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Effect of aqueous extract of sorghum and sunflower on field emergence and growth parameters of wheat and *Phalaris minor*

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Abstract
A field experiment was carried out in G.B Pant University of Agriculture and Technology, Pantnagar during *rabi* season of 2018-19 to find out the effect of aqueous extracts of sorghum and sunflower on growth parameters of wheat and *Phalaris minor*, as well as their effects on yield of wheat. The experiment was conducted with eight treatments, each with three replications in Randomized Block Design (RBD). Treatment containing pre *fb* early post-emergence application of sunflower extract recorded lower emergence and no of shoots/m^2 of *Phalaris minor*. The treatments had non significant effect on the emergence of wheat. Weed free plot had highest no of shoots/m^2 of wheat, which was at par with pre *fb* early post-emergence application of sunflower extract in every stage of plant growth. The grain yield of weedy, pre *fb* early post emergence application sorghum, pre *fb* early post emergence application sunflower, weed free plot was recorded as 2331, 4126, 4385, 5137 kg/ha respectively.

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

Introduction
Wheat is one of the second most important crop of India next to rice. On the world scale the crop occupies about 17% crop land and contributes 35% of the food grain production, hence have a vital role on global food security in coming future (Tesfay *et al.*, 2014) [15]. Wheat 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) [3]. In Pantnagar Singh *et al.* (2001) [14] reported that uncontrolled weeds caused 45.6% reduction in the grain yield of wheat as compared to weed free condition. Hence, to manage the weeds in wheat field conventionally farmers go for chemical method of weed management. Among all the grassy weeds associated with wheat *Phalaris minor* is the most noxious one and require a huge application of herbicides for its control Om *et al.* (2002) [12]. Due to repeated application of herbicides in a sub optimal dose *Phalaris minor* gradually developed resistance to many of the conventional herbicides like Isoproturon (Chhokar and Malik, 2002) [6]. However, isoproturon resistant *Phalaris minor* was reported first in 2011 from GBPUAT, Pantnagar (AICRP WM, Pantnagar). To tackle the emerging problem of herbicide resistance in *Phalaris minor* allelopathic approach can be a potential tool (Dimitrova, 2008) [7]. In several experiments it is reported that both sorghum and sunflower are have a very good allelopathic effect in controlling *Phalaris minor*, without hampering wheat crop (Cheema, 1988; Naseem, 1997) [5, 11].

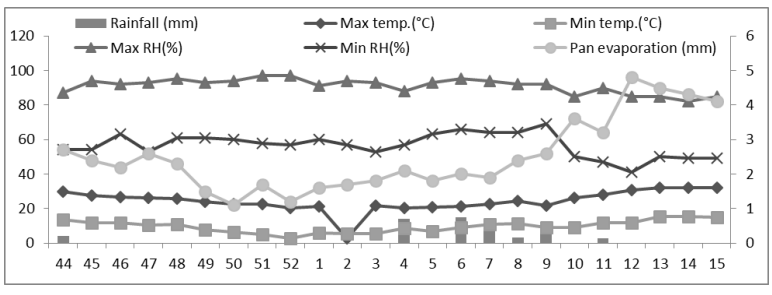

Fig 1: Meteorological data of *rabi* season of 2018-19

Material and methods

An one year field experiment was conducted during *rabi* season of 2018-19 at N.B Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The area under study received an rainfall of 40 mm, with maximum temperature of 32˚C and minimum temperature of 5˚C during the study period. (Figure 1). The soil of the experimental site was clay loam in texture with 0.92% organic matter, and pH of 6.9. Available N, P and K content in the soil was 248.3, 27.7 and 182.4 kg/ha, respectively. Wheat variety DBW 17 with seed rate of 100 kg/ha was sown manually in 20 cm row-row spacing. Crop was fertilized with 120:60:40 kg N, P_2O_5 and K_2O/ha. P_2O_5 and K_2O were supplied at basal and N was applied with three splits (50% basal, 25% at first irrigation, and 25% at second irrigation). The experiment was laid out in a randomized block design with three replications. The aqueous extracts were applied at pre-emergence (1 DAS) and early post-emergence (10 DAS) using 400l/ha of water with knapsack sprayer fitted with a flat fan nozzle.

