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Potential allelopathic interference of aqueous extracts of winter weeds on yield and yield attributing characters of wheat (*Triticum aestivum* L.)

Aaradhana Chilwal, SP Singh, VP Singh, BS Mahapatra, DK Shukla and Shirazzudin

Abstract
Allelopathy is an important mechanism of plant competition by producing phytotoxins to the plant environment to decline other plant growth and development. In this study, allelopathic potential of weed aqueous extracts (10% concentration) of *Medicago denticulata, Chenopodium album* and *Melilotus indica* and their combinations was evaluated on yield and yield attributing characters of wheat by control of dominant weed of wheat, *Phalaris minor*. Under application of different weed aqueous extracts, thousand grain weight and spike length of wheat gave non-significant results. However, the other yield attributing characters at harvest, viz., number of spikes per square metre, number of spikelets per spike and number of grains per spike were found highest under *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) which was at par with *Melilotus indica* (10%) + *Chenopodium album* (10%). Grain yield, straw yield and biological yield differed significantly owing to application of various allelochemicals as weed aqueous extracts. Combined application of *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) was found to produce higher grain yield, straw yield and biological yield, which was at par with *Melilotus indica* (10%) + *Chenopodium album* (10%). All the plots in which weed aqueous extracts was applied produced significantly higher biological yield than weedy check (control). This indicated that effective weed control reduced competition between crops and weeds which resulted in higher yield and proved the efficiency of weed aqueous extracts in controlling *Phalaris minor*.

Keywords: *Medicago denticulata, Melilotus indica, Chenopodium album, Phalaris minor,* allelo-chemical, aqueous extract

1. Introduction

Weeds are the most severe biotic stress to the crop and account for about one third of total losses caused by various biotic stresses (Gopinath and Mina, 2009) [4]. Weed infestation is a major bottleneck to higher wheat productivity also. *Phalaris minor* Retz. is one of the most predominant and troublesome annual grassy weed of wheat in India. Its morphological similarity with wheat in vegetative stage, occurrence at high density, ability to tiller freely, similar growth period as wheat, high reproductive potential, earlier shedding of seeds and ability of seeds to remain dormant in the soil for several years, have attributed for its strong competitive ability. *Phalaris minor* is highly competitive and can cause yield reductions of up to 100% (Chhokar and Malik 2002) [1] and requires huge amounts of herbicides for its control (Om *et al.* 2002) [5]. The serious yield reduction caused by this weed and morphological similarity with wheat crop warrant the use of herbicide to control this weed. Isoproturon was recommended for the control of *Phalaris minor* in wheat. However, total dependence on herbicide for weed control did not prove useful in long term. Extensive use of isoproturon over many years has led to the evolution of resistance in *Phalaris minor* in northwest India (Chhokar and Malik, 2002) [1]. This led to adoption of fenoxaprop, clodinafop, and sulfosulfuron in isoproturon resistant areas since 1997 that initially gave higher yields, but resulted in a weed flora shift and resistance problems at few places, which eventually reduced yields and increased the cost of weed management. To overcome these problems, there is a need to reduce the reliance on synthetic herbicides and shift to low-input sustainable agriculture. Therefore, it is imperative to devise non-chemical and organic ways of controlling weeds in field crops (Farooq *et al.*, 2011) [3]. In this direction, efforts to utilize allelopathy and natural plant products for effective weed management are being made (Singh *et al.*, 2003) [8]. In accordance with this, screening of natural plant products depicting herbicidal and pesticidal potential has gained momentum since they are biodegradable (Duke *et al.*, 2002) [2].

Allelopathy is defined as the direct or indirect harmful of beneficial effects of one plant on another through the release of chemical compounds into the environment (Rice, 1974) [7]. Recent allelopathic research has played an important role as allelochemicals may be used for integrated weed control and thud reducing environmental pollution. Allelopathy offers potential for biorational weed control through the production and release of allelochemicals leaves, flowers, seeds, stems and roots of living or decomposing plant materials.
Information is available on the allelopathic effect of weeds on crop plants, crop plants on weeds, weeds on weeds or crops on crops. Little has been done to explore phytotoxic potential of weed species on other weeds under field condition. Studies specifically exploring the management of *Phalaris minor* by using medicinal/allelopathic plants are very few (Om *et al*., 2002) [5]. However, the three major broad leaved weeds of wheat- *Medicago denticulata*, *Melilotus indica* and *Chenopodium album* are known to release certain allelochemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids etc. from their roots, stems, leaves and decomposition products that inhibit the germination and growth of number of crop plants and weed species. The above facts inspired this study which was undertaken with the objectives of evaluating the allelopathic effect of aqueous extracts of *Medicago denticulata*, *Melilotus indica* and *Chenopodium album* at 10% concentration as sole and combined pre emergence application on yield and yield attributing characters of wheat by control of most dominant weed of wheat crop, *Phalaris minor*.

