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Kapil Sharma, C. K. Dixit and Rajneesh K. Agnihotri

Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 12
Issue: 04

Res Jr of Agril Sci (2021) 12: 1353–1357

CARAS

Res. Jr. of Agril. Sci. (July-Aug 2021) 12(4): 1353–1357
www.rjas.org

Full Length Research Article

Assessment of the Allelopathic Effects of two Weed Species on Seedling Growth of Wheat

Kapil Sharma[1], C. K. Dixit[2] and Rajneesh K. Agnihotri*[3]

Received: 07 May 2021 | Revised accepted: 09 Jul 2021 | Published online: 03 Aug 2021

ABSTRACT

The allelopathic potential of weeds on germination and growth of crops varies with the weed and crop. The present investigation was undertaken to assess the allelopathic effects of two common weeds *Chenopodium murale* and *Solanum nigrum* on the germination and growth of *Triticum aestivum* (wheat). To achieve the above objectives, in-vitro and greenhouse experiments were set up to assess the allelopathic effects of selected weeds on seed germination and seedling growth. In the petri dish experiment, wheat seeds were treated for ten days with 50 % and 100% concentrations of cold and hot water extracts of weeds. In the pot experiment dried leaf residues of each weed were applied separately to pots in two concentration 5g/kg and 10g/kg soil and maintained for three weeks. Above two weeds affected the physiological parameters of wheat to different degree. Overall, *C. murale* was found to have the strongest negative effects on germination and growth of *Triticum aestivum.* In the lab study, the germination of wheat was highly decreased in case of both the weeds. The inhibitory effect increased with the concentration of leachates applied. It was observed that cold aqueous leachates of *C. murale* was more effective than their hot aqueous leachates. The reverse was true in the case of *Solanum nigrum.* In the pot experiment also the germination of wheat was decreased due to dried leaf residue of weeds incorporated in the soil. However, the efficacy observed was very different from what was seen in the lab experiment with aqueous extract. *Chenopodium murale* had the strongest negative effects among the test weeds in the petri-plate study. It had the most detrimental effects on all the physiological parameters of wheat as well. On the other hand, in the pot study *C. murale* proved to be the strongest inhibitor in all the growth parameters tested. *Solanum nigrum* had the least negative effect on germination, SVI, shoot length in the laboratory and was ranked third in the pot experiment.

***Key words*:** Allelopathy, Leachates, Seedling growth, Seed vigour index, Weed

The phenomenon of allelopathy received great attention in 1974 after the publication of the first book on the allelopathy by Elroy L. Rice. According to him, allelopathy has both positive and negative impacts on agricultural crops. “Allelopathy has been defined as the inhibitory and stimulatory effects on a plant or microorganism on other plants through the release of chemical compounds in to the environment”. These chemical substances are present in virtually all plant tissues including leaves, fruits, flowers, roots, rhizomes, seeds and pollen [1-2]. Allelopathic substances are most commonly found in plant extracts and in plant residues of soil while some are found in live plant exudates and as volatile gases liberated from leaves and rhizomes. Allelopathic chemicals emancipated as exudates, leachates and residues by many plant parts and reported to have interference with growth of the other plant mainly seed emergence and seedling level [3-7]. In present investigation the effects of root, shoot aqueous extract of *Chenopodium murale* and *Solanum nigrum* are studied on seed germinability and related traits of wheat (*Triticum aestivum*).

As per the study of FAO, the total losses worldwide caused by the crop pests, the weed account for 35% of losses in wheat, 28% in vegetables, 29% in fruits plant species and 37% in tobacco etc. Which prove the high losses to important food and other cereal crops and has become most serious problems in agricultural sector. About 30,000 plant species are known so far which are considered as weed. Such a huge number of plant species as weeds posing serious impact on important fruit crops like wheat (*Triticum aestivum*) which play great role in global economy and food security and deeply rooted in human culture and civilization [8]. Wheat is used to make flour or leavened, flat and

* Rajneesh K. Agnihotri
✉ rk_agnihotri@rediffmail.com

[1-3] Department of Botany, School of Life Sciences, Khandari Campus, Dr Bhimrao Ambedkar University, Agra - 282 005 Uttar Pradesh, India

steamed breads and most of the baked foods and for fermentation to make alcohol and beer [9]. According to the study conducted by Kumar *et al*. [10], wheat is one of the cheapest sources of food that provide good number of calories and protein in normal human diet.

