RESPONSE OF POTATO AND ASSOCIATED WEEDS TO WATER EXTRACTS OF MAJOR TREES OF UPPER DIR KHYBER PAKHTUNKHWA PAKISTAN

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ABSTRACT

District Upper Dir, Khyber Pakhtunkhwa is a hilly area and its major cash crop is potato. The area produces good quality potato and the farmers have small land holdings and thus majority of the farmers prefer to grow potato. There are limited pathogens or insect that can significantly affect the potato while presence of weeds is a major concern for the potato growers. As per our documentation survey, Amaranthus viridis and Chenopodum album were found as major weeds infesting potato fields. At maturity, the seeds of these weeds were collected and the major trees that were found on the sides of nearly all potato fields were identified as Juglans sp, Cedrus sp, and Pinus sp. The bark, stem and leaves of these species (donor plants) were collected and stored. After drying, the plant materials were grinded. The powder of each species and each part were soaked separately at 100 g per liter and 150 g per liter to get two different aqueous extracts. The objectives of the studies were to investigate the allelopathic effect of extracts of different parts of donor species on weed seed germination and growth of potato. Weed seed germination test was conducted in petri-dishes while potato related studies were conducted in pots. Our data revealed that all the aqueous extracts of all the three donor plants significantly decreased the seed germination of A. viridis and C. album as compared to control. All three species have confirmed allelopathic effect and thus can affect the germination of weeds. In addition, the aqueous extracts of the donor species significantly affect potato. The degree of weed seed and potato suppression was dependent on species, part used and concentrations of the donor species. It is concluded that all three species (Juglans sp., Cedrus sp., and Pinus sp.) have allelopathic effect and can suppress the germination of the two major weeds. However, at the same time, the allelopathic potential of these donor species also negatively affect the potato. Therefore selective application of these extracts in potato crop is suggested. However, further research is suggested to make concept of the allelopathy applicable and easy for the farmers.

Keywords: Allelopathy, aqueous extracts, *Chenopodium album,* donor plants, *Solanum tuberosum*.

Citation: Umm-e-Kulsoom, S. Hashim, F. Wahid, H. Gulzar, and T. Bakht. 2019. Response of Potato and Associated Weeds to Water Extracts of Major Trees of Upper Dir Khyber Pakhtunkhwa Pakistan. Pak. J. Weed Sci., 25 (2): 111-119

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important and major vegetable and cash crop for the farmers of district Dir (Upper), Khyber Pakhtunkhwa, Pakistan. Dir consists of hilly areas and thus the farmers have small land holdings. The farmers in the area always prefer cash crops due to the fact that the cash crops and especially the potato fetches higher price in the market. As the quality and taste of the potato produced in district Dir is liked by the consumers therefore the farmers earn more money from potato as compared to other cash crops. Thousands of tons of potato are produced each year in Dir and transported to different parts of the country mainly Gujranwala, Punjab. The primitive methods of sowing, irrigation and harvesting are used by the potato farmers. Therefore, there is a need to train the farmers by using latest crop production techniques. Due to the primitive methods of agriculture, the yield of potato is lower in the region. Thus, all cultural practices need to be improved to get higher yield of potato including weed management. Among other factors of yield reduction, the problem of weeds is also important. Despite the small land holdings, the farmers ignore the weed management in potato crop. In addition to other factors, the presence of several indigenous species like *Juglans* sp, *Cedrus* sp, and *Pinus* sp. are the major trees in the area and are found around the potato fields. These trees are distributed randomly and the farmers want these trees to be present so that they can get the wood to be used as fuel. The above mentioned trees release allelochemicals into soil therefore, it is expected that the allelochemicals released by these trees will have negative effect on the growth of potato and associated weeds. The potential of the allelochemicals to inhibit the growth of potato and associated weeds is not well documented.

Allelopathy is the direct or indirect effects of chemicals released into the environment which influences other organisms (Coder and Daniel, 1999). The use of allelopathy is environment-friendly method to control weeds and increase yield of crops (Cheema, 1988). It has already been reported that several plant species have strong allelopathic effects on other plants. It has been reported that mature plant of sorghum possesses nine allelochemicals that are water soluble having phytotoxic effects on weeds like *Phalaris minor* Retz., *Chenopodium album* L., *Rumex dentatus* L. and *Convolvulus arvensis* L. Therefore the roots of sorghum plants suppressed the biomass of weed up to 50% which resultantly increased the yield of wheat up to 8% (Cheema, 1988). These allelochemicals provide opportunities to release new herbicides (Duke *et al*., 2000). Several studies have shown that various plant species have strong allelopathic potential that can retard the growth of weed species (Afridi and Khan, 2014; Khan *et al*., 2016). There is a potential of using plants as a source of allelopathy against different weeds (Khan *et al*., 2015)

