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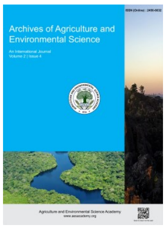

ORIGINAL RESEARCH ARTICLE

CrossMark

Reduction in use of herbicides by combining aqueous extract of grass pea for weed management and yield of wheat

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ABSTRACT

Nowadays, the increasing costs in the agricultural sector, increasing public concern about the widespread use of herbicides and the development non-chemical methods of weed control programs are alerting management. In this regard, an experiment was conducted to evaluate the effect of aqueous extract of grass pea residues on weed management and crop performance of wheat. The experiment was comprised of three varieties of wheat viz., BARI Gom-30, BARI Gom-31, BARI Gom-32 and six different levels of treatments such as no weeding, recommended dose of herbicide, aqueous extraction of grass pea, 90% recommended dose + aqueous extraction of grass pea,80% recommended dose + aqueous extraction of grass pea, 70% recommended dose +aqueous extraction of grass pea, 60% recommended dose + aqueous extraction of grass pea. The experiment was laid out in a randomized complete block design with three replications. Weed population, weed dry weight and weed control efficacy were significantly influenced by aqueous extract of grass pea crop residues and varieties. The highest numbers of tillers hill^{-1}, numbers of grains spike^{-1}, 1000 grain weight and grain yield were observed where recommended dose of herbicide was used followed by the application of 90% recommended dose +aqueous extraction of grass pea. BARI Gom-31along with 90% recommended dose +aqueous extraction of grass pea produced the highest grain and straw yield among the treatment combination. Therefore, aqueous extract of grass pea crop residues might be used as an alternative way for weed management in effective and sustainable crop production.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is regarded as one of the major cereal crop globally, as majority of the world population largely depends on this grain for vital nourishment (Talaat, 2019). In Bangladesh, wheat is considered as second staple food after rice (Ahmed *et al*., 2015). In the year of 2020-2021, the total area under wheat cultivation and total productionwere3,28,924 ha and 10,85,368 metric ton (AIS, 2020). However, several barriers like weed, disease-pest infestation render from attaining maximum crop yield, where significant amount of yield reduction in wheat cultivation around 24-40% occurs due to only weed infestation (Oad *et al*., 2007). Several methods of weed control such as manual, mechanical and chemical are used for weed management in wheat crop with each of methods having limitations. For instance, manual weeding is laborious and time-consuming method, also not feasible for larger areas (Khan *et al*., 2016). Weeding by mechanical methods is usually expensive and poor farmers cannot afford it. Moreover, the frequent use of excessive chemicals/herbicides for controlling weeds in wheat had generated resistance in various weed species (Delye *et al*., 2013) and also caused severe environmental pollution.

Therefore, sustainable weed management is essential to sustain the productivity wheat.

Application of water extracts of different allelopathic plants has revealed as potential for weed management in wheat and other crops (Khan *et al*., 2013, Khan *et al*., 2015). Allelochemicals may play a significant role in suppressing weed population in organic crop farming without harming the environment with better crop yield (Soltys *et al*.,2013). Natural plant derivatives obtained from higher plants may be a promising source of allelochemicals (Soltys *et al*., 2013). In plants, allelochemicals were found in the leaves, bark, roots, root exudates, flowers, and fruits (Weir *et al*., 2004). Moreover, plants can release allelochemicals (e.g., phenolics, terpenoids, alkaloids, coumarins, tannins, steroids, quinines) into the environment through exudation from the roots, leaching from the leaves and other aerial plant parts, volatile emissions, and the decomposition of plant material (Xuan *et al*., 2005). For example, several plant species are inherently enriched with allelochemicals like *Parthenium hysterophorus* contains sesquiterpene, lactone, parthenin and *Sorghum halepense* contains hydrophilic phenols, hydrophobic sorgolenone (Alsaadawi and Dayan, 2009; Hussain and Reigosa, 2011). Regarding this, crop residues can be used as crop or its parts are left in field after harvesting (Kumar and Goh, 2000). Though these were regarded merely as waste earlier, but currently because of their effectiveness, considered as an important resource which under decomposition can bring significant changes in soil properties. Moreover, several studies have been revealed the induction of phytotoxic effects by plants and their residues for many crops, comprising major grain crops like rice, wheat, sorghum, rye, mustard, buckwheat and other crop residues (Uddin and Pyon, 2010; Uddin *et al*., 2010; Won *et al*., 2013; Ferdousi *et al*., 2017; Hossain *et al*., 2017; Sheikh *et al*., 2017; Ahmed *et al*., 2018; Pramanik *et al*., 2019; Sarker *et al*., 2020).

