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Research Paper

Allelopathic effect of aqueous extracts of major weed species plant parts on germination and growth of wheat

Dessalegne Gella[1] • Habtamu Ashagre[2] • Takele Negewo[1]

[1]Ambo Plant Protection Research Center P.O. Box 77, Ethiopia.
[2]Ambo University P.O. Box 19 Ambo, Ethiopia.

*Corresponding author. E-mail: habt.alem@yahoo.com

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Abstract. A laboratory experiment was conducted at Plant Protection Research Center, Ambo to assess allelopathic effect of aqueous extracts of *Amaranthus hybridus*, *Parthenium hysterophorus*, *Datura stramonium* and *Argemone mexicana* leaf, stem and root parts on seed germination, seedlings growth and biomass production of wheat cultivars; HAR–1685 and Durum wheat. Aqueous extracts at 1 g/ml ratio concentrations were prepared for each weed species plant parts uniformly and applied to seeds placed sparsely in petri dish. Highest wheat seed germination reduction (22%) was caused by leaf extract of *P. hysterophorus*. Uniformly more inhibition on radicle length of wheat seedlings was observed with leaf extracts of the test weed species than the other plant part extracts. Plumule length of the wheat seedlings were reduced by 60 and 40% due to leaf extracts of *P. hysterophorus* and *A. hybridus*. In general, the investigation showed that *P. hysterophorus* and *A. hybridus* plant leaf and stem extracts consistently cause considerable reduction on percent seed germination, respectively. In addition, leaves extract of both weed species gave the highest negative effect on radicle and plumule elongation of the seedlings. Thus, farmers shall be advised to give special attention in avoiding or minimizing those weed species from farm to contain their adverse effects on the crop.

Keywords: Allelopathy, germination, growth, plumule, radical, weed species, wheat.

INTRODUCTION

The antagonism between weeds and crops in the field is a complex phenomenon that it could be physical competition, allelopathy or both. Allelopathy is an interference mechanism in which live or dead plant materials release chemical substances, which inhibit or stimulate the associated plant growth (May and Ash, 1990). There are several reports that some weed species have allelopathic effects on seed germination and seedlings growth of economically important crop plants (Mulatu et al., 2009; Shibu and Andrew, 1998; Rice, 1984; Delabays et al., 2004).

Weeds cause more loses to agriculture than all pests, understanding the nature of weeds is necessary in order to learn how to reduce their effects on agricultural crops. According to Putnam (1988) chemical with allelopatic potential present (commonly in conjugated form) in almost all plants and in many tissues, like leaves, stems, flowers, fruits, seeds and roots. Under specific conditions, these chemicals are released in to atmosphere or rhizosphore in ample quantities and long persistence to affect a neighbouring or successional plant. Discharge of allelochemicals into the environment occurs by exudation of volatile chemicals from living plant parts, by leaching of water soluble toxins from aboveground parts in response of action of rain (Tukey, 1966), by exudation of water soluble toxins from below ground parts (Fay and Duke, 1977), by release of toxins from non–living plant parts through leaching of litter decomposition (Mulatu et al., 2009) or microbial by–products resulting litter decomposition (Kaminsky, 1981; Chou, 1990).

Allelopathy is a difficult phenomenon to study. It is difficult to separate the effects of allelopathy from those of competition because growth and yield may be influenced by each (Batish et al., 2007). For example, adverse effect of plant residues on seed germination and plant growth could be the result of immobilization of large amounts of nutrients by micro-organisms involved in decomposition, by allelochemicals, or both. Qassem (1995) reported that fresh shoot or root extracts of *Amaranthus* spp. reduced germination, coleoptiles length and dry weight of wheat under laboratory conditions. He also found out that, in the field, incorporation of *Amaranthus* residues into the soil reduced height, grain and straw yield of wheat. Root exudates collected from undistributed seedlings of wild oat (*Avena fatua*) inhibited the root and coleoptile growth of spring wheat seedlings (Hussien et al., 1992). Aqueous extracts of Parthenium leaf and flower inhibited seed germination and caused complete failure of seed germination of teff (*Eragrostis tef*) when the leaf extract concentration of Parthenium weed was 10% (Tefera, 2002). In India, yield decline of 40% in agricultural crops and 90% reduction in forage production has been reported due to allelopathic effect of Parthenium (Singh et al., 2003). In eastern Ethiopia, sorghum grain yield was reduced from 40 to 90% depending on the year and the location due to both allelopathic and competition effect of Parthenium in the field (Tamado et al., 2002).

