uncontrolled and long-term pesticides for pests e.g., bacteria, fungi, insects, and weeds. The Green Revolution in the agriculture field encouraged farmers to utilize synthetic pesticides to control pests resulting in healthy crops and higher yields in developing countries. Abrupt use of such agrochemicals undouble increases the productivity in the agriculture sector but simultaneously seeds harmful pesticides in the ecosystem for biomagnification which results in decreased soil health, contaminated water bodies, development of resistant microbiome and microbiome, triggers genetic variation in crops, the introduction of toxic residues food chain, and cause health issues in vertebrates (i.e., human and animals). Thus, pesticide from natural resources has the potential to combat pests and to protect the ecosystem from harmful synthetic pesticides. The prospects of further work include the purification and characterization of bioactive agents with pesticidal properties. These pesticides could also be used to control bacterial and fungal infections in the healthcare sector to protect against a variety of microbial diseases. Some studies also support the blending of biofertilizers with biopesticides for sustainable pest control and to increase crop yield.

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