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Research Article

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Comparative Evaluation of Allelochemical Bio-extracts on Growth and Yield Parameters of Wheat (*Triticum aestivum* L.), Punjab

Somak Maity and Subhra Sahoo*

School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

***Correspondence to:**
Subhra Sahoo
Assistant Professor, School of Agriculture,
Lovely Professional University,
Phagwara, Punjab, India.
E-mail: subhra.28223@lpu.co.in

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Abstract

Weed infestation seriously threatens agricultural crop production and their management. 45% yield losses happen only due to high weed infestation. To control the high weed population in the field, conventional methods are followed which are costly and labor-intensive. Blind application of herbicides for weed control is highly hazardous for the crop. In order to reduce the herbicide application, research was conducted during 2022-23 in Punjab by utilizing aqueous extracts of allelopathic plants namely *Sorghum bicolor, Oryza sativa, Parthenium hysterophorus, and Lantana camara.* First those leave extract are made then applied to the field and all the data (i.e., plant height, effective tillers per plant, spikes per sq. m, ear length, number of grains per spike) are taken manually This study is mainly focused on the effect of allelochemicals on wheat growth and yield. The present study shows that *P. hysterophorus* root aqueous extract at 5% concentration improves the wheat crop height (20.67, 64.62 and 84.89 cm), the number of tillers and yield parameters (Effective tillers per plant, spikes per sq. m, ear length, number of grains per spike). Alongside *P. hysterophorus* leave extract, *O. sativa* aqueous extract and hand weeding also effectively control the weed and contribute to wheat yield. However, these extracts can be used as a viable weedicide but further research is needed to explore the full effectiveness of these allelochemicals.

Keywords

Allelochemicals, Allelopathic, Aqueous extract, Effective tillers per plant, Spikes per sq. m, Ear length, Number of grains per spike

Introduction

Wheat is one of the most producing cereals crop in the world but in India, wheat is the second most important food grain crop after rice. It is enriched in proteins, vitamins, and carbohydrates. Due to its high nutritive value wheat is grown as the second most important staple food in India. It is a major staple food for millions of northern and north-western Indians. In 1965-67 wheat production and productivity increased bumper all over the world due to the introduction of semi-dwarf varieties and the use of chemical fertilizers. Which makes countries like India more self-dependent on wheat production.

The present global population of 8 billion is expected to reach 9 billion by 2037. To feed this population food production need to improve by 80 to 100%. There are several constraints which can reduce the production of wheat. Weeds are the most important biotic constraint in crop production. High weed infestation causes 45% yield loss compared to insects (25%) and pathogens (20%) [1]. Weed compete with the crop for sunlight, water, nutrient and carbon dioxide, and they also harbour major insects and pathogens which damages the crop. To control this type of weed problem farmers generally follow the conventional method which is the usage of chemical herbicides. But usage of heavy chemical herbicides

is a major drawback it damages the ecosystem.

Agriculture faces a double problem of feeding the world's growing population while maintaining biodiversity and increasing agriculture production through proper weed control. To solve this problem different weed management approaches are needed which are based on ecological principal and non-conventional weed management [2]. The 9th goal of SDGs, new innovation which is the only approach to follow the path of sustainable agriculture. Sustainable agriculture has the ability to conserve natural resources and provide high returns with less cost, sustainable weed control is required for environmental and economic reasons [1, 3]. There are several new innovations happened for weed control use of allelochemicals as herbicide is one of them. It is a low-input and environmentally friendly method for weed control which increase interest among scientists [4].

Experimentation

Materials

An experiment is conducted in the field (31°13'42.25"N, 75°41'53.07"E) of Lovely Professional University, Punjab during 2023-24 to observe the allelochemical bio-extract effect on wheat growth. The experiment was laid out in a Randomized Block design with 3 replications and 8 treatments.

The treatments are T1 - Application of Sorghum stalk aqueous extract. T2 - Application of Paddy straw aqueous extract. T3 - Weedy check. T4 - Application of *P. hysteropterous* leave extract. T5 - Application of *P. hysterophorus* root extract. T6 - Application of *L. Camara* leaves extract. T7 - Application of Pendimethalin + sulfosulfuron. T8 - Hand weeding.

