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Allelopathic effect of common weeds on germination and seedling growth of rice in wetland paddy fields of Mizoram, India

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Abstract: Weed invasion of crops contested for environmental resources alongside releasing a certain chemical into the soil and thereby lowering yield potential. The possible allelopathic influence of aqueous extract from leaves and shoots of *Alternanthera philoxeroides* (Mart.) Griseb., *Ludwigia octovalvis* (Jacq.) P.H. Raven and *Persicaria hydropiper* (L.) Delarbe on germination and seedling growth of rice (*Oryza sativa* L.) was investigated in this study. To prepare the extract, powdered air-dried leaves and shoots of certain weeds were soaked in distilled water (1:10) for 24 h at room temperature, and a different dilution was made from the stock. Aqueous extracts from various plant parts were found to suppress seed germination and the development of rice seedlings. As the extract concentration increases, the intensity of inhibition on germination, shoot length, root length and dry matter reduction increases. The average percent inhibition (API) of leaf extract treatments, namely 8% and 10% *A. philoxeroides*, 8% and 10% *L. octovalvis*, and 10% *P. hydropiper*, was found to be greater than 45%. Shoot extracts containing 2% *A. philoxeroides*, 2% and 4% *L. octovalvis*, and 2% *P. hydropiper* have less than 15% average percent inhibition. According to the findings, different weeds contain allelochemicals of variable types and quantities, and different portions of the same weed have distinct effects on germination and rice seedling development.

Keywords: final germination percentage; inhibitory effect; mean germination time; phytotoxin

Weeds are an unavoidable and constant threat to agricultural productivity. Weeds and agricultural crops are both plants, and their growth and development require similar conditions. Weeds stifle crop growth by competing for nutrients, moisture, light, space and air, as well as releasing secondary metabolites into the environment (Zimdahl 2007, Riaz et al. 2009). Weeds have been a persistent challenge for farmers since the beginning of agriculture, inflicting financial losses by reducing crop yields and raising the cost of agricultural products (Abouziena and Haggag 2016).

Allelopathy refers to the inhibitory effects of one plant on another caused by the release of chemical compounds into the environment. Weeds have an impact on agricultural plants by producing phytotoxins found in their seeds, as well as decomposing residues, leachates, exudates and volatiles (Veenapani 2004, Trezzi et al. 2016). The allelopathic effect of weed on a crop can be determined by the latter's reduced germination and growth. It causes a series of morphological, physiological, biochemical and molecular changes that have a negative impact on plant growth and productivity. Most weed species have an inhibitory effect on crops; however, some weed species have stimulatory effects (Kadioglu et al. 2005).

The complicated process of allelopathic suppression by weeds involves interactions between several kinds of chemicals, including flavonoids, alkaloids, steroids, terpenoids, phenolic compounds and amino acids. Since the majority of these substances contain phytotoxic properties, they generally have an adverse effect on crop plants' ability to germinate and thrive (Aziz et al. 2008). Allelopathic interactions are most likely the result of a mixture of different compounds rather than a single substance (Veronneau et al. 1997). Cell membranes are organelles that are primarily vulnerable to the impacts of the stress factor.

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They are in charge of maintaining the stability and integrity of all cell structures (Matuszak-Slamani and Mila 2017).

Alternanthera philoxeroides (Mart.) Griseb., *Ludwigia octovalvis* (Jacq.) P.H. Raven and *Persicaria hydropiper* (L.) Delarbe are invasive aquatic weeds that pose a significant threat to agrobiodiversity in several countries around the world and are found primarily in Mizoram paddy fields. These weeds may have an impact on the growth of nearby plants in either a positive or negative way. Weeds react to various fertilisers under different tillage techniques, depending on the rate and application method (Blackshaw and Brandt 2008). Information about the allelopathic effects of water extracts of different parts of *Alternanthera philoxeroides* (Mart.) Griseb., *Ludwigia octovalvis* (Jacq.) P.H. Raven and *Persicaria hydropiper* (L.) Delarbe on the germination and seedling growth of rice seeds are scarcely available. As a result, the allelopathic effects of the aforementioned weeds' shoot and leaf extracts on the germination and development of *Oryza sativa* were investigated in the laboratory.