The combined approach of crop rotation, growing of high yielding wheat varieties and applying of water extracts from allelopathic plant parts may bring fruitful result in weed management in wheat cultivation (Ullah *et al*., 2021). Currently, researchers are giving more emphasis using different crop residues for controlling weeds. Though crop residues are easily available and inexpensive in Bangladesh, but there is limited work to investigate the efficacy of individual crop residues suitable for weed management. Therefore, crop allelopathy may be deployed by using extracts of grass pea crop residue for achieving sustainable weed management in wheat production. Combination of both allelopathic crop water extracts and lower rate of herbicides together may provide lower desired weed control levels thereby reducing herbicide usage. Keeping all these in views, the present research project was designed to determine the synergistic or additive phytotoxic effects of aqueous extracts of grass pea with reduced rates of herbicides for effective weed management and crop performance in upland wheat crops.

MATERIALS AND METHODS

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2020 to March 2021, located at 24° 25' N latitude and 90°50' E longitude at an elevation of 18m above the sea level belonging to non-calcareous dark grey floodplain soil under the Sonatala series of the Old Brahmaputra Floodplain which falls under Agro-ecological region of the Old Brahmaputra Floodplain (AEZ-9) (FAO and UNDP, 1988). The soil of the experimental site was more or less neutral in reaction with pH value 6.8, low in organic matter and fertility level. The experimental treatment consisted of two factors, Factor A- Variety (3): i) BARI Gom- 30 (V_1), ii) BARI Gom- 31 (V_2) and iii) BARI Gom- 32 (V_3) and Factor B-Aqueous extract of grass pea crop residue and herbicide (7): i) no weeding (T_1), ii) recommended dose of herbicide (T_2), iii) aqueous extraction of grass pea (T_3), iv) 90% recommended dose +aqueous extraction of grass pea (T_4), v) 80% recommended dose +aqueous extraction of grass pea (T_5), vi) 70% recommended dose +aqueous extraction of grass pea (T_6), vii) 60% recommended dose +aqueous extraction of grass pea (T_7). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The whole experimental land was prepared properly and divided into three blocks and 63-unit plots maintaining the desired spacing. The experimental plots were fertilized with urea, triple super phosphate, muriate of potash, gypsum at the rate of 220-157-110-110 kg ha^{-1}, respectively. One-third of urea and the entire amounts of triple super phosphate, muriate of potash, gypsum was applied as basal dose at the time of final land preparation. The remaining two-thirds of urea were applied in two equal installments at 21 days after sowing and maximum tillering stage at 45 days after sowing followed by irrigation. The seeds were sown on 21 November 2018 as per treatment specifications. The depth of sowing was 5 cm in each treatment and the seeds were covered with soil. After collection, the crop residues were dried properly and cut as small as possible by using sickle. Then the small pieces of grass pea crop residues were dipped into water maintaining the ratio of 1:20 (w/v) for 24 hours and then collected the aqueous extract from residues. The prepared grass pea aqueous extract was applied as per the specified treatments and suitable herbicide was applied. Effect of application of herbicide and aqueous extract of grass pea against several weed species were evaluated. Thirty days after treatment, weeds were collected and kept separately in brown paper bags and then placed in an electric oven at 72°C for 3 days. The samples were weighed separately. Percent inhibition as compared to the control was calculated for all data collected. Data on yield and yield contributing characters were recorded from five randomly selected sample plants from each plot. Data on grain and straw yields were collected from an area of $1m^2$ in the middle of each plot. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}. Finally, data on different parameters of both crop and weed were compiled and tabulated in proper form and subjected to statistical analysis. The Analysis of variance was done with the help of computer package MSTAT-C program. The mean differences among the treatments were adjudged by Duncan's Multiple Range Test (DMRT) as laid out by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Infested weed species in the experimental field

In the experiment field, six weed species belonging to five families were observed. Local name, scientific name, family, morphological type and life cycle of the weed in the experimental plot have been presented in Table 1. The weeds of the experimental plots were *Polygonum hydropiper*, *Chenopodium album*, *Echinochloa colonum*, *Paspalum scrobiculatum*, *Cyperus rotundus* and *Hedyotis corymbosa*. Among the weeds of the experimental plots, morphological types like broad leaved, grass and sedge were observed where most of them were annual growing except one perennial growing weed species. In a study, Ahmed and Uddin (2018) also found similar types of weeds infestation during wheat cultivation through the application of sorghum crop residue to suppress weed growth.