Several weed species have been reported to have affected growth at different developmental stages in various plants of economical use. According to Jabeen *et al*. [11], wheat productivity and quality is greatly impaired by weeds infections which compete for water, nutrients and sunlight. Weeds are responsible to cause 17-25% losses in wheat annually due to their competitive and allelopathic affects. In the present investigation, *Chenopodium murale* and *Solanum nigrum* are considered as weed species and their effect on wheat has been observed. Some growth parameters like percentage germination, root length, shoot length and biomass are taken into consideration by two experimental methods i.e., pots and petri dishes. *Chenopodium murale* (nettle leaf goose foot) is one of the fast-growing annuals of the family Chenopodiaceae and is widespread throughout different habitat types in Egypt [12-13]. This weed was introduced from Europe and grows in moist soil. Its sociological characteristics have been reported negative association with many plant species, even with similar ecological requirements. Therefore, *C. murale* can be hypothesized that this weed may have allelopathic activity, which may play a vital role in its wide geographical distribution.

Another weed, *Solanum nigrum* the European black nightshade is a native to Eurasia and introduced in the America, Australia and South Africa. *Solanum nigrum* of Solanaceae family, is a common herb or short-lived perennial, found in many wooded areas as well as disturbed habitats. Several studies showed that it can be a serious agriculture weed when it competes with crops of economically important. It has been reported as a weed in 61 countries in 37 crops. Moreover, an initiative has been taken for the optimization of suitable concentration or allelochemicals for wheat crop growth promotion, commercialization of natural water extract as growth promoters and employment of breeding and biotechnology to develop crop with more allelopathic potential as well as responsiveness to applied allelopathic water extract. In the long run it can ensure the provision of wholesome and nutritious food and also would be a hopeful direction to proceed in order to achieve agricultural sustainability, food safety, resource conservation and economic stability.

MATERIALS AND METHODS

In vitro greenhouse experiments were setup to assess the allelopathic effect of two weeds (*Chenopodium murale*, *Solanum nigrum*) on wheat (*Triticum aestivum*) on the seedling growth parameters of wheat. Selected weeds growing in different ecological habitats in Agra district were collected in polythene bags and stored at 5 ºC till the end of experiment. To achieve the target, two experiments, petri dish and pot and sand culture were simultaneously conducted to assess the effect of selected weeds on wheat seed germination, seedling growth and total biomass was laid out in a completely randomized block experimental design in three replicates. The seeds were first washed with distilled water and were then soaked in 5% Bavistin. They were then washed with distilled water for 5-10 minutes and soaked in 0.1% mercuric chloride and further washed with distilled water for 5-10 minutes. The oven dried seeds were then transferred to petri-plates as well as to pot and sand culture. The two types of aqueous extracts of weeds i.e., *Chenopodium murale* and *Solanum nigrum* were prepared as described below:

Cold and hot water extract

100g fresh shoot and root of both the weeds were weighed and washed and rinsed twice or thrice with tap water and distilled water to remove dust and then dried in fan air to remove water. These were then placed in an airtight flask of 1000 ml capacity containing 500ml distilled water and kept in refrigerator. The leachates were filtered twice using muslin cloth and through Whatman No. 1 filter paper after seven days. This was used as 100% concentration of shoot root extract for experiments. Root shoot extract of 50% concentration were also prepared by mixing equal amount of distilled water and were stored in a refrigerator. For hot water extract, similar procedure was followed except that the leachates were kept in 500 distilled water at 100°C for 15 minute.

Petri dish and pot experiment

Ten seeds of test plant were placed in each sterilized petri dish. The seeds then were treated with both concentration (50 and 100%) of cold and hot water extract with shoot and root extracts of both weeds as and when required. The seeds were then allowed to germinate of ten days at a temperature of 23±5°C in the BOD incubator. Three replicates of each treatment were setup and the seeds treated with distilled water were considered as control. For pot experiments, root and shoot of the selected two weed species were air dried in shade for about 15-20 days and then powdered. Pots were filled with previously sterilized soil and sand in 3:1 ratio and autoclaved at 121°C and 12-14 pressure for about 25 minutes. Root shoot powder was supplied separately to pots into concentrations 5g/kg and 10g/kg soil in triplicate. All pots were maintained in random block design and watered with tap water.