MATERIAL AND METHOD

Preparation of plant extract

The plant's samples of three common weed species, viz. *Alternanthera philoxeroides* (Mart.) Griseb, *Ludwigia octovalvis* (Jacq.) P.H. Raven and *Persicaria hydropiper* (L.) Delarbe were collected from the paddy fields of Buhchangphai, Kolasib district of Mizoram, and the paddy fields of Champhai, Champhai district of Mizoram. The samples were thoroughly cleaned, cut into small pieces with scissors and air-dried at room temperature for a month. The leaves and shoots of the samples were separated and ground into a fine powder. 100 g of powdered plant material were also taken by a digital electronic weighing machine and suspended in 1 000 mL of distilled water. A rotary shaker was then used to mix it for 24 h at room temperature to produce a uniform extract. The extracts were filtered through the Whatman No. 1 filter paper, and the filtrates obtained were considered to be 10% aqueous extract (*w*/*v*).

Experimental treatment

The fresh plant extract was prepared for various dilutions from the stock solution, including 2, 4, 6, 8 and 10% (*w*/*v*). The seeds of a local rice cultivar named Buhpui were obtained from the farmers. It was then surface-sterilised for 3 min with 1% sodium hypochlorite, washed twice with distilled water and stored for germination.

A series of laboratory experiments were carried out at the Research Laboratory, Department of Botany, Pachhunga University College, Mizoram, using the aqueous extracts of *Alternanthera philoxeroides* (Mart.) Griseb., *Ludwigia octovalvis* (Jacq.) P.H. Raven and *Persicaria hydropiper* (L.) Delarbe. Germination tests were performed in sterile Petri dishes lined with filter paper and sterile tissue paper. At room temperature, fifty (50) sterile seeds were planted in 15 cm Petri dishes. Daily, approximately 10 mL of different plant extracts were applied to each Petri dish of the respective treatment to keep the seeds moist enough for germination and growth. In the control treatment, only distilled water was used. In each set of treatments, three replicates with the same number of seeds were kept.

Data collection and analysis

Germination percentage. The germination percentages were calculated as the average of three replicates of 50 seeds. The germinated seeds were counted and recorded daily for up to ten days. The final count was performed after 10 days, and the final germination percentage was calculated using the following formula (Ellis and Robert 1981):

$$\text{FGP (\%)} = \text{number of final germinated seed/total number seed tested} \times 100$$

Mean germination time and T_{50}. The mean germination time (MGT) was calculated as a measure of the speed of germination or emergence after Ellis and Roberts (1981):

$$\text{MGT} = \sum(Dn)/\sum n$$

where: n – number of seeds germinated on day D; D – number of days counted from the start of germination.

The time taken to 50% germination (T_{50}) was calculated according to the formula described by Coolbear et al. (1984) as modified by Farooq et al. (2004):

$$T_{50} = t_i + (N/2 - n_i)\,(t_j - t_i)/(n_j - n_i)$$

where: N – total number of germinated seeds; n_j and n_i – total number of seeds germinated by adjacent counts at times t_j (day) and t_i, (day), respectively, when n_i N/2 n_j.

Shoot and root length. After the 10th day, the shoot and root of each replication's seedlings were

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measured. The percentage (%) reduction in shoot and root length of rice seedlings caused by the allelopathic effect of aqueous weed extracts was calculated using the formula below.

Percent reduction = C – T/C × 100

where: C – value under the control treatment (distilled water); T – value obtained under the extract treatment.

The dry weight of the seedling. The seedlings' dry weight was determined by drying the sample in an oven at 70 °C until it reached a constant weight. The dry weight of shoot and root reduction percentage was computed as follows:

Percent reduction = C – T/C × 100

where: C – value under the control treatment (distilled water); T – value under extract treatment.

Average percent inhibition. Average percent inhibition (API) was used to analyse the overall impacts (API) of plant extracts on the growth of rice, and it is expressed by the formula given by Karim et al. (2014).

API = (% germination reduction + % root reduction + % shoot reduction + % dry weight reduction + % mean germination time reduction + % T_{50} reduction)/6

where: 6 – total number of parameters covered.

Statistical analysis

To ensure consistency of results, the laboratory experiment was repeated three times. The Statistical Package for the Social Sciences (SPSS, version 16, New York, USA) and Microsoft Office Excel (USA) were used to analyse all of the data. A standard one-way analysis of variance was used to examine the differences between variables (ANOVA). At $P < 0.05$, differences were considered significant.