Allelopathy is a viable technique and is extensively studied worldwide for practical application under field conditions. There are success stories but the dose, time of application, method of application and the sources and time of collection of plants give variable results. Therefore all aspects of allelopathy need to be addressed. During the present studies, the major crop of the area (potato) and the major weeds were selected for the studies. In addition, the indigenous plants found nearby the potato fields were also tested for their allelopathic effects.

The water extracts of these three different trees species against potato tubers and the associated weeds were tested with the objectives to identifying major weeds of potato and test allelopathic effect of major trees on weeds and potato yield.

MATERIALS AND METHODS

Laboratory and pot experiments were conducted at Shaheed Benazir Bhutto University Sheringal, Dir Upper, KPK, Pakistan during 2017-2018. Potato fields in the Dir (Upper) district were visited to record the major weeds

associated with potato crop. *Chenopodium album* and *Amaranthus viridis* were found major weeds in the farmers' fields of district Dir and the seeds of these weeds were collected at maturity. There were other weeds present in the potato fields but their densities and distribution were not important in term of potato yield reduction. Therefore, these two weeds were selected for experiments. In addition, the leaves, stem and bark of the *Juglans* sp., *Cedrus* sp. and *Pinus* sp.; the three dominant trees were also collected from the respective locations. Two different concentrations of aqueous extracts of leaves, stem and bark of the *Juglans* sp., *Cedrus* sp. and *Pinus* sp. trees were prepared to check against different major weeds seeds germination %, plant height of potato and number of main stem of potato. In laboratory, the seed germination of different weeds was tested under different concentrations of the extracts.

For pot experiment, completely randomized design was used. In addition, in pot studies, the response of potato to different extracts of the three trees was also tested. The focus of the study was to judge the effects of different concentrations of leaves, stem and bark extracts of J*uglans* sp., *Cedrus* sp. and *Pinus* sp. against the germination % of potato associated weeds, plant height of potato and number of main stems of potato.

The experiments were undertaken in petri dishes (weeds germination) in in petri-dishes under laboratory and the second experiment on potato was conducted in pots in a screen house. Several meaningful parameters like germination percentage, plant height of potato and number of main stems of potato were studied. For this purpose, a small screen house was made. Completely randomized design was used where the weed seeds were sown in petri-dishes and potato in pots. Different extracts of the above-mentioned trees were applied to different seeds and potato tubers. The undergraduate students were trained because the agriculture as a separate department is new in SBB university and thus lacks basic facilities of screen house, petri dishes and other minor equipment.

Collection of allelopathic plants for extracts

Juglans sp, *Cedrus* sp, and *Pinus* sp. were collected from near the farmer fields of district Upper Dir. These leaves, stem and bark were collected separately with help of a cutter. The plants were cleaned from the dust and other particles and then were dried in oven for 72 h at 65°C and then were ground with the help of a grinder. The final ground samples were kept in paper bag for further use in the both experiments. *Chenopodium album* and *Amaranthus viridis* seeds were collected from potato fields during the crop season in different areas of Dir, Pakistan for petri dishes experiments.

Preparation of water extracts

After collection, the dried powder of the allelopathic plants (*Juglans* sp, *Cedrus* sp, and *Pinus* sp) were weighed and mixed in distilled water at 100 and 150 gL^{-1} at room temperature for 48 h and finally filtered to collect the respective water extracts. The extracts were filtered through muslin cloth and finally through Whatman No. 1 filter paper. Water extracts were individually bottled and tagged for further process in the experimentation. Fresh extracts were prepared for both experiments.

Petri dishes experimental details

For the laboratory experiment, the seeds of two weed species (*Chenopodium album* and *Amaranthus viridis*) were placed in petri dishes. Petri dishes (each having 9 cm in diameter) were washed and dried. These Petri dishes were sterilized in autoclave at 110-120^{o}C for 1 h. Two filter papers were kept in each Petri dish and ten seeds of each test species (*Chenopodium album* and *Amaranthus viridis*) were placed. Each treatment had three repetitions. All the Petri dishes were moistened with the help of pipette as per need of the extracts. All the

experimental Petri dishes were kept at room temperature of 20±2°C for 15 days. The germinated seeds in each treatment were counted and percentage were computed and recoded for each treatment. Seed having 2 mm radicle were considered as germinated in petri dish experiment.