Materials and Methods

Collection of donor plant material

The fresh biomass of required weeds was collected from the Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *rabi* season 2015-16.

Collection of test materials

Wheat (*Triticum aestivum* L.) and *Phalaris minor* Retz. were used to test the allelopathic potential of aqueous extracts of *Chenopodium album*, *Medicago denticulata* and *Melilotus indica*. The seeds of wheat and *Phalaris minor* were collected from Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. the seeds of *Phalaris minor* were of rabi season 2014-15.

Preparation of aqueous extracts from weed samples

Biomass of the weeds collected was shade dried for one week at the shade area of Weed Agronomy block centre in Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and then kept in plate dryer for 72 hours at 65±5ºC in processing laboratory. After complete drying the entire biomass was finely grinded. Grinded biomass of weed plant was weighed using electronic balance, then was well mixed in distilled water with 1: 2 (w/v) ratios and soaked for 48 hours at room temperature; the mixture was then filtered using muslin cloth. Using this method weed aqueous extracts of 50% were prepared by adding 500g of grinded sample to distilled water and making the final volume to 1.0 l. 50% of aqueous solution was further diluted by adding water to get 10% extract for application to the field. Combination treatments were prepared by mixing the sole extracts in equal amount.

Application of weed aqueous extracts

Weed aqueous extracts were applied as pre-emergence spray to the field by battery operated sprayer 2 days after sowing.

Results and Discussion

Yield contributing characters

Differences in spike length and 1000-grain weight due to application of various allelochemicals prepared from weed aqueous extracts were found non-significant. However, longest spike length has been recorded in case of *Melilotus indica* (10%) (9.8 cm) while highest 1000-grain weight was found *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (41.68 g). The other yield attributing characters at harvest, viz., number of spikes per square metre, number of spikelets per spike and number of grains per spike were found highest (after weed free condition) under *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) which was at par with *Melilotus indica* (10%) + *Chenopodium album* (10%). Number of spikes per square metre, number of spikelets per spike and number of grains per spike under *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) were 472, 20 and 38, respectively. The data pertaining to yield attributing characters at harvest under different treatments are shown in Table 1.

Yield and harvest index

Grain yield

Grain yield differed significantly owing to application of various weed aqueous extracts. Significantly highest yield was recorded under weed free condition (4893 kg/ha) followed by *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (3907 kg/ha), *Melilotus indica* (10%) + *Chenopodium album* (10%) (3604 kg/ha), *Medicago denticulata* (10%) + *Melilotus indica* (10%) (3504 kg/ha) and *Melilotus indica* (10%) (3574 kg/ha), respectively which were statistically similar to each other.
Reasons attributed to higher grain yield were higher dry matter production by wheat, better control of *Phalaris minor* and higher number of spikes per square metre under *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%), *Melilotus indica* (10%) + *Chenopodium album* (10%) and *Medicago denticulata* (10%) + *Melilotus indica* (10%) and *Melilotus indica* (10%).

Straw yield

Differences in straw yield due to various treatments were found significant under various treatments. Straw yield was recorded significantly highest under weed free (5830 kg/ha) which was at par with *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (4670 kg/ha), *Melilotus indica* (10%) + *Chenopodium album* (10%) (4497 kg/ha) and *Medicago denticulata* (10%) + *Melilotus indica* (10%) (4759 kg/ha).Straw yield of the rest of the treatments was at par with each other. Numerically, lowest straw yield was under weedy check (2841 kg/ha).

Biological yield

Biological yield differed significantly owing to application of various weed aqueous extracts. Significantly highest biological yield was obtained under weed free condition (10722 kg/ha) followed by *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (8578 kg/ha), *Medicago denticulata* (10%) + *Melilotus indica* (10%) (8363 kg/ha), *Melilotus indica* (10%) + *Chenopodium album*

(10%) (8300 kg/ha), and *Melilotus indica* (10%) (7552 kg/ha) Numerically, the lowest straw yield was under weedy check (5319 kg/ha).

The treatments having lower density of weeds gave higher yield of wheat. This indicates that effective weed control reduces competition between crops and weeds which results in higher yield. In accordance with the above result, Ranjit *et al*. (2006) [6] also reported that due to its strong competitive ability with wheat, *Phalaris minor* can cause 10-50% yield losses. Weedy plot resulted in lowest grain yield, straw yield and biological yield. Low yield in weedy plot may be due to higher crop-weed competition and poor root growth.

Harvest index
Harvest index of wheat gave non-significant results under various treatments. However, numerically, harvest index was reported highest under control and *Melilotus indica* (10%).

Comparative grain yield, straw yield, biological yield and harvest index under different treatments are shown in Table 2 and Fig. 1.