RESULT AND DISCUSSION

Final germination percentage

All seedlings were regarded as having germinated if their radicles measured at least 2 mm in length. When the hypocotyls rose above the surface of the growth medium, seedling emergence was recorded. The effect of aqueous extract of different plant parts of *A. philoxeroides*, *L. octovalvis* and *P. hydropiper* on seed germination of rice (*O. sativa*) was shown in Table 1. The number of germinated seeds was lower in the plant's aqueous extract treatment than in control. This shows that the phytochemicals found in the tested weeds inhibit rice seed germination. The water extract of the weed species significantly ($P < 0.05$) reduced the percentage of rice emergence. The percentage of germination decreased gradually as the concentration of extract increased, and seed germination was found to be more affected by leaf extract than by aqueous shoot extract. The control treatment (distilled water) has the highest percentage of germination (98.66%). The lowest percentage of seed germination reduction (9.12%) was observed in a 2% (*w*/*v*) shoot extract of *L. octovalvis*, while the highest (41.89%) germination reduction percentage was observed in a 10% (*w*/*v*) leaf extract of

Table 1. Germination percentage of rice seed as influenced by aqueous extracts of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		Germination percentage on different dilutions (%)					
		control	2	4	6	8	10
Leaves extract	*Alternanthera philoxeroides*	98.66 ± 2.02	77.33 ± 1.45*	70.33 ± 1.02*	67.33 ± 1.20*	64.33 ± 1.15*	57.33 ± 1.76*
	Ludwigia octovalvis		79.33 ± 1.20*	73.66 ± 1.20*	69.66 ± 1.45*	65.66 ± 1.85*	59.33 ± 1.45*
	Persicaria hydropiper		81.33 ± 1.02*	74.33 ± 1.45*	71.33 ± 1.15*	67 ± 1.52*	61.66 ± 1.76*
Shoot extract	*Alternanthera philoxeroides*	98.66 ± 2.02	86.33 ± 1.20*	83.66 ± 1.76*	76 ± 2.02*	72 ± 1.45*	68.66 ± 1.20*
	Ludwigia octovalvis		89.66 ± 1.15*	86 ± 1.15*	82.66 ± 1.02*	76.66 ± 1.02*	72.33 ± 1.85*
	Alternanthera philoxeroides		88.33 ± 1.76*	85.33 ± 2.15*	78 ± 2.02*	75.66 ± 1.76*	70.66 ± 2.15*

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

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Table 2. Mean germination time of rice seed as influenced by aqueous extracts of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		Mean germination time on different dilutions (days)					
		control	2%	4%	6%	8%	10%
Leaves extract	*Alternanthera philoxeroides*	2.72 ± 0.06	3.5 ± 0.16*	3.98 ± 0.13*	4.86 ± 0.12*	5.61 ± 0.1*	6.22 ± 0.22*
	Ludwigia octovalvis		3.18 ± 0.03*	3.72 ± 0.02*	4.63 ± 0.01*	5.32 ± 0.03*	5.75 ± 0.02*
	Persicaria hydropiper		3.12 ± 0.03*	3.60 ± 0.02*	4.48 ± 0.02*	5.15 ± 0.03*	5.31 ± 0.17*
Shoot extract	*Alternanthera philoxeroides*	2.72 ± 0.06	2.98 ± 0.04*	3.41 ± 0.1*	3.66 ± 0.92*	4.15 ± 0.03*	4.55 ± 0.07*
	Ludwigia octovalvis		2.85 ± 0.05*	3.05 ± 0.04*	3.35 ± 0.05*	3.91 ± 0.16*	4.27 ± 0.02*
	Persicaria hydropiper		2.91 ± 0.01*	3.25 ± 0.15*	3.52 ± 0.14*	4.05 ± 0.08*	4.36 ± 0.04*

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

A. philoxeroides, followed by a 39.86% reduction in a 10% (*w*/*v*) leaf extract of *L. octovalvis*.

Mean germination time and T_{50}

The germination of rice seeds was significantly ($P < 0.05$, Table 2) affected by water extracts of weeds under test. Mean germination time (MGT) was observed at 3.27–6.22 days, 3.12–5.75 days and 3.02–5.21 days in various dilutions of leaf extract, whereas it was 2.98–4.55 days, 2.80–4.27 days and 2.86–4.36 days in different concentrations of shoot extract of *A. philoxeroides*, *L. octovalvis* and *P. hydropiper*, respectively. The longest (6.22 days) delay in mean germination time was observed when rice seeds were treated with 10% (*w*/*v*) leaf extract of *A. philoxeroides* (56.27% times reduction), whereas the lowest percentage of mean germination time reduction (4.56%) was found in 2% (*w*/*v*) shoot extract of *L. octovalvis* (2.85 days).