For preparing aqueous extract of sorghum and sunflower the fresh biomass of these crops were dried under shade for one week and then dried at 65±5˚C in electric drier for 72 hours. After full drying the biomass was ground finely in electric grinder. 10% (w/v) aqueous extract was prepared by dissolving 400g of dried biomass powder in 4l of distilled water.

At the time of sampling (20, 40, 60 days after sowing and maturity; DAS), a quadrate of 50 × 50 cm^2 was placed at a fixed place in each plot to determine the dry weight of *Phalaris minor*. Dry weight was recorded after drying the samples at 65±5˚C for 72 h. Weed control efficiency was calculated based on the data recorded at 20, 40, 60DAS and maturity in wheat as per standard formula. Number of spikes/m^2, spike length (cm), grains/spike, 1000 grain weight (g), grains/panicle, grain and straw yield (kg/ha) was recorded just before harvesting. The grain and straw yield was recorded from net plot area of 1.2 m^2 area, and wheat grain yield was expressed at 12% moisture content.

Data were analyzed using statistical package STPR, developed by College of Basic Science and Humanities, GBPUA&T, Pantnagar. The data of *Phalaris minor* dry matter was square root transformed before analysis. The CD was provided at 5% level of significance.

Results and discussion

Emergence count of wheat and *P. minor*

The emergence of wheat per square metre was found non significant under various treatments. However, numerically, highest (275) and lowest (228) emergence of wheat per square metre was found under aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence and control, respectively at 15 DAS.

Table 1: Effect of aqueous extracts of sorghum and sunflower (10%) on emergence count (no./m^2) of wheat and *Phalaris minor*

Treatments	Application stages(DAS)	Emergence count (No./m^2) (15 DAS)	
		Wheat	*Phalaris minor*
Control (No Application)	-	228	10(103)
Sorghum (10%) PE	1 DAS	248	8(61)
Sorghum (10%) EPoE	10 DAS	258	9(73)
Sorghum (10%) PE *fb*EPoE	1 DAS & 10 DAS	275	6(37)
Sunflower (10%) PE	1 DAS	235	8(59)
Sunflower (10%) EPoE	10 DAS	260	8(68)
Sunflower (10%) PE *fb*EPoE	1 DAS & 10 DAS	269	5(25)
Weed free	-	260	1(0)
SEm±	-	21.21	0.33
CD(0.05)	-	NS	1

*Original values are given in parenthesis; PE= pre emergence, EPoE= early post emergence

The emergence of *Phalaris minor* was significantly affected by the application of sorghum and sunflower aqueous extract. The emergence of *Phalaris minor* was recorded lowest in aqueous extract of sunflower at concentration of 10%, applied as pre *fb* early post-emergence spray (25/m^2), which was statistically at par with aqueous extract of sorghum at concentration of 10%, applied as pre *fb* early post-emergence spray (37/m^2). Highest emergence of *Phalaris minor* was observed in control plot (103/m^2) whereas, remaining treatments were found at par with one another. These findings are in agreement with the findings of Cheema (1988) [5] and Anjum and Bajwa (2005).

Number of shoots

Wheat

At all the stages of wheat growth numerically highest and lowest plant density of wheat was found in case of weed free and control plot respectively. The reason behind this is zero weed competition and severe weed competition respectively.

At 20 DAS, statistically highest and lowest plant density was found in weed free (302/m^2) and control plot (232/m^2) respectively. All the other treatments were found at par with each other.

At 40 DAS highest plant density was recorded in weed free plot (734), which was statistically similar with aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray (723/m^2) and aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray (702/m^2). Which is further followed by aqueous extract of sunflower10% pre-emergence spray (634/m^2), aqueous extract of sunflower10% early post-emergence spray (621/m^2), aqueous extract of sorghum 10% pre-emergence spray (607/m^2). Statistically lowest plant density was recorded in control plot (492/m^2)

At 60 DAS significantly highest plant density was observed in weed free (767/m^2) treatment, that was statistically at par with aqueous extract of sunflower10% pre-emergence*fb* early post-emergence spray (759/m^2). The plant density of aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray was at par with the latter one.