Methodology

There are different growth parameters and yield parameters. Growth parameters are plant Height and number of tillers. For the growth parameter's data, 10 healthy plants are chosen. Yield parameters are effective tillers per plant, spikes per sq. m, ear length, number of grains per spike, straw yield, grain yield, and harvest index. Grain yield was taken from the net plot.

- Plant height (cm): It is the most important growth trait among the cereals crop and pulses. The height of the plant is measured by measuring tape from the base of the plant to the tip of the plant.
- Number of tillers per plant: Tiller production started after 55-60 DAS (Days After Sowing). The number of tillers per plant was counted at an interval of different growth stages (30, 60 and 90 DAS).
- Number of effective tillers per plant: Tillers are the main functional unit of the plant. It absorbs light and water from the soil and to the plant stem which helps to continue photosynthesis. Effective tillers are those tillers which are able to complete photosynthesis. This data was taken at 120 DAS by only visional observation.
- Spike per sq. m: Spike per sq. m is directly related to number of effective tillers per plant. One sq. m quadrate is used to collect this data at 120 DAS.
- Ear length (cm): Ear is the inflorescence of wheat. Yield completely depends on the ear. Randomly ears are collected from 10 plants and measured the length by using a measuring scale.
- Number of grains per spike: It is one of the important yield attributes of wheat. Number of grain is counted per spike or ear of 10 randomly selected plants.
- Biological yield: It represents the total biomass (Grain yield + Straw yield). It includes leaf, stem, root and grains. After harvesting crops from the net plot we take the weight of those plants.
- Straw yield: The stover yield of cereals can vary depending on the crop species, management practices and environmental conditions. In general, cereals have higher stover yield due to their taller stature and larger canopy.
- Harvest index: It is the ratio of economic yield or grain yield and total biological yield. A high value of the harvest index indicates efficient utilization of assimilated photosynthates.

$$HI = \frac{\text{Economic yield (Grain Yield)}}{\text{Biological Yield (Grain yield + Straw yield)}} \times 100$$

Results and Discussion

The research was conducted at the student's field, Department of Agronomy, Lovely Professional University, Punjab during the Rabi season of 2022-23 to study the effect of different allelochemical bio-extracts on the growth and yield of wheat crops. This study was carried out in a three replicated Randomized Block design.

Effect of allelopathic bio-extracts on plant height (cm of wheat

The result of plant height of wheat affected by allelochemical bio-extracts is presented in figure 1. The result pointed out that plant height showed indicative results in response to allelochemical bio-extracts. The presented figure 1 displayed the plant height of wheat at different DAS that is 30 DAS,

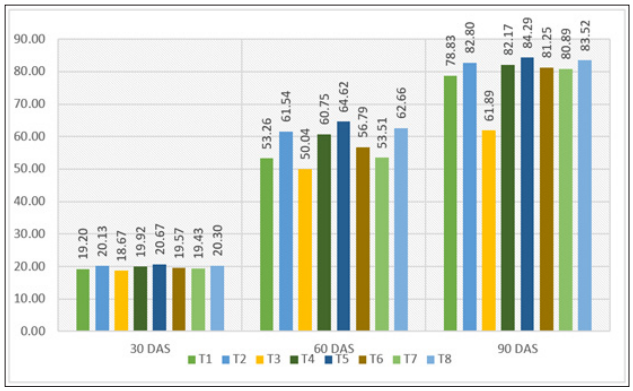

Figure 1: Effect of allelopathic bio-extracts on plant height (cm) of wheat at different growth stages. Where statistical significance is $p \leq 0.01$.

60 DAS and 90 DAS. At 30 DAS maximum plant height was observed @ application of *P. hysterophorus* roots extract (20.67 cm) followed by 20.30 and 20.13 @ hand weeding and application of *O. sativa* bio-extracts. The minimum plant height (18.67 cm) was seen in the weedy check plot. At 60 DAS and 90 DAS maximum plant height was observed @ application of *P. hysterophorus* root extracts (64.62 and 84.29) respectively followed by hand weeding, and @ application of *O. sativa* bio-extract.