Effect of variety on number, dry weight and control efficiency of different weeds

Weed population of bishkatali, bathua, khudashama, angta and khetpara was not significantly affected by variety but mutha was significantly affected by variety (Table 2). Numerically the highest weed population for khudashama (6.76) was found in BARI Gom-32and the lowest weed population for bathua (2.19) was obtained from BARI Gom-30. Moreover, weed dry weight and weed control efficiency were significantly affected by variety (Table 2). The highest weed dry weight (10.04 g) was found in BARI Gom-31 and the lowest weed dry weight (9.60 g) was obtained in BARI Gom-32. The highest weed control efficiency (62.52%) was in BARI Gom-31 and BARI Gom-32 produced the lowest weed control efficiency (59.78%). Similar result was found from a study, Ahmed *et al*., (2018) stated that variety have significant effect on weed population for biskatali, tit begun, shama and angta. The control efficacy of weed is significantly influenced by variety of transplanted Aman rice and residual effect of grass pea (Ashraf *et al*., 2021).

Table 1. Infested weed species found growing in the experimental plots in wheat.

S.N.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Biskatali	*Polygonum hydropiper*	Polygonaceae	Broad leaved	Annual
2	Bathua	*Chenopodium album*	Chenopodiaceae	Broad leaved	Annual
3	Khudashama	*Echinochloa colonum*	Poaceae	Grass	Annual
4	Angta	*Paspalum scrobiculatum*	Poaceae	Grass	Annual
5	Mutha	*Cyperus rotundus*	Cyperaceae	Sedge	Perennial
6	Khetpara	*Hedyotis corymbosa*	Rubiaceae	Broad leaved	Annual

Table 2. Effect of variety on number, dry weight and control efficiency of different weeds.

Variety	Number of weeds						Weed dry weight (g)	Weed control efficacy (%)
	Bishkatali	Bathua	Khudashama	Angta	Mutha	Khetpara		
V_1	3.04	2.19	6.42	3.04	4.23a	3.57	9.83ab	61.22ab
V_2	2.85	2.33	6.42	3.04	4.28a	3.47	10.04a	62.52a
V_3	2.76	2.23	6.76	3.04	3.00b	3.90	9.60b	59.78b
Level of sig.	NS	NS	NS	NS	**	NS	*	**
Aqueous extract								
T_1	7.77a	6.00a	15.55a	8.55a	10.88a	10.33a	25.36a	0.000f
T_2	0.44e	0.44f	2.11f	0.44e	0.66e	0.55e	2.41f	90.47a
T_3	3.33c	2.44c	9.33b	3.66b	5.22b	4.44b	11.36b	55.07e
T_4	0.33e	0.66ef	1.88f	0.66e	0.88e	0.77e	2.43f	90.38a
T_5	1.55d	1.22de	4.55e	1.66d	1.66d	1.66d	7.32e	71.01b
T_6	2.22d	1.77cd	5.44d	2.55c	3.00c	3.00c	9.26d	63.30c
T_7	4.55b	3.22b	6.88c	3.77b	4.55b	4.77b	10.62c	57.96d
Level of sig.	**	**	**	**	**	**	**	**
CV (%)	4.75	5.55	2.07	8.59	2.78	9.67	6.92	4.21

In a column, figures with the same letter do not differ significantly as per DMRT; ** =Significant at 1% level of probability, NS= Non significant; V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32, T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea.

Table 3. Interaction effect of variety and aqueous extract of grass pea and herbicide on number, dry weight and control efficiency of weeds.