Germination percentage

The germination percentage was calculated by the following formula given in the Handbook of Association of Official Seed Analysis [14].

$$\text{Germination \%} = \frac{\text{No. of germination seeds}}{\text{Total number of seeds}} \times 100$$

Seed vigour index

Seedling Vigour Index was calculated according to Abdul-Baki and Anderson [15].

$$\text{SVI} = \frac{\text{Seedling shoot length} \times \text{Germination \%}}{100} \times 100$$

Seeds of wheat crop were sown and observed for three weeks. No root shoot powder was added to control pots. In both the experiment i.e., petri dish and pots, the no. of seeds germinated was recorded every day for 10 days. After three weeks, samples were taken from each treatment and their root and shoot length and biomass were measured.

RESULTS AND DISCUSSION

Effects of aqueous extracts of shoot and root of the two weeds on the seedling growth of wheat performed in petri-plates are presented in (Table 1). The hot extracts with 50% concentration of shoot affected markedly as compared to cold extract treatment. Almost similar results were obtained when seeds were treated with 100% concentration in both the weed species. Hot aqueous extract of shoot and root at 50% and 100% concentration in case of *Chenopodium murale*, root lengths were recorded 2.72 and 1.72 cm and length 2.84 and 2.52 cm. Similarly shoot lengths were recorded 3.80 and 3.23, 4.06 and 3.76 cm. In similar line of observation considerable reductions in biomass were recorded 20.30 and 15.43; 21.30 and 22.55mg in the comparison to control (untreated) seedlings.

The cold aqueous extract of shoot and root of *C. murale* was found to have fewer effects on seedling growth of wheat. At 50% cold aqueous shoot extract of *C. murale* had most detrimental effects on almost all the seedling growth parameters as compared to 100% concentration. Cold shoot extract having 50 and 100% concentration reduced the root length ranged 6.38 to 8.01 cm, shoot length 7.16 to 9.43 cm and biomass 20.31 to 23.55mg.

Table 1 Effect of aqueous extracts of weeds on growth of wheat (Petri-plates)

S. No.	Weed	Plant part	Extract	Conc.	Root length (cm)	Shoot length (cm)	Biomass (mg)	SVI
1.	Control		-	-	8.10±0.29	9.99±0.34	23.43±2.27	9.24±0.72
2.	*C. murale*	Hot	Shoot	50%	2.72±0.36	3.80±0.28	20.30±1.54	2.14±0.04
				100%	1.72±0.25	3.23±0.34	15.43±5.29	1.56±0.35
			Root	50%	2.84±0.53	4.06±0.26	21.30±5.78	3.65±0.44
				100%	2.52±2.0	3.76±0.23	22.55±7.36	2.93±0.37
		Cold	Shoot	50%	6.38±0.43	7.16±0.32	23.27±2.28	5.95±1.10
				100%	6.52±0.49	7.09±0.34	23.17±0.56	4.50±0.93
			Root	50%	7.50±0.62	9.03±0.32	23.55±6.22	8.81±0.95
				100%	8.01±0.54	9.43±0.25	20.31±5.34	7.58±0.43
3.	*S. nigrum*	Hot	Shoot	50%	3.11±0.48	5.02±0.18	32.88±4.22	4.75±0.83
				100%	3.09±0.36	4.88±0.12	31.18±1.47	3.99±0.25
			Root	50%	3.20±0.22	6.18±0.18	22.65±4.41	5.77±0.65
				100%	2.83±0.33	5.63±0.17	21.86±2.96	5.16±0.62
		Cold	Shoot	50%	7.26±0.24	7.00±0.26	24.54±6.44	6.83±0.64
				100%	7.19±0.28	6.43±0.46	19.21±3.22	5.99±0.79
			Root	50%	10.22±0.36	10.03±0.24	28.11±0.29	9.83±0.91
				100%	8.30±0.56	9.53±0.34	25.45±2.33	9.10±0.48

Another weed *Solanum nigrum* found to be less effective parallel to *Chenopodium murale* where similar treatment was given to wheat seeds. But the common feature among the both weeds was that the hot aqueous extract 100% concentration of shoot was more effective than the cold aqueous extract. Hot shoot extract of 50% concentration reduced the root length by 3.11 cm, but increased up to 7.26 cm when treated with cold extract. At similar concentration root cold extract reduced the root length was markedly increased up to 7.26 cm to 10.22 cm. Not much reductions in root lengths were observed at 100% hot and cold shoot and root extract except when cold root of 100% concentration for *Solanum nigrum* as a weed.