The result revealed that the allelopathic effect of *P. hysterophorus* root extracts resulted in a positive and significant impact on the plant's height at a different timeline. At low concentrations, *Parthenium* sp. root extract affects the plant height positively because at low concentrations (5%) it does not contain a high amount of hazardous phenolic acid which can reduce the plant height but it is enough to control weed effectively [5]. So, through effective weed control *P. hysterophorus* root bio-extracts create enough space for the proper growth of wheat. Moreover, *P. hysterophorus* leaves extracts show an inhibitory effect on plant height than *Parthenium* sp. root extracts [5]. It happened because in *Parthenium* leaf, high amount of phenolic compound is present which is more suppressive than *parthenium* root [6]. The minimum plant height (18.67, 50.04 and 61.89 respectively) was observed in a weedy check plot where weed is dominant and creates more competition for wheat growth.

Effect of allelopathic weeds bio-extracts on the number of tillers

The result of the number of tillers of wheat affected by allelochemical bio-extracts which is presented in figure 2. The presented figure 2 exhibited number of tillers at different days after sowing is 30, 60 and 90 DAS. At every duration, the *P. hysterophorus* root extract applied plot shows more tillers (2.73, 9.90 and 11.73 respectively) followed by a hand weeding plot, *O. sativa* extract and *P. hysterophorus* leaves extract applied plot. The minimum number of tillers (1.80, 4.73 and 8.83 respectively) was seen in the weedy check plot.

The result stated that the number of tillers is greatly affected by different weed management practices. Tiller production started after 50-60 DAS. At this stage, tiller emerges and increases substantially if narrow-leaf weeds are controlled efficiently [6]. The use of *P. hysterophorus* root and leaf extracts effectively controlled the narrow-leaved weed which helps to increase the number of tillers**.** Solo application of *parthenium* leaf and root bio-extract increases the number of tillers, leaf length and the number of leaves [7]. But, in this research *P. hysterophorus* leaf extract was used in higher concentrations because of that the emergence of tillers is less than *P. hysterophorus* root extracts. Proper hand weeding at 20 and 40 DAS helps to control weeds more effectively which directly affects the tiller emergence.

Effect of allelopathic weeds bio-extracts on grain and straw yield and harvest index

The result of grain yield (t/ha) of wheat is affected by allelopathic weed bio-extract which was presented in figure 3. The presented figure 3 revealed that maximum grain yield (4.64) was observed @ application of *parthenium* root extracts followed by hand weeding (4.24), *O. sativa* (4.13) and *parthenium* leaves bio-extract (4.01) applied plot. The minimum grain yield (3.01) was observed in the weedy check treatment.

Statistical analysis has shown a significant effect of allelopathic bio-extract upon the straw yield (t/ha) of wheat, which was represented in figure 3. The highest straw yield (9.17) was observed @ application of *P. hysterophorus* root extract followed by (8.30 and 8.97) @ *P. hysterophorus* leave extract and hand weeding. The lowest straw yield (6.97) was observed in the weedy check treatment.

Through statistical analysis we can explain that the highest harvest index (33.54) was observed @ *O. staiva* bio-extract applied plot followed by (33.50 and 32.60) @ *P. hysterophorus* root extract and *P. hysterophorus* leave extract.

The result unfolded that the *P. hysterphorus* root and leaf bio-extract very effectively control weeds. It inhibits germination and reduces the seedling growth of wheat's associative weeds like *Phalaris minor, Avena fatua,* and *Lepidium* sp. [8, 9]. So, through proper weed control grain yield increases in *parthenium* applied plot. Solo *Parthenium* sp. root and leaf extract reduces the germination of wheat weed seed thus it improves the wheat seedling length and yield [7]. Straw yield increases with increased grain yield because both are proportionally related. Harvest index (%) is directly related to grain yield and straw yield. At various concentrations, water extracts increased the harvest index of wheat. A higher harvest index

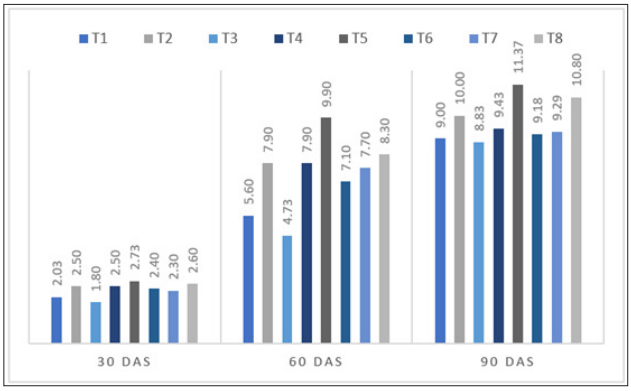

Figure 2: Effect of allelopathic weeds bio-extracts on the number of tillers. Where statistical significance is $p \leq 0.01$.

