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Impact of allelochemicals from sorghum and sunflower on germination parameters of wheat and *Phalaris minor*

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Abstract
A laboratory experiment was conducted in seed physiology laboratory of Department of Agronomy, GBPUA&T, Pantnagar to evaluate the allelopathic potential of aqueous extracts of sorghum and sunflower on germinating seedlings of *Phalaris minor* and wheat. Sorghum and sunflower aqueous extracts were applied at the rate of 10% (w/v) on the seed of *Phalaris minor* and wheat and the parameters like germination percent, total seedling length, seed vigour index, root length, shoot length, relative elongation ratio of root, relative elongation ratio of shoot, phytotoxicity percent were calculated. In all the calculated parameters it was found that the aqueous extracts of both sorghum and sunflower are highly allelopathic to *Phalaris minor* and they have a very little effect on wheat. Both sorghum and sunflower aqueous extracts significantly reduced the germination of *Phalaris minor* as compared to control (distilled water), but sunflower was more allelopathic than sorghum with 85.5% of germination inhibition.

Keywords: Allelopathy, aqueous extract, *Phalaris minor*, sorghum, sunflower

Introduction
Wheat is the most important cereal crop of the world and the second most important in India having 30.17 million hectare area and 99.70 million tonnes of production (Anonymous, 2018) [2]. It has a lion share of. about 35% in national food basket. Wheat is a very rich source of nutrients, which have 76% carbohydrate, 1.5% fat and 13% protein. Albumins, globulins are the major proteins of the gluten complex. The contents of minerals and of dietary fibers are very low; 0.5% and 1.5%, respectively (Belderok *et al.*, 2000) [5]. Rice-wheat cropping system is the most dominant cropping system of India. In Rice-Wheat cropping system along with other traditional weed flora *Phalaris minor* became a major problem causing drastic reduction in wheat yield (Chhokar *et al.*, 2006) [8]. Wheat fields in Northern India are badly infested with wide range of grassy and non grassy weeds in general and *Phalaris minor* Retz. in particular. Continuous application of herbicides at suboptimal dose, *Phalaris minor* gradually developed resistance against these **(**Chhokar and Malik, 2002) [7]. Hence, to tackle this problem alternative weed control methods like allelopathic approach can be a potential tool in future.

Materials and Methods
The laboratory experiment was conducted in seed physiology laboratory, Department of Agronomy, Collage of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand**.** Sorghum and sunflower biomass was collected from the Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and were shade dried for about one week at Weed management block (D2). Then the biomass of sorghum and sunflower shade dried at 65±5 ºC for 72 hours and finely ground with an electric grinder after fully drying. The grinded biomass was placed in an air tight container in cool and dry place. The ground biomass was weighed using high precision electronic balance. After this the grinded biomass was well mixed in distilled water and soaked for 48 hours in refrigerator to avoid fermentation. This was then filtered using muslin cloth to get aqueous extract. Using this method aqueous extracts of sorghum and sunflower of 10% concentration (w/v, dry weight basis) was prepared.
The experiment was carried out in Completely Randomized Design (CRD), with three treatments *i.e.* control (distilled water), 10% aqueous extract of sorghum, 10% aqueous extract of sunflower, each with three replications.

Healthy, disease free and uniform seeds of both wheat (variety-DBW 17) and *Phalaris minor* were collected and treated with thiram to avoid fungal infection. Petridishes with 15cm diameter was also taken and cleaned properly with chromic acid to remove all the dirt adhering with it. Then it was washed with distilled water and put in hot air oven for drying. After the drying is completed the petridishes were sterilized with methanol. On the bottom side of petridish two filter papers were put to hold the aqueous extract. Then 50 seeds were arranged uniformly on the filter paper and 5ml aqueous extract was added to each petridish with help of pipette. Finally the pertidishes were put in a seed incubator at 25±1 ºC for 7 days for the germination procedure to be completed. Followings are the parameters calculated-

1. Germination percent

Germination percentage is calculated on the final day *i.e.*7th day after putting for germination. It is calculated as the ratio of number of healthy germinated seedlings to the number of total seeds set for germination. The seedlings which have at least 2mm long radical are said to be germinated. During this process diseased, incompletely germinated, fungal infected, insect infected seedlings are not considered as germinated. The observation was taken according to the Association of Official Seed Analysts method (AOSA,1998) [4].

$$\text{Germination percent} = \frac{\text{No. of seeds produced normal seedlings}}{\text{No. of seedlings set for germination}} \times 100$$

2. Seedling length(cm)

Total seedling length was calculated by adding mean root length with the mean shoot length and expressed in cm.

3. Seed vigor index

It is calculates as the product of germination percent and mean seedling length. It gives an information about the health of plant.

Seed vigor index= Germination percent× Mean seedling length

4. Root length(cm)

The root length of five randomly selected seedlings were taken on the final day by a scale and their average was taken and expressed in cm.

5. Shoot length(cm)

The shoot length of five randomly selected seedlings were taken on the final day by a scale and their average was taken and expressed in cm.