As far as other parameters are concerned, the root and shoot length and biomass at 50% and 100% hot and cold shoot and root extract were recorded as 5.02 cm and 32.88 mg; 4.88 cm and 31.18 mg, 6.43 cm and 19.21 mg 10.03 cm and 28.11 mg and 9.53 cm and 25.45 mg respectively as compared to root length 8.10 cm, shoot length 9.99 cm and biomass 23.43 mg in control seedling.

Table 2 Effect of leaf residues of weeds on Growth of wheat (Pots)

S. No.	Weed	Part used	Conc.	Root length (cm)	Shoot length (cm)	Dry biomass (mg)	SVI
1.	Control		-	20.24±1.8	27.47±1.7	36.54±1.16	25.3±2.19
2.	*C. murale*	Shoot	5g	12.27±1.5	19.8±0.5	28.04±0.87	14.27±2.57
			10g	6.97±1.8	15.44±0.9	25.44±0.65	8.99±4.90
		Root	5g	15.3±1.2	24.1±1.0	34.0±0.72	20.98±1.25
			10g	14.8±0.3	22.36±0.6	29.84±2.22	19.90±1.33
3.	*S. nigrum*	Shoot	5g	15.2±0.6	23.97±0.7	31.44±1.74	20.99±2.03
			10g	8.6±1.3	15.67±0.7	29.9±4.52	4.20±2.90
		Root	5g	19.17±2.3	25.23±2.4	35.4±3.46	23.15±2.27
			10g	17.97±3.9	24.26±2.7	32.2±0.50	21.2±2.39

To observe the effect of shoot and root residues on the seedling growth simultaneously another experiment was also conducted in triplet in pot and sand culture along with control without mixing any dry residues: As the data depicted in (Table 2), the 10g shoot residue of *Chenopodium murale* exhibited more destructive effects on seedling growth parameters including seed vigour index. The root length at 10g shoot residues application was 6.97 cm in comparison to 5g shoot residue which was 12.27. The shoot length also shows similar pattern of reduction as it was 15.44 cm and at 5g residue it was 19.8 cm. At both the shoot residue i.e., 5g and 10g biomass was also reduced to 25.44 mg as compared to biomass recorded from control (36.54). About 30 to 50% reduction were noted when seed vigour index was measured indicating that the seeds when treated with shoot dry residue greatly affected the seedling germinability.

Similarly, the root residue applied in pots in similar concentration were observed meager effects on seedling growth parameters taken into the consideration and not much difference was noted for both the concentration of root residue of *C. murale*. The root length, shoot length, dry biomass and SVI recorded at 5g and 10g root residues were 15.3 and 14.8 cm 24.1 and 22.36 cm and 34.0 and 29.84 mg and 20.98 and 19.90 respectively.

Almost similar results were recorded in case of *Solanum nigrum* shoot dry residues 5g and 10g was applied in pots. Shoot residues of 10g concentration and showed marked reduction in seedling growth parameters whereas root residue of 5g did not affect the seedling growth. Shoot and root residue of 10g concentration reduced the root length, shoot length, dry biomass and SVI as 8.6 cm and 17.97 cm; 15.67 and 24.26 cm, 29.9 mg and 32.2 mg, 4.20 and 21.2 as compared to control where these parameters were 20.24 cm, 27.47 cm, 36.54 mg and 25.3 respectively. The highlight of results was that the seed vigour index at 10g shoot residue greatly affected when *S. nigrum* weed was used in pots.

At last, it can be concluded that, *S. nigrum* was the least inhibitory weed in the both the experiments, the petri-plate and the pot experiment. It had the least negative effect on germination, SVI and shoot length in laboratory and was ranked third in the pot experiment in germination, SVI, shoot and root elongation.