Pot experiment experimental details

For the pot experiment, potato tubers of equal size were planted in plastic pots with 12 cm height and 15 cm in diameter, filled with 1 kg of soil. These pots were replicated three times. All the plastic pots were irrigated with the help of mini sprayer as per needed. All the experimental plastic pots were discarded after 45 days. In pot experiment after germination, the plant height of potato was measured with a ruler in cm for all the germinated plants in each treatment and number of main stems of potato was noted then means were calculated.

There were ten treatments in each (petri-dish and pot) experiment in which one was a control. Each treatment was replicated three times in completely randomized design. The experiments were repeated once to confirm the findings. Separate experiments were conducted by testing two concentrations of the allelopathic plants.

The variables like germination percentage of *Amaranthus viridis,* germination percentage of *Chenopodium album,* plant height of potato and number of main stems of potato were recorded.

In peti-dishes and in pots the leases, bark and stem of *Cedrus* sp., *Pinus* sp and *Juglans* sp. were used at two concentrations (100 g L^{-1} and 150 g L^{-1}. Control was also included for comparison.

STATISTICAL ANALYSIS

After termination of the experiments and collection of data, the data for each parameter were subjected to the analysis of variance and the significant means were separated using STATISTIX 8.1 and means were separated using LSD test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Seed germination of *Amaranthus viridis*

The aqueous extracts of the three donor plant species like *Cedrus* sp., *Pinus* sp. and *Juglans* sp. showed that both the concentrations of these species significantly decreased the seed germination of *Amaranthus viridis* (Table-1). Data showed that at concentration of 100 g L^{-1}, highest seed germination of *A. viridis* was observed in the control which was significantly higher than the rest of the treatments. These results confirmed the presence of allelochemicals in these donor plant species. However, the degree of decreasing the the seed germination of the weed was dependent on the donor plant. It was revealed that allelopathic effect of *Pinus* leaves was more effective by decreasing the seed germination. *Pinus* sp proved more allelopathic as compared to the other species like *Juglans* and *Cedrus*. Afridi and Khan (2015) also communicated that phytochemicals can be used for weed suppression in field conditions. However, more scientific understanding is still unknown to scientists.

Amaranthus viridis is a broadleaf weed and thus can compete with potato for the above ground and below ground resources. Therefore, the negative impact of the alleloapthic effects on this weed can be further explored for weed suppression. It has previously reported that essential oils extracted from plants can stop the seed germination and growth of several crops and inhibit germination of weeds like *Amaranthus palmeri* and *Brassica nigra* (Dudai, 1999).

The data in Table-1 shows the allelopathic effect of the donor plant at concentration of 150 g L^{-1}. The results of aqueous extracts of *Juglans* sp., *Cedrus* sp.and *Pinus* sp. on seed germination of *A. viridis* were similar at lower (100 g L^{-1}) and higher concentration (150 g L^{-1}). At lower concentration the *Pinus* sp was more toxic for the seed germination of

A. viridis. While the allelopathic effect of *Cedrus* sp. and *Juglans* sp. were statistically comparable. While at higher concentration (150 g L^{-1}), the *Pinus* sp. was promising by decreasing seed germination of *A. viridus* followed by *Cedrus* sp. These results confirmed the stronger allelopathic effect of *Pinus* sp. and thus can be used for weed management. Data further revealed that the allelopathic compounds are different in different parts of the plants like bark, leaves and stem. As per our visits to the different fields of potato, *A. viridus* was noticed as the major weed of potato. Therefore, in light of the present findings, it is suggested that different parts of the donor plants need to be tested for the suppression of *A. viridus*. As failure of seed germination of any weed is considered a viable and effective weed management technique therefore in light of the present studies, it is concluded that these donor plants need to be explored for the management of *A. viridis.* Use of allelopathic plants for weed suppression is passing through experimental stages and there is a hope that in near future, botanical extracts will be commercialized. Because botanical extracts are environment friendly and cost effective. In addition, no special precautionary measures need to be adopted for their application. Therefore, it is suggested that all the parts of the selected plants need to be tested against other weed species for possible success. By reporting and confirming the allelopathic effects of a plant species, Tet-Vun and Ismail (2006) reported that *D. linearis* cause its allelopathic effect on weed density, emergence, and growth via its secretion of these phenolic compounds into the soil. Khan *et al.* (2016) also reported that many plants have very strong allelopathic effects and thus can be used for weed suppression. They suggested that weed extracts alone and in combination with other extracts or low dose of herbicides were more effective to control weeds.