In Ethiopia barring some stray observations, no scientific evidence on the allelopathic effect of major weed species on germination and growth of economically important widely grown crops like wheat is available. Hence, this study was made to investigate the allelopathic effect of major weed species; *A. hybridus, P. hysterophorus, D. stramonium* and *A. mexicana* plant part aqueous extracts on the germination and growth of improved and local wheat cultivars under laboratory condition.

MATERIALS AND METHODS

A laboratory experiment was conducted under room temperature in Weed Science Research Unit of Plant Protection Research Center, Ambo. Factorial Complete Randomized Design (CRD) with three replications was used to arrange the treatments. The experiment consisted of three factors; Factor A: Two wheat cultivars; HAR–1685 and Durum wheat, Factor B: Four weed species; *A. hybridus, P. hysterophorus, D. stramonium* and *A. mexicana* and Factor C: Extracts of the three main plant parts; leaf, stem and root parts, and distilled water as control treatment. Vegetative growing fresh tissues of the weed species plants were collected from fields around the research centre. For each weed species, plants were separated into leaf, stem and root parts, crushed and grinded with pestle and mortal. The grind plant material was mixed in distilled water at 1 g/ml ratio, soaked and blended with blender as of Oudhia et al. (1999). The mixtures were extracted by using 100 × 100 rpm centrifuge for twenty minutes. The filtered extracts were poured into long necked and flat bottomed 250 ml volumetric flasks, well covered and preserved in refrigerator set to -5°C for use. Ten seeds of each wheat cultivars were sown sparsely in a filter paper covered glass petri dish having 9.5 cm diameter. A 5 ml aqueous extract of each weed species plant parts was applied to each petri dish; whereas 5 ml distilled water was applied in the case of control treatment. The treated petri dishes were placed in incubator adjusted to a temperature of 24°C. Moistening seeds with equal amount water and germination data collection were carried out at two days interval. After 15 days seedlings removed, and data on radicle and plumule length and biomass weight collected. The collected data were analyzed and tested using MSTATC software programme.

RESULTS AND DISCUSSION

Effect of aqueous extracts of major weed species plant parts on germination percentage

P. *hysterophorus* leaf extracts showed significantly higher reduction on seed germination of both wheat types than the other weed species and plant part extracts (Table 1). Tefera (2002) report that aqueous extracts of leaf and flower of *P*. *hysterophorus* caused complete failure of seed germination of teff (*Eragrostis tef*). Recently, Naeem et al. (2012) also reported similar finding on wheat. However, in the case of *A. hybridus,* stem extract gave significant reduction on the germination of wheat seeds.

Allelopathic effects of aqueous extracts of plant parts on radicle and shoot lengths

Extracts of all test weed species plant parts found significantly affected the radicle length of wheat seedlings, but inhibition due to leaf extract was more serious (Table 2).

In addition, extracts of root of *A. hybridus* and A. *mexicana*, and stem of *P*. *hysterophorus* caused substantial inhibiting effect on the radicle length of the wheat seedlings. The highest inhibiting effect of leaf extracts of all weed species on radicle length of the wheat seedlings could be due to the high accumulation of allelochemicals in the top meristems of the plants. Other authors (Kanchan and Jayachandra, 1980) also reported the highest inhibitory effect of parthenium leaf is due the presence of high quantity of photochemical in its leaf.

There were distinct differences among the plant parts extract in their effect on plumule length of wheat seedlings (Table 3). Leaf extracts of *P*. *hysterophorus* followed by *A. hybridus* significantly reduced the plumule

Table 1. Effect of aqueous extracts of major weed species plant parts on percent germination of wheat seeds.