The longest time taken for 50% germination (T_{50}) was found when seeds were treated with 10% leaf extract of *A. philoxeroides* (6.07 days) followed by 10% leaf extract of *L. octovalvis* (5.26 days), whereas the shortest time to 50% germination (2.28 days) was recorded in distilled water treatment (Table 3).

Table 3. 50% germination (T_{50}) of rice seed as influenced by aqueous extracts of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		T_{50} on different dilutions (days)					
		control	2%	4%	6%	8%	10%
Leaves extract	*Alternanthera philoxeroides*	2.28 ± 0.05	2.98 ± 0.04*	3.65 ± 0.05*	4.53 ± 0.043*	5.01 ± 0.11*	6.07 ± 0.07*
	Ludwigia octovalvis		2.76 ± 0.05*	3.51 ± 0.05*	4.12 ± 0.047*	4.86 ± 0.07*	5.26 ± 0.06*
	Persicaria hydropiper		2.65 ± 0.06*	3.31 ± 0.02*	3.90 ± 0.057*	4.68 ± 0.05*	5.08 ± 0.04*
Shoot extract	*Alternanthera philoxeroides*	2.28 ± 0.05	2.59 ± 0.05*	3.20 ± 0.03*	3.45 ± 0.035*	3.81 ± 0.06*	4.18 ± 0.03*
	Ludwigia octovalvis		2.42 ± 0.01*	2.84 ± 0.03*	3.14 ± 0.03*	3.39 ± 0.06*	3.71 ± 0.03*
	Persicaria hydropiper		2.49 ± 0.05*	2.90 ± 0.05*	3.25 ± 0.04*	3.60 ± 0.03*	3.97 ± 0.03*

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

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Table 4. Shoot length/reduction percentage of rice seedlings as influenced by aqueous extract of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		Shoot length (mm)/reduction percentage					
		control	2	4	6	8	10
Leaves extract	*Alternanthera philoxeroides*	128.66 ± 2.15	89.66 ± 1.57* (30.31%)	81.66 ± 1.201* (36.53%)	73.66 ± 1.20* (42.74%)	62.33 ± 1.15* (51.55%)	50.66 ± 1.45* (60.62%
	Ludwigia octovalvis		92.33 ± 1.02* (28.23%)	87.33 ± 1.20* (32.12%)	82.66 ± 1.52* (35.75%)	69.66 ± 1.45* (45.85%)	56.33 ± 1.45* (56.21%)
	Persicaria hydropiper		94.33 ± 1.20* (26.68%)	90.33 ± 1.15* (29.79%)	85 ± 1.15* (33.93%)	75 ± 2.08* (41.71%)	60.66 ±1.54* (52.85%)
Shoot extract	*Alternanthera philoxeroides*	128.66 ± 2.15	107.66 ± 1.21* (16.32%)	103 ± 1.15* (19.94%)	95.66 ± 1.45* (5.64%)	86.33 ± 2.02* (32.90%)	78.33 ± 1.21* (39.12%)
	Ludwigia octovalvis		112 ± 1.15* (12.95%)	108.66 ± 1.45* (15.54%)	102 ± 1.52* (20.72%)	92.66 ± 1.45* (27.98%)	84.33 ± 1.20* (34.45%)
	Persicaria hydropiper		110.66 ± 1.45* (13.99%)	106.33 ± 1.21* (17.35%)	98.66 ± 1.45* (23.32%)	89.33 ± 1.76* (30.57%)	81.66 ± 1.52* (36.53%)

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

An increase in mean germination time and time to 50% germination indicates that the treatment is delaying germination. The allelopathic inhibitory effect of the test weed species' leaf extract was stronger than that of other plant parts. It demonstrates that leaves produce more water-soluble