Seed germination of *Chenopodium album*

Chenopodium album is a broadleaf weed and is considered as a major competitive weed with many crops. Due to bigger biomass and higher seed production potential, this weed is successful in agro-ecosystem. The data in Table-2 depicted that seed germination of *C. album* was maximum in control and minimum in the treatments where water extracts of Juglans bark was used. The seed germination in the rest of the treatments was comparable to the rest of the extracts. However, there were variations depending on the species of the donor species and concentration. It was noted that the allelopathic effect of the water extracts on the *A. viridus* was more pronounced as compared to *C. album*. Hence it can be concluded that *C. album* was more tolerant to the water extracts of the tested donor species as compared to A. *viridus*. This might be the reasons that *C. album* is more successful and dominant species in the areas visited. Marwat *et al.* (2008) claimed that the effect of plant based water extracts were effective to cause reduction in weed seed germination and their growth. Therefore, they suggested that all available local fauna need to be tested for their allelopathic effects.

The data in Table-2 also show similar trends. The data show when the donor plant water extracts were applied at 150 g L^{-1}. There was a consistent negative effect of water extracts of all the donor plant species on the seed germination of *C. album* when compared with the control. However, the negative effect of the donor plants on the germination was stronger when applied at higher concentrations. Therefore, these results are meaningful for biologist and thus these donor species like *Juglans* sp., *Cedrus* sp. and *Pinus* sp. can be further used for weed suppression. To confirm the results and formulate weed management strategy the joint venture of all allied subjects is suggested to isolate the chemical compounds and use practically for weed

suppression in field conditions. Because, *C. album* is considered a major weed in many countries of the world including Pakistan. Razzaq *et al.* (2010) also found that weeds associated with wheat crop were decreased due to application of allelopathic plant water extracts. They suggested that aqueous extracts of the plants in combination with reduced dose of herbicides can be used in field for weed management.

Number of main stems of potato

The water extracts of different parts (bark, stem and leaves) of three donor plants like *Juglans* sp, *Cedrus* sp and *Pinus* sp were used for their allelopathic effects on weeds. Any negative effect on weed seed germination and growth suppression is considered as a success. However, any negative effect on the potato is undesirable. Because, any negative effect on number of main stems of potato will decrease the yield of potato. Therefore any negative effect of the water extracts of the donor plants were also studied for meaningful results. The data presented in Table-3 showed that two of the treatments (leaves of the *Pinus* sp and bark of the *Juglans* sp.) significantly decreased the number of main stems of potato almost by 50%. These results showed that the donor plants can negatively affect the potato as well. Like the weeds, the potato is also affected by the water extracts of the donor plants. Therefore, these results are alarming for the farmers. Because all the three types of the donor plants are present on the sides of the fields. The plant materials like leaves and bark etc are mixed with the soil and thus are added to the potato fields. In addition, when rains occur or snowfalls will also cause washing of the leaves and bark and thus the phytochemicals are dissolved and thus added to the soil directly or indirectly. In this way, the potato growth can be affected. The data in Table-3 exhibit that when the donor plants were applied at higher rate (150 g/L). The results were similar to lower concentration.

The data regarding number of main stems of potato show that the allelopathic plants can not only suppress weeds but can also affect the main crops like potato (Table-3). Therefore, selected application of allelopathic plants for weed suppression by avoiding the crop plants is suggested. As the farmers intentionally grow the above mentioned donor plants because these plants are used by the farmers for fuel wood, timber wood and other uses therefore the presence of these donor plants on the sides of agricultural field needs to be discouraged. More studies, to detect the phytochemicals in the soil and their concentrations that can significantly affect the weeds and crop plants are also suggested. Uddin *et al*. (2013) also found similar results. They observed that allelopathic plants provide unlimited opportunities to be used for suppression of other plants. However, further studies were suggested for selective application of plant based extracts.

Plant height (cm) of potato

Biomass and height of the plant shows their competitive ability with the weeds. The data presented in Table-4 showed that at lower concentration, the plant height of potato was maximum in control (no extract) as compared to the rest of the treatments except the treatment where *Juglans* bark was used. This treatment was statistically comparable with the control. All other treatments significantly decreased the plant height of potato. It revealed that the *Juglans* sp., *Cedrus* sp. and *Pinus* sp. contain water soluble compounds that can suppress the growth of potato. When the extracts were used at higher concentration (150 g/L) then the trend was similar to lower concentrations (Table-4). Thus, the lower and higher concentrations were comparable and verified the allelopathic effects on the biomass and plant height of potato.