Table 2: Effect of aqueous extracts of sorghum and sunflower (10%) on number of shoots/m^2 of wheat

Treatments	No. of shoots /m^{2}of Wheat		
	20 DAS	40 DAS	60 DAS
Control (No Application)	232	492	518
Sorghum (10%) PE	277	607	638
Sorghum (10%) EPoE	296	582	617
Sorghum (10%) PE *fb*EPoE	284	702	734
Sunflower (10%) PE	271	634	667
Sunflower (10%) EPoE	279	621	650
Sunflower (10%) PE *fb*EPoE	298	723	759
Weed free	302	734	767
SEm±	11.31	11.21	10.25
CD (5%)	35	34	31

PE= pre emergence EPoE= early post emergence

From the above mentioned data, an inference can be drawn that the allelochemicals have a little effect on the tillering and growth of wheat crop, which also agrees with the result obtained from the laboratory experiment conducted earlier. Hence, the variation among the treatments with regard to plant density is due to weed competition, that means plot having higher *Phalaris minor* population has lower plant density of wheat. This type of result is also reported by Duary and Yaduraju (2005) [8] from IARI, New Delhi. According to him as the density of weed increases, the plant population per unit area of wheat reduces. It can also be observed that the treatment with aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray has a better performance than rest of the treatments in every stage of crop growth. This depicts the probable cause that sunflower has a better allelopathic effect than sorghum on *Phalaris minor* and combined application both at pre and post-emergence gives an advantage over sole application.

Phalaris minor

At 20DAS, the number of shoots of *Phalaris minor* varied significantly among the treatments. The lowest number of shoots of *Phalaris minor* were recorded under aqueous extract of sunflower10% applied as pre *fb* early post-emergence spray (7/m^2), which was statistically at par with extract of sorghum10% combination as pre *fb* early post-emergence spray (7/m^2). Which was followed by aqueous extract of sunflower10% pre-emergence spray (9/m^2), aqueous extract of sorghum10% pre-emergence spray (9/m^2), and aqueous extract of sunflower10% early post-emergence spray (9/m^2). Highest shoots of *Phalaris minor* per square meter was observed under control condition (12/m^2).

Table 2: Effect of aqueous extracts of sorghum and sunflower (10%) on number of shoots/m^2 of *Phalaris minor*

Treatments	Number of shoots of *Phalaris minor* (No/ m^2)			
	20 DAS	40 DAS	60 DAS	At maturity
Control (No Application)	12(140)	12(149)	12(152)	12(138)
Sorghum (10%) PE	9(85)	10(92)	10(93)	9(76)
Sorghum (10%) EPoE	10(98)	10(106)	10(108)	10(93)
Sorghum (10%) PE *fb* EPoE	7(49)	8(56)	8(60)	7(48)
Sunflower (10%) PE	9(79)	9(84)	9(88)	8(61)
Sunflower (10%) EPoE	9(89)	10(95)	10(98)	8(70)
Sunflower (10%) PE *fb* EPoE	7(42)	7(49)	7(51)	7(42)
Weed free	1(0)	1(0)	1(0)	1(0)
SEm±	0.32	0.05	0.08	0.07
CD (5%)	0.99	0.17	0.25	0.22

Original values are given in parenthesis.
PE= pre emergence EPoE= early post emergence

At 40 & 60 DAS lowest density of *Phalaris minor* was observed under aqueous extract of sunflower(10%) applied as pre *fb* early post-emergence spray (7&7/m^2) followed by aqueous extract of sorghum (10%) pre-emergence *fb* early post-emergence spray (8&8/m^2), which was further followed by aqueous extract of sunflower10% pre-emergence spray (9&9/m^2). Highest plant density was observed under weedy (12&12/m^2) and rest of the treatments were at par with each other.

At maturity number of shoots of *Phalaris minor* were decreased. Numerically lowest number of shoots were found under aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray (7/m^2), which was statistically at par with aqueous extract of sorghumr10% pre-emergence *fb* early post-emergence spray (7/m^2). Highest number of shoots were found in case of weedy check (12/m^2).