Table 5. Root length/reduction percentage of rice seedlings as influenced by aqueous extracts of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		Root length (mm)/reduction percentage					
		control	2	4	6	8	10
Leaves extract	*Alternanthera philoxeroides*	56.16 ± 1.30	39.16 ± 1.20* (29.07%)	35.5 ± 1.33* (36.78%)	32.83 ± 1.17* (41.56%)	27.66 ± 1.52* (50.74%)	23.33 ± 1.53* (58.45%)
	Ludwigia octovalvis		41.66 ± 1.20* (25.83%)	37.66 ± 1.20* (32.94%)	34.16 ± 1.36* (39.17%)	30.66 ± 1.5* (45.40%)	25.33 ± 1.2* (54.89%)
	Persicaria hydropiper		43.66 ± 0.88* (22.25%)	40.66 ± 1.76* (27.59%)	36.83 ± 0.73* (34.41%)	31.5 ± 1.15* (43.91%)	28.5 ± 1.04* (49.25%)
Shoot extract	*Alternanthera philoxeroides*	56.16 ± 1.30	48.16 ± 2.05* (14.52%)	46.33 ± 1.20* (17.50%)	42.56 ± 1.45* (24.21%)	38.16 ± 1.48* (32.05%)	35.5 ± 0.76* (36.78%)
	Ludwigia octovalvis		52.83 ± 1.75* (5.83%)	49.16 ± 1.02* (12.46%)	46.83 ± 1.73* (16.61%)	44 ± 1.15* (22.18%)	37 ± 1.15* (34.11%)
	Persicaria hydropiper		51.5 ± 1.2* (8.16%)	47.16 ± 0.44* (16.01%)	45.5 ± 1.02* (18.98%)	40.83 ± 1.15* (27.29%)	36 ± 1.15* (35.89%)

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

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Table 6. Dry weight per seedling/reduction percentage of rice seedlings as influenced by aqueous extract of *Alternanthera philoxeroides, Ludwigia octovalvis* and *Persicaria hydropiper*

Plant species		Dry weight of seedling (mg)/reduction percentage					
		control	2%	4%	6%	8%	10%
Leaves extract	*Alternanthera philoxeroides*	22.59 ± 0.25	14.59 ± 0.18* (35.41%)	13.54 ± 0.25* (39.06%)	12.42 ± 0.28* (45.01%)	11.33 ± 0.93* (49.84%)	9.83 ± 0.14* (56.48%)
	Ludwigia octovalvis		15.8 ± 0.14* (30.05%)	14.18 ± 0.13* (37.22%)	13.68 ± 0.18* (39.44%)	12.1 ± 0.16* (46.43%)	10.48 ± 0.15* (53.60%)
	Persicaria hydropiper		16.09 ± 0.26* (28.77%)	15.53 ± 0.13* (31.25%)	14.29 ± 0.18* (36.74%)	12.33 ± 0.17* (45.41%)	11.02 ± 0.18* (51.21%)
Shoot extract	*Alternanthera philoxeroides*	22.59 ± 0.25	18.47 ± 0.32* (18.23%)	17.58 ± 0.28* (21.17%)	16.24 ± 0.19* (28.10%)	15.95 ± 0.24* (29.39%)	14.82 ± 0.14* (34.39%)
	Ludwigia octovalvis		19.25 ± 0.44* (14.78%)	18.59 ± 0.17* (17.70%)	17.42 ± 0.28* (22.88%)	16.9 ± 0.15* (25.18%)	15.65 ± 0.14* (30.72%)
	Persicaria hydropiper		18.93 ± 0.15* (16.20%)	17.94 ± 0.14* (20.58%)	17.02 ± 0.22* (24.65%)	16.47 ± 0.23* (27.09%)	15.17 ± 0.11* (32.28%)

Each value represents the mean (± standard error) of three replicates. *Asterisk indicates significant differences as compared to control for $P < 0.05$

phytotoxins, which can slow down germination to a greater extent. Our findings show that water extracts of *A. philoxeroides*, *L. octovalvis* and *P. hydropiper* have inhibitory effects on rice seedling germination and that the concentration of the extract increases the phytotoxicity.

Shoot and root reduction. The measurement of seedling shoots and root lengths has been the most commonly used parameter for illustrating allelopathic potential (Khaliq et al. 2013). A ruler was used to measure plant height, and root length and the results were stated in millimetres. The findings suggested that water extracts of various parts of the selected weeds had a significant impact on the development and growth of rice seedlings. When different concentrations of weed leaf and shoots extracts were applied to rice seedlings, the results were significantly different. When rice seedlings were treated with 10% *A. philoxeroides* leaf extract, the maximum reduction in the shoot (60.62%) and root length (58.45%) was observed compared to the control treatment. The minimum or lowest reduction in the shoot (12.95%) and root length (5.83%) was observed in a 2% shoot extract of *L. octovalvi*s (Tables 4 and 5)

Water-soluble inhibitors in weed plants may be responsible for a significant reduction of rice root and shoot length (Kil and Yun 1992). The reduction in root and shoot length of rice seedlings could be due to soluble allelopathic compounds altering DNA synthesis in the apical meristem or change in cell mitotic indices (Denise et al. 2000). The functions of gibberellin and indole acetic acid were known to be inhibited by an allelopathic compound that may affect cell division and which reduced the root and shoot length of rice seedlings (Tomaszewski and Thimann 1966). Different extracts' effects and activities in suppressing rice seedling growth may be due to differences in the type and concentration of allelochemicals present in these extracts.