In light of the present findings, it is suggested that the studied donor plants have allelopathic effects and can suppress any plant. Therefore, the presence of these donor plants on the sides of agricultural fields needs to be discouraged. However, to accommodate the farmers, alternate trees be suggested because these donor plants are need of the farers for different purposes. Farooq *et al*. (2013) found

that plants can be used for pest management including insects, weeds and pathogens. However, all these plants against various pests are passing through experimental stages and thus more studies were suggested.

Table-1. Seed germination % of *Amaranthus viridus* in different extracts with and concentrations (100 g L^{-1} and 150 g L^{-1}).

Treatments	**100 g L^{-1}**	**150 g L^{-1}**
Control	40.000 a	43.333 ab
Cedrus sp. leaves	23.333 abc	23.333 bc
Cedrus sp. Stem	30.000 abc	30.000 abc
Cedrus sp. Bark	20.000 abc	26.667 bc
Pinus sp. Leaves	10.000 c	50.000 a
Pinus sp. Stem	16.667 bc	30.000 abc
Pinus sp. Bark	23.333 abc	10.000 c
Juglans sp. Leaves	26.667 abc	43.333 ab
Juglans sp. stem	36.667 ab	30.000 abc
Juglans sp. bark	26.667 abc	43.333 ab
$LSD_{0.01}$	21.816	21.201

Table-2. Seed germination % of *Chenopodium album* in different extracts with concentrations (100 g L^{-1} and 150 g L^{-1}).

Treatments	**100 g/L**	**150 g/L**
Control	50.000 a	46.667 a
Cedrus sp. leaves	43.333 ab	40.000 ab
Cedrus sp. Stem	40.000 abc	33.333 ab
Cedrus sp. Bark	36.667 abc	36.667 ab
Pinus sp. Leaves	33.333 bc	46.667 a
Pinus sp. Stem	43.333 ab	40.000 ab
Pinus sp. Bark	36.667 abc	43.333 ab
Juglans sp. Leaves	30.000 bc	33.333 ab
Juglans sp. stem	30.000 bc	26.667 b
Juglans sp. bark	26.667 c	33.333 ab
$LSD_{0.01}$	14.770	13.846

Table-3. Effect of different concentrations on number of main stems of potato in different extracts with concentrations (100 g L^{-1} and 150 g L^{-1})

Treatments	**100 g/L**	**150 g/L**
Control	2.33 bc	3.33 ab
Cedrus sp. leaves	3.67 ab	2.33ab
Cedrus sp. Stem	4.00 a	4.00ab
Cedrus sp. Bark	2.67 abc	4.00ab
Pinus sp. Leaves	2.00 c	4.33a
Pinus sp. Stem	3.33 abc	4.33a
Pinus sp. Bark	3.00 abc	3.67ab
Juglans sp. Leaves	3.67 ab	3.67ab
Juglans sp. stem	2.00 c	2.00b
Juglans sp. bark	3.00 abc	4.33a
$LSD_{0.01}$	1.4544	2.1045

Table-4. Plant height (cm) of potato in different extracts with concentrations (100 g L^{-1} and 150 g L^{-1}).

Treatments	**100 g/L**	**150 m/L**
Control	45.00 a	36.50a
Cedrus sp. leaves	18.53 c	22.00bc
Cedrus sp. Stem	25.73 bc	16.50c
Cedrus sp. Bark	34.67 abc	33.83ab
Pinus sp. Leaves	35.67 abc	32.00ab
Pinus sp. Stem	34.63 abc	28.17abc
Pinus sp. Bark	28.10 abc	34.67ab
Juglans sp. Leaves	43.60 ab	23.50abc
Juglans sp. stem	37.23 ab	32.00ab
Juglans sp. bark	46.00 a	26.00abc
LSD0.1	18.601	13.821

CONCLUSION

Overall the results showed that the studied donor plants have allelopathic effects and thus can affect the germination and distribution pattern of the associated plants. Therefore, further comprehensive studies are suggested to explore all aspects of these donor plants for their use in weed management programs.

ACKNOWLEDGEMENTS

The authors are highly indebted to the Higher Education Commission, Islamabad, Pakistan for providing funds to undertake this Research under 21-1384/SRGP/R&D/HEC/2016.

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