Several workers have the opinion, that the effect of allelochemicals present in soil depends upon number of factors including texture, and accumulation capability of microbial activity of the soil. For exhibition of allelopathy, the toxin must accumulate to a physiological active level. In continuation to this fact, [16] opined that natural condition are more complicated than laboratory bioassays. Therefore, field experiments are necessary before any final conclusions are made on allelopathic effect of any weed species.

It is evident from the present investigation that the two weeds tested, affected physiological parameters of wheat to different degrees. *Chenopodium murale* was found to have the strongest negative effects on germination growth of *Triticum aestivum*. The germination of wheat was highly decreased in case of both the weeds studied in petri dish experiment. The inhibitory effect increased with the concentrations of leachates applied. It was observed that cold aqueous leachates of *C. murale* were more effective than their hot aqueous leachates. The reverse was true in the case of *Solanum nigrum*. However, the efficacy observed was very different from wheat was seen in the lab experiment with aqueous extracts. *Chenopodium murale* had the strongest negative effect among the test weeds in petri-plate study. It had the most detrimental effects on all the physiological parameters of wheat such as germination, SVI, root and shoot length as well as total biomass.

Allelopathic effect of leaf extract of some selected weed flora (*Phalaris minor*, *C. murale*, *Sonchus oleraceus*, *Cynodon dactylon* and *Convolvulus arvensis*) on seed germination and seedling growth of *T. aestivum* [17]. Aqueous extracts of all the weeds caused inhibitory effects on seed germination, seedling length and seedling dry weight of crop which increased on increasing the concentration of weed plant part extract.

In the pot study also, *C. murale* proved to be strong inhibitory in the all parameters considered in the present investigation. On the other hand, *Solanum nigrum* was ranked second in the terms of inhibitory effect on germination, SVI, shoot and root length. Allelopathic action of four selected medicinal plants (*Ageratum conyzoides*, *Cannabis sativa*, *Eclipta prostrata* and *Woodfordia fruiticosa*) and concluded that the extent of inhibitory and stimulatory effect of extracts varied with the plant species [18]. The extract reduced the germination of the test seeds. The observed allelopathic activity of the extract of selected medicinal plants on the seed germination and seedling growth of wheat and pea was attributed to the presence of the allelopathic phytochemicals in medicinal plants. The result showed that *A. conyzoides* and *W. fruticose* had strong inhibitory effect on germination as well as root and hypocotyls growth of test seeds.

The result of present investigation was in agreement to earlier reports which suggested that alligator weed species produce high allelopathic effects on field crops including wheat [19-20]. Many studies have shown that residues from several allelopathic weed species release phytochemicals in to the soil, thus affecting the production of associated and next session crop plants [21-22]. The presence of phenolic compounds such as caffeic acid, chlorogenic acid, 4-hydroxy-3-methoxybenzoic acid, gallic acid, syringic acid, vanillic acid, ferulic acid, m-coumaric acid and p-coumaric acid in the weeds play a vital role in inhibiting the seed germination and other growth traits of the wheat [23]. Phenolic compounds are major phytotoxins which cause impairment in seed germination and early seedling development as observed in present study [24].

CONCLUSION

On the basis of research findings of several workers and the present investigation, it can be concluded that allelopathy is a difficult phenomenon to study and not always straight forward to demonstrate. The effect of weeds depends not only on the species being affected but the dosage, plant part used, type of extract used and unneglected experiment design as well as environmental factors for examples, adverse effect of plant residues on seed germination and plant growth could be the result of immobilization of large amounts of nutrients by microorganisms involved in decomposition by allelochemicals, or both. It has been remarked that allelopathy studies under laboratory conditions often do not take into account the effect of microorganisms are said to exaggerate the potential allelopathic effects compared to field conditions. Despite these difficulties in research methodology, a few studies demonstrated allelopathic effects of cover crops on growth. Thus, any *in-vitro* findings should always be correlated with subsequent greenhouse and field trials where natural conditions can be considered and studied. After all, it is both biotic and abiotic factors that make of the environment where any organism survive and none of the two can be said to have an effect not compounded by the other. Therefore, there is utmost need to further work on allelochemicals produced by weeds is very important keeping in the mind the diverse climatic and edaphic conditions.

Acknowledgement

Authors are thankful to Department of Botany, School of Life Sciences, Dr. Bhimrao Ambedkar University, Khandari Campus Agra for providing necessary research facilities.

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