The dry weight of seedlings. The allelopathic effect of selected weed aqueous extracts on rice seedling growth (root and shoot length) was mirrored in dry matter output. All concentrations of water extract from the selected weeds lowered the dry matter production of rice seedlings. The reduction rate ranged from 35.41–56.48%, 30.05–53.6% and 28.77–51.21% in leave extract, whereas 18.23–34.39%, 14.78–30.72% and 16.2–32.28% in shoot extract of *A. philoxeroides*, *L. octovalvis* and *P. hydropiper*, respectively. Table 5 shows that the maximum dry matter percent reduction (56.48%) was discovered in a 10% leave extract of *A. philoxeroides*, while the lowest reduction percent-

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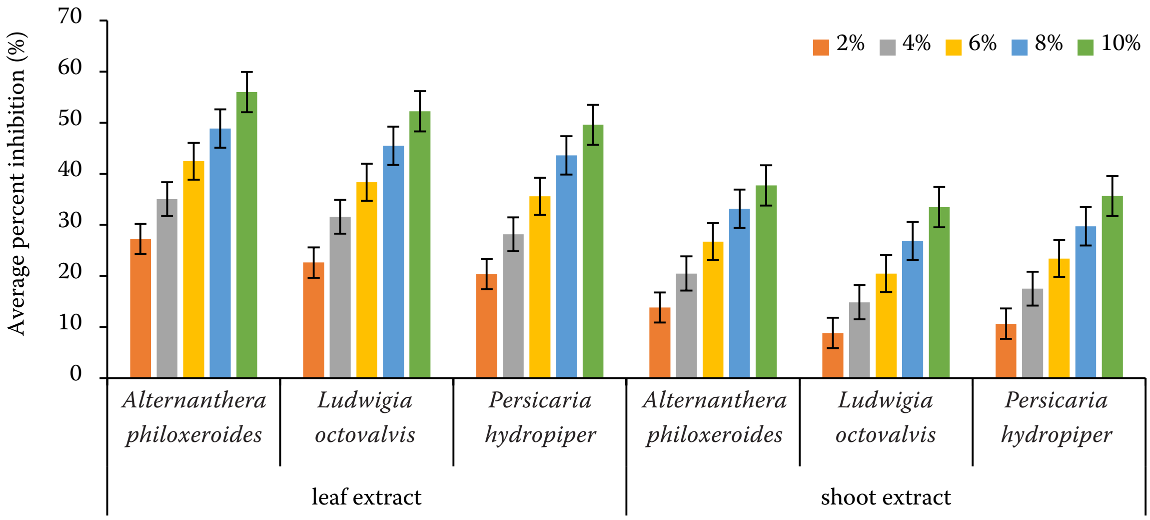

Figure 1. Average percent inhibition of aqueous extract of *Alternanthera philoxeroides*, *Ludwigia octovalvis* and *Persicaria hydropiper* on germination and seedling growth of rice

age was found in a 2% shoot extract of *L. octovalvis* (14.78%) (Table 6). The plant extracts reduced the length and thickness of seedlings, which resulted in a decrease in dry matter output. According to Al-Wakeel et al. (2007), delayed seedling elongation may be caused by allelochemicals directly interfering with the process of cell division, which affects the balance of several growth hormones.

Average percent inhibition. The most useful measure for identifying the allelopathic variety is average percent inhibition. API is the most relevant metric for analysing allelopathic confirmation because it is the average of all the parameters. The API levels were used to determine the allelopathic potential of the plant extract. An extract with a higher API score has a higher allelopathic potential and *vice versa*. When the treatments were grouped by average percent inhibition (Figure 1), it was found that five treatments of leaf extract, namely 8% and 10% *A. philoxeroides*, 8% and 10% *L. octovalvis*, and 10% *P. hydropiper*, exhibited more than 45% inhibitions. The inhibition of shoot extracts containing 2% *A. philoxeroides*, 2% and 4% *L. octovalvis*, and 2% *P. hydropiper* is found to be less than 15%. The highest allopathic activity on germination, shoot and root growth, and dry matter production was found in a 10% (*w*/*v*) *A. philoxeroides* leaf extract, followed by a 10% *L. octovalvis* leaf extract, and the lowest in a 2% *L. octovalvis* shoot extract. It was observed that all the tested weed species showed significant allelopathic activity in seed germination and rice seedling growth.

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