6. Relative elongation ratio of root (%)

Is is defined as the ratio of root length of treated plant to ratio of root length of control plant (Rho and Kill,1986) [11].

$$\text{Relative elongation ratio (root)} = \frac{\text{Mean root length of treated plant}}{\text{Mean root length of control}} \times 100$$

7. Relative elongation ratio of shoot (%)

It is defined as the ratio of shoot length of treated plant to ratio of shoot length of control plant (Rho and Kill,1986) [11].

$$\text{Relative elongation ratio (shoot)} = \frac{\text{Mean shoot length of treated plant}}{\text{Mean shoot length of control}} \times 100$$

8. Phytotoxicity per cent (%)

The symptoms of phyto- toxicity include discoloured roots, shortened roots, inhibition of root hair development *etc.* The phyto toxicity symptoms are prominent at the early stages of growth. The symptoms can also be seen in the plumular region. The formula was proposed by Surendra and Pota (1978) [12].

$$\text{Phytotoxicity percentage} = \frac{\text{Seedling length of control-seedling length of treated plant}}{\text{Seedling length of control}} \times 100$$

Results and Discussions

Germination percent (7 days after incubation)

From the table 1, it can be observed that there is no significant difference in germination of wheat between the treatments, which is a desirable character. But, numerically maximum germination percent was found in case of control and extract of sunflower (96.00%). However, minimum (94.0%) was achieved by the application of extract of sorghum at 10 %.

In case of *Phalaris minor* highest germination was observed in control (82.66%). In case of aqueous extract of sunflower lowest germination percent of *Phalaris minor* was found (12%), which is significantly lower than both control and aqueous extract of sorghum at same concentration. The application of aqueous extract at 10 percent concentration reduced the population of *Phalaris minor* by 85.4% and 42.7% under sunflower and sorghum extracts respectively with respect to control.

It is evident that sorghum and sunflower extracts have strong allelopathic effect on *Phalaris minor* but little allelopathic effect on wheat. It also matches with the findings of Cheema (1988) [6] and Anjum and Bajwa (2005) [1].

Among sorghum and sunflower, sunflower has higher inhibitory effect on *Phalaris minor* and it also does not affect germination of wheat, there by fulfilling our aim. Hence, sunflower aqueous extract can be used as a potential tool for *Phalaris minor* control in wheat. Based on these findings a field experiment was also conducted by the sequential (pre *fb* early post) application of both the aqueous extracts of sorghum and sunflower at same concentration (10%).

Seedling length(cm) (7 days after incubation)

The seedling length of wheat and *Phalaris minor* was affected by aqueous extract of sorghum and sunflower in the same manner as root length and shoot length.

Seedling length was found maximum in wheat (13.73cm) and *Phalaris minor* (11.16cm) under control treatment. However, minimum seedling length was found under aqueous extract treatment of sunflower *i.e.* 4.11cm and 5.14cm in wheat and *Phalaris minor*, respectively. In both the cases the seedling length is significantly lower in aqueous extract of sunflower treatment than control and aqueous extract of sorghum applied treatment. The seedling length under aqueous extract of sorghum treatment was significantly lower than control but significantly higher than aqueous extract of sunflower applied treatment.

Seed vigor index

Highly significant variation was observed between the treatments for seed vigour index of wheat as well as *Phalaris minor*. The maximum seed vigour index of wheat was achieved under control (1346.24), which is followed by application of aqueous extract of sorghum (1259.47) and aqueous extract of sunflower (354.20) at 10 percent

concentration. The similar type of significance was also found in *Phalaris minor*. .

This might be due to the presence of allelochemicals present in both crop biomass, which cause the germination inhibition of *Phalaris minor* and suppression of seedling elongation of wheat. This may be desirable in case of *Phalaris minor* but not at all desirable in case of wheat crop.

Table 1: Effect of aqueous extracts of sorghum and sunflower (10%) on germination percent, seedling length, seed vigour index of wheat and *Phalaris minor*

Treatment	Germination percent		Seedling length(cm)		Seed vigor index	
	Wheat	*Phalaris minor*	Wheat	*Phalaris minor*	Wheat	*Phalaris minor*
Control (distilled water)	96.00	82.66	13.73	11.16	1346.24	10.05 (1016.72)
Sorghum (10%)	94.00	47.33	12.19	8.52	1259.47	7.63 (557.31)
Sunflower (10%)	96.00	12.00	4.11	5.14	354.20	3.94 (52.75)
SEm±	0.94	1.30	0.20	0.08	15.35	0.02
CD (5%)	NS	4.50	0.74	0.30	54.14	0.59

*Original values are given in parenthesis

Root length(cm) (7 days after incubation)

The maximum root length of wheat and *Phalaris minor* was found under control situation (6.6 and 4.83 cm respectively.), which is significantly higher than aqueous extract of sorghum and sunflower treated seeds. However, smallest root length was obtained with aqueous extract of sunflower treatment (2.96cm and 0.76 cm), followed by aqueous extract of sorghum treatment (5.38 and 3.51cm) in wheat and *Phalaris minor*seedlings, respectively. This revaels that sunflower aqueous extract significantly retards root growth of wheat and *Phalaris minor* seedling.