Variety× Aqueous extract	Number of weeds						Weed dry weight (g)	Weed control efficacy (%)
	Bishkatali	Bathua	Khudashama	Angta	Mutha	Khetpapri		
V_1T_1	9.00a	6.00a	16.00a	7.66b	12.66a	10.00a	25.40b	0.000h
V_1T_2	0.33hi	0.66gh	2.00jk	0.33h	0.66l	0.66hi	2.63i	89.60a
V_1T_3	3.33de	2.33cde	8.00d	4.33c	6.00de	4.33bc	11.86d	53.13g
V_1T_4	0.00i	0.66gh	2.00jk	0.66gh	0.66l	0.66hi	2.56i	89.87a
V_1T_5	1.66fg	1.00fgh	4.00i	1.66fg	1.33kl	1.66fgh	7.13h	71.89bc
V_1T_6	2.00f	1.66d-g	5.33gh	2.66def	2.66ij	3.33cd	8.86g	65.10d
V_1T_7	5.00c	3.00bc	7.66de	4.00c	5.66ef	4.33bc	10.40ef	58.92ef
V_2T_1	7.33b	6.00a	16.66a	10.00a	11.00b	10.00a	26.80a	0.000h
V_2T_2	0.66ghi	0.33h	1.66jk	0.33h	0.66l	0.33i	2.40i	91.04a
V_2T_3	3.33de	2.66bcd	8.33d	3.33cde	7.00d	4.66b	11.46de	57.17efg
V_2T_4	0.66ghi	0.66gh	1.33k	0.66gh	0.66l	0.66hi	2.51i	90.62a
V_2T_5	1.33fgh	1.33e-h	5.00hi	1.00gh	2.00jk	1.33ghi	7.27h	72.85b
V_2T_6	2.33ef	1.66d-g	5.66fgh	2.33ef	4.00gh	2.66def	9.04g	66.25d
V_2T_7	4.33cd	3.66b	6.33fg	3.66cd	4.66fg	4.66b	10.80def	59.69e
V_3T_1	7.00b	6.00a	14.00b	8.00b	9.00c	11.00a	23.90c	0.000h
V_3T_2	0.33hi	0.33h	2.66j	0.66gh	0.66l	0.66hi	2.20i	90.78a
V_3T_3	3.33de	2.33cde	11.66c	3.33cde	2.66ij	4.33bc	10.76def	54.90fg
V_3T_4	0.33hi	0.66gh	2.33jk	0.66gh	1.33kl	1.00ghi	2.23i	90.67a
V_3T_5	1.66fg	1.33e-h	4.66hi	2.33ef	1.66jkl	2.00efg	7.56h	68.28cd
V_3T_6	2.33ef	2.00c-f	5.33gh	2.66def	2.33ijk	3.00de	9.89fg	58.54ef
V_3T_7	4.33cd	3.00bc	6.66ef	3.66cd	3.33hi	5.33b	10.66ef	55.28fg
Level of sig.	**	**	**	**	**	**	**	**
CV (%)	4.75	5.55	2.07	8.59	2.78	9.67	6.92	4.21

In a column, figures with the same letter do not differ significantly as per DMRT; ** =Significant at 1% level of probability; V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32; T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea.

Effect of aqueous extract of grass pea and herbicideon number, dry weight and control efficiency of different weeds

Weed population of bishkatali, bathua, khudashama, angta, khetpara and mutha were significantly affected by aqueous extract of grass pea and herbicide. The highest weed population for mutha (10.88) was found in no weeding and the lowest weed population for biskhatali (0.33) was obtained from 90% Recommended dose +Aqueous extraction of grass pea (Table 3). Weed dry weight and weed control efficiency were significantly affected by aqueous extract of grass pea crop residues and herbicide (Table 2). The highest weed dry weight (25.36 g) was found in no weeding and the lowest weed dry weight (2.41 g) was obtained in recommended dose of herbicide. The highest weed control efficiency (90.47%) was in recommended dose of herbicide and no weeding produced the lowest weed control efficiency. In an experiment, extracts of sorghum leaf significantly inhibited the weeds growth and caused maximum reduction in weeds biomass (Won *et al.*, 2013). Weeds can be suppressed by allelochemicals secreted from crop residues (Khaliq *et al.*, 2015). Similarly, aqueous extract of crop residues was recorded effective in case of reducing both number, dry weight and percent inhibition of weeds (Ahmed *et al.*, 2018).

Effect of interaction between variety and aqueous extract of grass pea and herbicide on number, dry weight and control efficiency of different weeds

The interaction between variety and aqueous extract of grass pea crop residues was found to be significant on weed population, dry weight and weed control efficiency (Table 3). The highest khudashama weed population was (16.00) found in V_1T_1 and the lowest (0.33) was found in V_2T_2 for bathua, angta and khetpapri. The highest weed dry weight (26.80 g) was found in V_2T_1 and the highest weed control efficiency (90.67%) was in V_3T_4. Similarly, in a study, significant difference was observed from interaction between rice varieties and extracts of grass pea (Ashraf *et al.*, 2021).