Data representing number of shoots of *Phalaris minor* per square meter revealed that, numerically highest inhibition of number of shoots of *Phalaris minor* was recorded under aqueous extract of sunflower(10%) applied as pre *fb* early post-emergence, followed by aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray at different stages of observation. From this fact an inference can be drawn that the allelochemicals of sunflower have strong allelopathic effect on *Phalaris minor* than that of sorghum.. The plant density of *Phalaris minor* was in the aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray treatment was 70%, 67.1%, 66.4% and 69.5% lower than the control plot at 20,40,60 DAS and maturity stages respectively.

The reduction in shoot number of *Phalaris minor* might be attributed to combined effect of inter-plant competition and major five allelochemicals like (chlorogenic, caffeic, syringic, vanillic and ferulic acid) present in leaves, three allelochemicals in stem (chlorogenic, ferulic and vanillic acids) and only one (ferulic acid) in the roots (Ghafar *et al.*

2001) [9]. The allelopathic effect of sorghum might be attributed to allelochemicals like sorgoleone, cyanogenic glycosides-dhurrin, and a number of breakdown products of phenolics that causes weed suppression (Guenzi and McCalla 1966) [10]. These allelochemicals act by various ways by altering different physiological processes like cell division, microtubule formation, cell differentiation, photosynthesis inhibition, ion and water uptake, water status, phytohormone metabolism, respiration, and enzymatic activities in plants as reported by Singh *et al*. (2003) [13] and Belz and Hurle (2004) [4].

Table 3: Effect of aqueous extracts of sorghum and sunflower (10%) on yield of wheat

Treatments	Grain yield(kg/ha)	Straw yield(kg/ha)	Biological yield(kg/ha)	Grain:straw ratio	Harvest index
Control (No Application)	2331	3372	5683	0.70	0.41
Sorghum (10%) PE	3882	4780	8662	0.83	0.45
Sorghum (10%) EPoE	2924	3580	6504	0.87	0.46
Sorghum (10%) PE	4126	5305	9431	0.80	0.44
Sunflower (10%) PE	3568	4728	8296	0.76	0.43
Sunflower (10%) EPoE	3317	3612	6929	0.92	0.48
Sunflower (10%) PE *fb*EPoE	4385	5559	9731	0.82	0.45
Weed free	5137	5628	10696	0.93	0.48
SEm±	243.03	501.92	645.67	0.08	0.02
CD (5%)	774.30	1537.16	1977.42	NS	NS

Grain yield was differed significantly owing to application of various aqueous extracts of sorghum and sunflower. Significantly highest yield was observed under weed free condition (5137kg/ha) which was statistically at par with aqueous extract of sunflower 10% pre-emergence *fb* early post-emergence spray (4385kg/ha). It was also found that the yield of aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray (4385kg/ha), aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray (4126kg/ha) and aqueous extract of sorghum 10% pre-emergence spray (3882kg/ha) were statistically similar with each other.

The most probable reasons behind higher grain yield were higher dry matter production by wheat, higher weed control efficiency which ranged up to 23.04%, 12.08% and 17.63% under aqueous extractsunflower10% pre-emergence *fb* early post-emergence spray, aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray and aqueous extract of sorghum 10% pre-emergence spray and higher number of spikes per square meter.

Straw yield

Differences in straw yield due to various treatments were found significant under various aqueous extract treatments. Significantly highest straw yield was recorded under weed free (5628 kg/ha) which was at par with aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray (5559kg/ha), aqueous extract of sunflower 10% pre-emergence spray (4728kg/ha), aqueous extract of sorghum 10% pre-emergence *fb* early post-emergence spray (5305kg/ha), aqueous extract of sorghum 10% pre-emergence spray (4780kg/ha). Straw yield of the rest of the treatments were statistically similar with each other. However, numerically, lowest straw yield was under weedy check (3372 kg/ha).

Biological yield

Significant difference was observed in biological yield owing to application of various aqueous extracts of sorghum and sunflower. Significantly highest biological yield was obtained under weed free condition (10696 kg/ha), which was statistically at par with aqueous extract of sunflower10% pre-emergence *fb* early post-emergence spray (9731kg/ha) and aqueous extract of sorghum10% pre-emergence *fb* early post-emergence spray (9431kg/ha). Numerically, the lowest biological yield was under control plot (5683 kg/ha).

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