Extract of plant part		Percent germination		
		HAR 1685	Durum wheat	Mean
A. hybridus	Stem	83	97	90^{ab}
	Root	100	93	97^{a}
	Leaf	93	100	97^{a}
A. mexicana	Stem	100	90	95^{a}
	Root	100	97	98^{a}
	Leaf	93	93	93^{a}
D. stramonium	Stem	93	100	97^{a}
	Root	97	100	98^{a}
	Leaf	100	100	100^{a}
P. hystrophorus	Stem	97	100	98^{a}
	Root	100	100	100^{a}
	Leaf	83	73	78^{b}
Distilled water (Check)		100	100	100^{a}
Variety mean		95.31	95.61	95.46

CV (%) = 8.2; SE = 3.23; LSD = 12.12; alpha = 0.01. N.B: means within the same column followed by different letters differ significantly at 0.01 probability level DMRT.

Table 2. Allelopathic effects of aqueous extracts of major weed species plant parts on radicle length of wheat seedlings.

Extract of plant part		Radicle length (cm)		
		HAR 1685	Durum wheat	Extract mean
A. hybridus	Stem	6.137	6.260	6.198^{cde}
	Root	3.613	2.623	3.118^{ef}
	Leaf	1.823	0.987	1.405^{f}
A. mexicana	Stem	4.340	6.310	5.325^{def}
	Root	4.317	4.747	4.532^{ef}
	Leaf	3.390	4.508	3.949^{ef}
D. stramonium	Stem	10.388	8.730	9.559^{bcd}
	Root	8.863	10.983	9.923^{bc}
	Leaf	3.687	3.223	3.455^{ef}
P. hystrophorus	tem	4.327	3.773	4.05^{ef}
	root	13.933	10.333	12.133^{b}
	leaf	2.150	1.487	1.818^{ef}
Control/distilled water		19.237	16.126	17.681^{a}
Variety mean		6.627	6.160	6.393

CV (%) = 11.34; SE = 1.089; LSD = 4.089; alpha = 0.01. N.B: Means within the same column followed by different letters differ significantly at 0.01 probability level DMRT.

length. However, extracts of *P. hysterophorus* root, *D. stramonium* root and stem, and *A. mexcana* leaf found stimulated elongation of wheat seedlings. This could probably be due to the induction of growth promoting hormones. This is in agreement with the result obtained by many authors (Naeem et al., 2012; Oudhia, 2001;

Table 3. Allelopathic effects of aqueous extracts of major weed species plant parts on plumule length of wheat seedlings.

Extract of plant part		Plumule length (cm)		
		HAR 1685	Durum wheat	Mean
A. hybridus	Stem	18.717	16.693	17.705^{abcde}
	Root	17.657	13.088	15.372^{def}
	Leaf	12.057	6.850	9.453^{gh}
A. mexicana	Stem	18.843	13.440	16.141^{cdef}
	Root	22.433	20.647	21.54^{a}
	Leaf	18.273	19.779	19.03^{abcd}
D. stramonium	Stem	22.510	21.263	21.87^{a}
	Root	19.707	20.763	20.23^{abc}
	Leaf	16.103	12.087	14.09^{ef}
P. hystrophorus	Stem	16.373	12.257	14.31^{ef}
	Root	21.760	20.267	21.01^{ab}
	Leaf	7.245	4.683	5.96^{h}
Control/distilled water		15.152	14.34	14.75^{ef}
Variety mean		17.448	15.089	16.266

CV (%) = 17.51; SEM = 7. 831; LSD 2.145; alpha 0.01. N.B: Means within the same column followed by different letters differ significantly at 0.01 probability levels DMRT.

Table 4. Allelopathic effects of aqueous extracts of major weed species plant parts on biomass of the two wheat's seedlings.