Effect of variety on yield and yield contributing characters of wheat

Effect of variety on yield and yield contributing characters of wheat were observed with significant variation (Table 4). The studied different varieties significantly affected the grain yield (Figure 1). The highest grain yield (3.93 t ha^{-1}) was obtained in BARI Gom- 31. The lowest grain yield (3.66 t ha^{-1}) was obtained in BARI Gom- 32. This difference was observed due to different varietal characteristics of wheat plant. Harvest index was significantly affected by variety. The highest harvest index

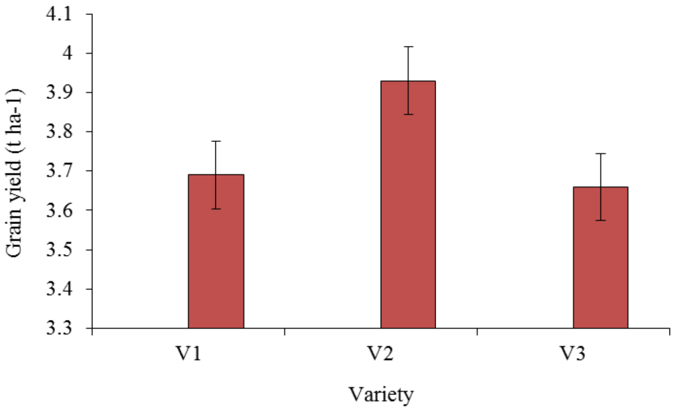

Figure 1. *Effect of variety on grain yield of wheat (Here, V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32).*

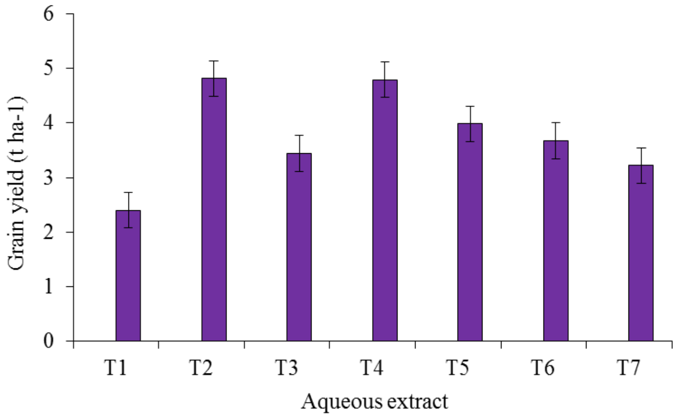

Figure 2. *Effect of aqueous extract of grass pea on grain yield of wheat (Here, T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea).*

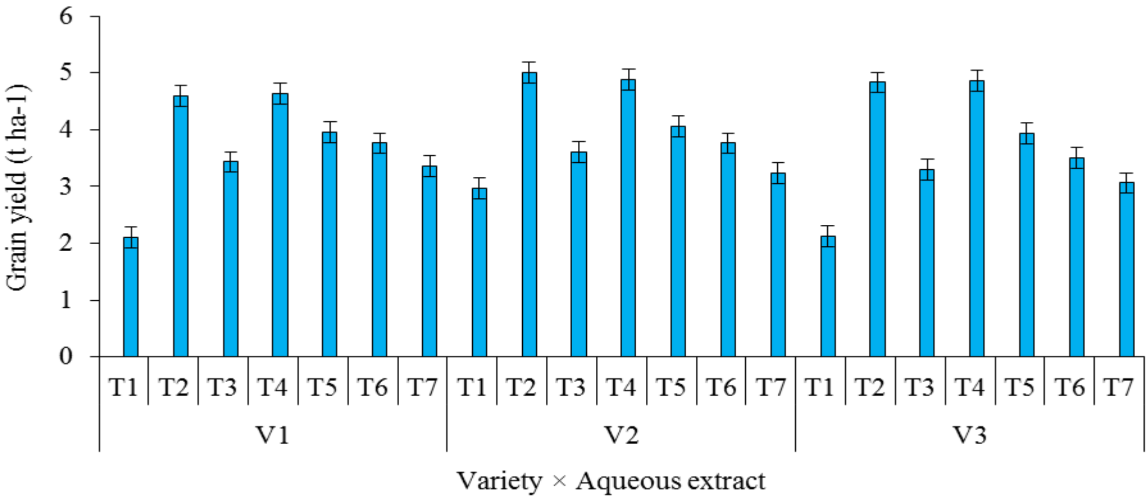

Figure 3. *Combined effect of variety and aqueous extract of grass pea on grain yield of wheat (Here, V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32; T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea).*