Conclusion
From the present study, it may be concluded that combination of aqueous extracts of *Medicago denticulata* (10%), *Melilotus indica* (10%) and *Chenopodium album* (10%) and *Melilotus indica* (10%) + *Chenopodium album* (10%) by achieving significant control of *Phalaris minor* produced higher yield of wheat. This validated the allelopathic potential of all three weed aqueous extracts in controlling *Phalaris mino*r. However, allelopathic potential of aqueous extracts of *Melilotus indica* was recorded higher than *Medicago denticulata* and *Chenopodium album* as higher wheat yield was observed under treatments containing aqueous extract of *Melilotus indica* than other treatments. Thus, aqueous extract of *Melilotus indica* could be a useful plant product for the possible utilization as a bioherbicide under Integrated Weed Management Programmes (IWMPs) in future.

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Table 1: Effect of treatments on yield contributing characters of wheat

Treatments	No.of spikes/ m^2	Spike length (cm)	No of Spikelets/ spike	No of grains/ spike	1000-grain weight (g)
Control (No Application)	376	9.7	12	23	38.70
Aqueous extract of *Medicago denticulata* (10%)	434	9.7	16	31	41.03
Aqueous extract of *Melilotus indica* (10%)	453	9.8	18	34	40.37
Aqueous extract of *Chenopodium album* (10%)	436	9.0	16	30	39.70
Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10%)	458	8.9	19	37	40.13
Aqueous extract of (*Medicago denticulata* 10% + *Chenopodium album* 10%)	432	8.7	16	31	39.30
Aqueous extract of (*Melilotus indica* 10% + *Chenopodium album* 10%)	462	8.7	19	36	40.27
Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10% + *Chenopodium album* 10%)	472	9.4	20	38	41.67
Weed free	578	9.1	21	42	41.20
SEm±	21	0.5	0.9	2	1.95
CD (5%)	63	NS	2.9	6	NS

NS- Non-significant

Table 2: Effect of treatments on yield of wheat

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Control (No Application)	2478	2841	5319	0.47
Aqueous extract of *Medicago denticulata* (10%)	2681	3141	5822	0.46
Aqueous extract of *Melilotus indica* (10%)	3574	3978	7552	0.47
Aqueous extract of *Chenopodium album* (10%)	2844	4226	7070	0.40
Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10%)	3604	4759	8363	0.43
Aqueous extract of (*Medicago denticulata* 10% + *Chenopodium album* 10%)	2604	2933	5537	0.47
Aqueous extract of (*Melilotus indica* 10% + *Chenopodium album* 10%)	3804	4496	8300	0.46
Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10% + *Chenopodium album* 10%)	3907	4670	8578	0.45
Weed free	4893	5830	10722	0.46
SEm±	213	502	547	0.03
CD (5%)	645	1518	1654	NS

NS- Non-significant

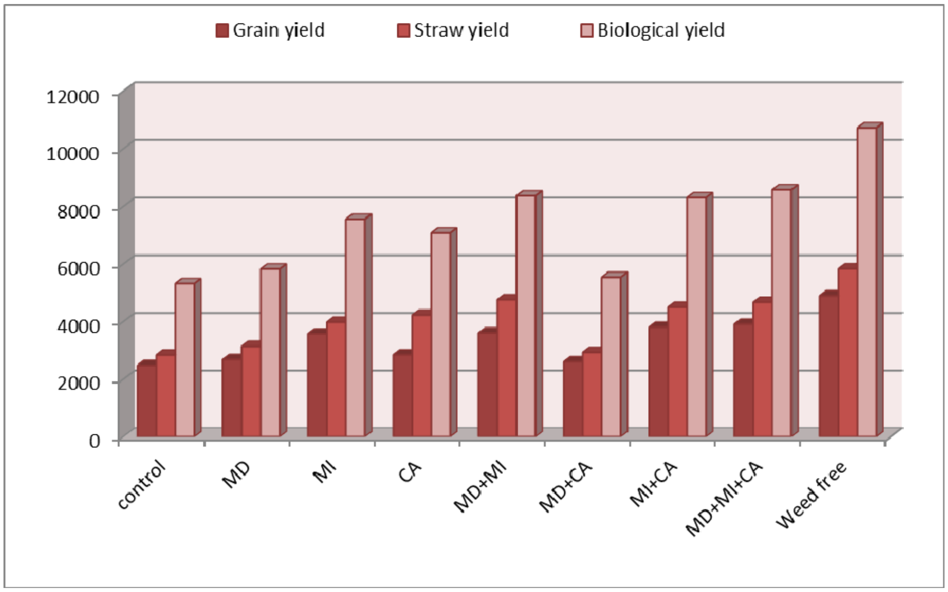

Fig 1: Grain yield, straw yield and biological yield under various treatments

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