Extract of plant part		Biomass (mg)		
		HAR 1685	Durum wheat	Mean
A. hybridus	Stem	3.01	3.63	3.32
	Root	3.12	2.92	3.02
	Leaf	3.21	3.19	3.2
A. mexicana	Stem	3.14	2.69	2.91
	Root	2.93	3.29	3.11
	Leaf	3.29	3.38	3.33
D. stramonium	Stem	3.65	3.97	3.81
	Root	2.40	3.10	2.75
	Leaf	3.03	3.33	3.18
P. hystrophorus	Stem	2.45	3.26	2.85
	Root	2.84	3.03	2.93
	Leaf	2.61	3.26	2.93
Control/distilled water		2.23	2.26	2.24
Variety mean		2.916	3.178	3.047

CV (%) = 19.70; SEM = 0.003; LSD 0.0419; alpha 0.010.

Table 5. Mean allelopathic effect of aqueous extracts of major weed plant parts on germination, radicle length, plumule length and biomass of wheat.

Extract	Germination (%)	Radicle length (cm)	Plumule length (cm)	Biomass (mg)
Stem	95.00^{ab}	6.283^{b}	17.512^{a}	3.22^{a}
Root	98.33^{ab}	7.427^{b}	19.540^{a}	2.95^{a}
Leaf	92.08^{b}	2.657^{c}	12.135^{c}	3.16^{a}
Control	100.00^{a}	17.682^{a}	14.746^{b}	2.25^{b}

N.B: Means within the same columns followed by different letters differ significantly at 0.01 probability level DMRT.

Table 6. Mean allelopathic effect of aqueous extracts of major weed species on radicle length of wheat.

Weed species	Radicle length (cm)
A. hybridus	6.921^{c}
A. mexicana	7.654^{bc}
D. stramonium	10.205^{a}
P. hystrophorus	9.269^{ab}

N.B: Means within the same column followed by different letters differ significantly at 0.01 probability level DMRT.

Table 7. Mean allelopathic effect of weed species aqueous extracts on plumule length of wheat seedlings.

Weed species	Plumule length (cm)		Weed species mean
	HAR 1685	Durum wheat	
A. hybridus	15.774	12.680	14.227^{b}
A. mexicana	18.718	16.210	17.464^{a}
D. stramonium	17.963	17.428	17.695^{a}
P. hystrophorus	15.617	13.477	14.547^{b}
Wheat mean	17.018^{a}	14.949^{b}	

N.B: Means within the same column and row followed by different letters differ significantly at 0.01 probability level DMRT.

Scrivanti, 2010).

Effects of aqueous extracts plant parts on the biomass of the wheat seedlings

There was no significant difference between the two wheat types in their response to the test weeds plant part aqueous extracts for all parameters recorded. Moreover, different plant parts extract effect on biomass yield was statistically indifferent, rather all extracts favoured biomass production of the wheat seedlings (Table 4). This finding was also in agreement with Naeem et al. (2012), they found statistically similar fresh root mass against the parthenium root, stem and leaf aqueous extracts on four cultivars of wheat.

In general, the mean allelopathic effect of aqueous extracts of plant parts showed that leaf extract of the test weed plants considerably reduced percent seed germination and seedlings radicle and plumule lengths than the other extracts (Table 5). *A. hybridus* and *A. mexicana* extracts significantly reduced the radicle elongation, and *A. hybridus* and *P. hysterophorus* the plumule length of both wheat types in that the effect was relatively high on durum wheat seedlings (Tables 6 and 7). By and large, stem and root extracts of most weed plants observed favoring plumule elongation of wheat seedlings.

CONCLUSION

Some weeds are causing more loses on agriculture with its different manners-competition and/or allelopathy

requiring to learn how to reduce the effects on agricultural crops. In line with this, this study showed that allelopatic weed plants pose threat on seed germination, seedlings radicle and plumule lengths of wheat. Leaf extracts of *P. hystrophorus* and *A. hybridus* found more inhibited wheat seed germination and seedlings growth than the other extracts evaluated. Thus, farmers should give special attention to avoid or minimize those weed species from their farm to contain their adverse affects on crops.

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