From this parameter we can conclude that sunflower has a good amount of allelopathic effect on both wheat and *Phalaris minor* by retarding their root growth. This may be due to five allelochemicals like (chlorogenic, caffeic, syringic, vanillic and ferulic acid) in leaves, three allelochemicals in stem (chlorogenic, ferulic and vanillic acids) and only one (ferulic acid) in the roots (Ghafar *et al*., 2001) [9].

Shoot length(cm) (7 days after incubation)

Shoot length of wheat and *Phalaris minor* seedlings are affected in the same manner as the root length by aqueous extract of sorghum and sunflower.

The maximum shoot length of wheat and *Phalaris minor* was found under control situation (7.13 and 6.33 cm respectively.), which is significantly higher than aqueous extract of sorghum and sunflower treated seeds. However, smallest shoot length was obtained with aqueous extract of sunflower treatment (1.15cm and 4.38 cm), followed by aqueous extract of sorghum treatment (6.81and 5.01cm) in wheat and *Phalaris minor*seedlings respectively. This reveals that sunflower aqueous extract significantly retards shoot growth of wheat and *Phalaris minor* at seedling stage.

Here an inference can be drawn that sunflower has a good amount of allelopathic effect on both wheat and *Phalaris minor* by retarding their shoot growth. Same type of results was also repored by Kandhro *et al.* (2016) [10] with cotton as a test crop.

Relative elongation ratio of root (%)

Relative elongation ratio of root gives an idea about elongation of roots in treated plants if we consider elongation of root in control as 100. In wheat seedlings this parameter was found maximum in control (100) followed by aqueous extract of sorghum (81.52) followed by aqueous extract of sunflower (44.85). In *Phalaris minor* seedlings also the same trend is observed *i.e.*control (100) followed by aqueous extract of sorghum (72.67) followed by aqueous extract of sunflower (15.73).There exists significant difference between all the three treatments

This type of results confirms the fact that there exists allelopathic effect of sorghum and sunflower on both wheat and *Phalaris minor*. The effect is very high in case of *Phalaris minor* as compared to wheat crop.

Relative elongation ratio of shoot (%)

Relative elongation ratio of shoot gives an idea about elongation of shoots in treated plants if we consider elongation of shoot in control as 100. In wheat seedlings this parameter was found maximum in control (100%) followed by aqueous extract of sorghum (95.51%) followed by aqueous extract of sunflower (16.12%). There exists significant difference between all the three treatments. In *Phalaris minor* seedlings also the same trend is observed *i.e.*control (100%) followed by aqueous extract of sorghum (76.34%) followed by aqueous extract of sunflower (46.06%).There exists significant difference between all the three treatments.

Here an inference can be drawn that, there exists an allelopathic effect of sorghum and sunflower on both wheat and *Phalaris minor*. The effect is very high in case of *Phalaris minor* and little in case of wheat.

Table 2: Effect of aqueous extracts of sorghum and sunflower (10%) on root length, shoot length, Relative elongation ratio of root, Relative elongation ratio of shoot of wheat and *Phalaris minor*

Treatment	Root length		Shoot length		RERR		RERS	
	Wheat	*Phalaris minor*	Wheat	*Phalaris minor*	Wheat	*Phalaris minor*	Wheat	*Phalaris minor*
Control (distilled water)	6.6	4.83	7.13	6.33	100	100	100	100
Sorghum (10%)	5.38	3.51	6.81	5.01	81.52	72.67	95.51	76.34
Sunflower (10%)	2.96	0.76	1.15	4.38	44.85	15.73	16.12	46.06
SEm±	0.09	0.06	0.06	0.08	0.77	0.31	1.01	0.79
CD (5%)	0.34	0.23	0.22	0.28	2.71	1.09	3.56	2.78

RERR- Relative elongation ratio of root, RERS-Relative elongation ratio of shoot

Phytotoxicity percent

Phytotoxicity percent is a vital parameter, which gives an idea about the extend of phytotoxicity of allelochemicals with respect to control. This is calculated on the basis of seedling lengths. The treatments are assigned a value out of 100% if the phytotoxicity of control is taken as 0%.

In case of wheat seedling significantly higher phytotoxicity is observed with aqueous extract of sunflower treatment (53.94%) followed by aqueous extract of sorghum (11.22%). The same trend was also observed on *Phalaris minor* that is significantly higher phytotoxicity is observed in case of aqueous extract of sunflower treatment (70.06%) followed by aqueous extract of sorghum extract (23.65%). All the treatments are significantly different.

Based on the results of laboratory experiment, it was obvious that aqueous extract of sunflower was more inhibiting than sorghum for *P. minor*.

Table 3: Effect of aqueous extracts of sorghum and sunflower (10%) on phytotoxicity percent of wheat and *Phalaris minor*

Treatment	Phytotoxicity %	
	Wheat	*Phalaris minor*
Control (distilled water)	0	0
Sorghum (10%)	11.22	23.65
Sunflower (10%)	53.94	70.06
SEm±	0.40	0.88
CD (5%)	1.40	3.06

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