(42.17%) was found in BARI Gom- 31 and the lowest harvest index (40.52%) was found in BARI Gom- 30. Similarly, significant variation in case of varieties regarding yield and yield contributing characters of wheat crops were observed growing by the application of mustard crop residues (Sarker *et al.*, 2020). In another study, Ahmed *et al.*, (2018) observed varietal effect on different growth parameters of wheat crops.

Effect of aqueous extract of grass pea and herbicide on yield and yield contributing characters of wheat

Grain yield was significantly influenced by aqueous extract of grass pea crop residues (Table 4). The highest grain yield (4.81 t ha^{-1}) was produced by T_2 treatment (Figure 2). The weeds compete with the crop for nutrient, water, air, sunlight and space. The increased yield was contributed in weed free condition by spike length and filled grains $spike^{-1}$. Harvest index was significantly influenced by aqueous extract of grass pea crop residues. The highest harvest index (44.50%) was observed in T_2 treatment and the lowest harvest index (35.39%) was observed in T_1 treatment. In an experiment, different phenolic compounds such as p-hydroxybenzoic acid, p-coumaric acid, and trans-cinnamic acid were identified in the extracts of sorghum leaves, these compounds were found to suppress weed population (Won *et al.*, 2013). Similarly, Sarker *et al.*, (2020) also reported similar crop performance while used water extracted from mustard residue.

Interaction effect of variety and aqueous extract of grass pea and herbicide on yield and yield contributing characters of wheat

Yield contributing characters were significantly influenced by the interaction between varieties and aqueous extract of grass pea crop residues (Table 5). The highest number of grain yield was produced by V_2T_2 treatment and the lowest number of grain yield was produced by V_1T_1treatment (Figure 3). The lowest grain yield ha^{-1} in the no weeding might be due to the poor performance of yield contributing characters like number of tillers $hill^{-1}$ and grain $spike^{-1}$. Severe weed infestation occurred between weed and wheat plants due to competition for moisture, nutrients. Harvest index was significantly influenced by the interaction between variety and aqueous extract of grass pea crop residues. The highest harvest index was observed in V_3T_4 treatment and the lowest harvest index was observed in V_1T_1 treatment. Similarly, combined effect of variety and extracts of crop reside were found to be effective (Ahmed *et al.*, 2018).

Table 4. Effect of variety on yield and yield contributing characters of wheat.

Variety	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Spike length (cm)	No. of grains spike^{-1}	1000 grain weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
V_1	89.83b	4.45a	3.50a	9.26b	35.64b	51.62ab	5.33a	40.52c
V_2	90.89a	3.80b	2.82b	9.63a	37.00a	51.29b	5.34a	42.17a
V_3	82.32c	3.53c	2.61c	9.29b	35.94b	51.84a	5.08b	41.30b
Level of sig.	**	**	**	**	**	**	**	**
Aqueous extract								
T_1	82.46d	3.51d	2.24e	8.75e	32.42f	50.34d	4.36d	35.39e
T_2	91.27a	4.36a	3.64a	10.04a	37.73b	52.77b	6.00a	44.50a
T_3	86.41c	3.81bcd	2.77cd	9.13cd	36.04d	52.39b	4.87c	41.59c
T_4	90.98a	4.44a	3.58a	10.00a	39.06a	53.38a	6.07a	44.11a
T_5	88.80b	3.95b	3.11b	9.37bc	36.97bc	51.26c	5.34b	42.77b
T_6	87.85b	3.84bc	2.87c	9.41b	36.26cd	50.66cd	5.18b	41.52c
T_7	85.98c	3.58cd	2.62d	9.05d	34.86e	50.27d	4.95c	39.40d
Level of sig.	**	**	**	**	**	**	**	**
CV (%)	5.14	8.07	7.37	2.80	2.58	3.22	3.88	2.79

In a column, figures with the same letter do not differ significantly as per DMRT;** =Significant at 1% level of probability, NS =Not Significant; V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32, T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea.