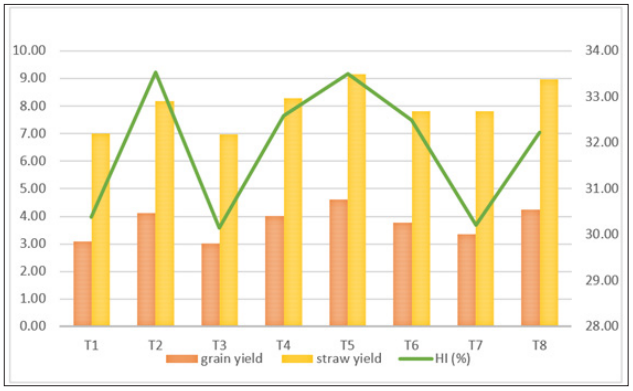

Figure 3: Effect of allelopathic weeds bio-extracts on grain and straw yield and harvest index. Where statistical significance is $p \leq 0.01$.

suggested better weed control and proper nutrient uptake by plants [10].

Effect of allelopathic bio-extract on yield attributes of wheat

The result of the yield parameter (i.e., effective tillers per plant, spikes per sq. m, ear length, number of grains per spike.) of wheat is greatly affected by allelochemical bio-extracts. The highest yield parameter (10.27, 436.00, 12.95 and 48.70 accordingly) was seen in the *P. hysterophorus* root bio-extract applied plot which is presented in table 1 followed by hand weeding @ *P. hysterophorus* leaves extracts and *O. sativa* aqueous extract. The minimum yield parameter (6.80, 320.00, 9.18. and 34.00) was observed in the weedy check plot.

Table 1: Effect of allelopathic bio-extract on yield attributes of wheat, where T1 - Application of Sorghum stalk aqueous extract , T2 - Application of Paddy straw aqueous extract, T3 - Weedy check , T4 - Application of *P. hysteropterous* leave extract, T5 - Application *of P. hysterophorus* root extract, T6 - Application of *L. camara* leaves extract, T7 - Application of Pendimethalin + sulfosulfuron, T8 - Hand weeding. Statistical significance is $p \leq 0.01$.

Treatments	Effective tillers per plant	Spikes per sq.m	Ear length	Number of grains per spike
T1	8.6	333	10.51	37.11
T2	9.7	411	11.68	45.06
T3	6.8	320	9.18	34
T4	9.73	407.33	11.64	44.61
T5	10.27	436	12.95	48.7
T6	9.67	349	11.67	43.19
T7	9.6	331.33	11.59	42.3
T8	9.77	422	11.85	45.52
S. EM	0.55	15.47	0.54	2.43
CD	1.65	46.92	1.65	7.36
CV	11.47	8.01	9.32	11.11

The result revealed that the yield parameters are greatly increased for most of the allelopathic bio-extracts but the highest yield parameter was observed on the *P. hysterophorus* root bio-extract applied plot followed by hand weeding. The highest number of spike per sq. m, grain per spike and other yield parameters were observed for the *P. hysterophorus* bio-extract and hand weeding plot [11, 12]. A weedy check plot produced the minimum number of grains per spike due to the presence of more weeds and crop plants [5].

Conclusion

Based on the current study it can be concluded that *P. hysterophorus* root aqueous extract has the potential to be used as a bioherbicide for weed management which can increase crop yield and also provide an alternative method for sustainable weed management. However major comprehensive study is needed regarding *parthenium* bio-extract as well as other bio-extract. It is because *P. hysterophorus* contain a high amount of phytotoxic compound which can decrease the yield of wheat if applied at higher concentration. Further drastic study is needed to pursue the allelopathy concept of such invasive and noxious weeds to reduce the use of expensive chemical herbicides.

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Conflict of Interest

None.

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