Table 5. Interaction effect of variety and aqueous extract of grass pea and herbicide on yield and yield contributing characters of wheat.

Variety × Aqueous extract	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Spike length (cm)	No. of grains spike^{-1}	1000 grain weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
V_1T_1	83.00jk	3.66efg	2.46ij	8.86f-i	32.01i	49.81i	3.73k	36.01e
V_1T_2	94.56a	5.23a	4.63a	9.72cd	37.41c-f	53.03abc	5.66bc	44.86a
V_1T_3	88.53gh	4.20bcd	3.06cde	9.03f-i	35.25gh	51.76def	5.64bc	37.82de
V_1T_4	93.80ab	5.20a	4.46a	9.77bc	38.94abc	53.60a	5.92b	43.87a
V_1T_5	91.53cd	4.56b	3.76b	9.04f-i	36.34d-h	52.02cde	5.62bcd	41.36b
V_1T_6	90.53def	4.43b	3.36c	9.26efg	36.00e-h	51.12efg	5.55cd	40.43bc
V_1T_7	86.90h	3.86c-f	2.76e-i	9.16fgh	33.51i	50.01hi	5.21ef	39.27cd
V_2T_1	84.46ij	3.60fg	2.23jk	8.75hi	33.20i	50.30ghi	4.85gh	37.91d
V_2T_2	94.56a	4.13b-e	3.40c	10.34a	38.88abc	52.35bcd	6.50a	43.48a
V_2T_3	89.36fg	3.80c-f	2.80e-i	9.64cde	37.75a-d	51.81def	4.68hi	43.48a
V_2T_4	94.23a	4.26bc	3.30cd	10.17ab	39.01ab	53.20ab	6.34a	43.48a
V_2T_5	92.36bc	3.73d-g	2.83e-h	9.98abc	37.54b-e	50.57ghi	5.28de	43.48a
V_2T_6	91.40cde	3.66efg	2.70f-i	9.70cd	36.68d-g	50.32ghi	4.89fgh	43.48a
V_2T_7	89.83efg	3.43fg	2.50hij	8.85ghi	35.98fgh	50.51ghi	4.88fgh	39.89bc
V_3T_1	79.93m	3.26g	2.03k	8.66i	32.06i	50.91fgh	4.49ij	32.26f
V_3T_2	84.70i	3.73d-g	2.90efg	10.05abc	36.92def	52.94abc	5.86bc	45.15a
V_3T_3	81.33lm	3.43fg	2.46ij	8.74hi	35.13h	53.61a	4.29j	43.48a
V_3T_4	84.93i	3.86c-f	3.00def	10.05abc	39.24a	53.35ab	5.94b	44.99a
V_3T_5	82.50kl	3.56fg	2.73e-i	9.08f-i	37.03def	51.20efg	5.11efg	43.48a
V_3T_6	81.63kl	3.43fg	2.56g-j	9.28def	36.11e-h	50.54ghi	5.11efg	40.67bc
V_3T_7	81.23lm	3.46fg	2.60ghi	9.16fgh	35.11h	50.30ghi	4.78ghi	39.06cd
Level of sig.	**	**	**	**	**	**	**	**
CV (%)	5.14	8.07	7.37	2.80	2.58	3.22	3.88	2.79

In a column, figures with the same letter do not differ significantly as per DMRT; ** =Significant at 1% level of probability; V_1= BARIGom-30, V_2= BARI Gom-31, V_3= BARI Gom-32; T_1= No weeding (Control), T_2= Recommended dose of herbicide, T_3= Aqueous extraction of grass pea, T_4= 90% Recommended dose +Aqueous extraction of grass pea, T_5= 80% Recommended dose +Aqueous extraction of grass pea, T_6= 70% Recommended dose +Aqueous extraction of grass pea, T_7 =60% Recommended dose +Aqueous extraction of grass pea.

Conclusion

Based on the experimental findings of current study it is revealed that grass pea aqueous extract was found as an effective crop residue to inhibit weeds. Growth, yield and yield contributing characters of wheat cultivars were significantly influenced by variety and crop residues application. Among the wheat varieties, BARI Gom-31 showed superior performance in respect of yield contributing characters and yield (3.93 t ha^{-1}). In case of rate of crop residues application, 90% recommended dose +aqueous extract of grass pea crop residues showed highest grain yield (4.81 t ha^{-1}) of wheat. Further research will be conducted based on findings of these experiments.

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