Asian Plant Research Journal

5(4): 7-30, 2020; Article no.APRJ.58983
ISSN: 2581-9992

Evaluation of Different Weed Management Practices on Growth Variables and Yield of Wheat Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MFK and MGM planned the experiment and lead the research. Authors SS, MEH and MGM designed and carried out the research. Authors MEH and SAH performed the statistical analysis. Authors MGM and KF carried out the research on the field. Authors MGM, KF and TK collected the data. Authors MEH and BA wrote the manuscript. Authors MEH, SAH, MAH and SS managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/APRJ/2020/v5i430112
Editor(s):
(1) Dr. Shiamala Devi Ramaiya, University Putra Malaysia, Malaysia.
Reviewers:
(1) Syed Inzimam Ul Haq, Islamia College Peshawar, Pakistan.
(2) Tusharkumar Patel, College of Agriculture, NAU, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/58983

Original Research Article

Received 02 May 2020
Accepted 08 July 2020
Published 23 July 2020

ABSTRACT

A field experiment was conducted in medium fertile soil at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2017 to April 2018 in Rabi season with a view to evaluate the performance of wheat varieties under different weed control methods. The experiment was carried out with three varieties i.e. BARI Gom-28, BARI Gom-29 and BARI Gom-30 in the main plot and

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five weed management methods *viz.* control (no weeding), two hand weeding at 20 and 40 DAS, Panida 33EC (Pendimethalin) @ 2000 ml ha^{-1} at 5 DAS pre-emergence, Afinity 50.75WP (Isoproturon) 1500 g ha^{-1} at 25 DAS as post-emergence herbicide and Panida 33EC (Pendimethalin) @ 2000 ml ha^{-1} at 5 DAS + Afinity 50.75WP (Isoproturon)1500 g ha^{-1} at 25 DAS in the sub plot in split plot design. Nine different major weed species were found in the field such as *Cynodon dactylon, Cyperus rotundus, Echinochloa colonum, Eleusine indica, Chenopodium album, Alternanthera philoxeroides, Brassica kaber, Leliotropium indicum, Vicia sativa.* Results reveled that BARI Gom-30 contributed the highest grain yield 3.01 tha^{-1}. Pre-emergence application of Panida 33EC controlled weeds significantly which showed highest growth followed by yield achieved in wheat. BARI Gom-30 in combination with Panida 33EC produced the highest grain yield 3.52 tha^{-1} while the lowest grain yield 2.09 t ha^{-1} was obtained from BARI Gom-28 with no weeding treatment. Results reveled that Panida 33EC (pre-emergence) was found more effective to controlling weeds in wheat. Results of the study finally reveled that Panida 33EC might be considered as a feasible option for combating weed and ensuring higher yield in wheat cultivation.

Keywords: Control management; growth parameters; weed populations; wheat varieties and yield.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is a cereal grain cultivated worldwide and one-third of the world's people depend on it for their nourishment and provender. World production of wheat was 734.1 million tons [1], and 757.52 million tons making it the third most produced cereal after maize and rice [2]. According to USDA, [3] currently more than 65% of wheat crop is used for food, Wheat grain contains 33% Protein, 29% Carbohydrate, 5% Fat, 17% for animal feed and 12% in industrial applications. CIMMYT predicted that demand for wheat in the developing world is projected to increase 70% by 2050 from now, although Global 2017/18 wheat supplies are reduced, primarily on lower production forecasts for Australia, Russia even in United States [3]. By considering annual production Wheat is the third important cereal after rice and maize in Bangladesh [4] covering an area estimated 4,15,339 hectares in 2016-2017 and average yield of wheat has been estimated 13,11,473 metric tons at 3.16 metric tons per hectare [4].

Wheat provides 20 percent of the calories and protein people consume globally. An estimated that, 80 million farmers in the developing world rely on wheat for their livelihoods. Certainly, the crop is at risk from new and more aggressive pests and diseases, diminishing water resources, limited available land and unstable weather conditions related to climate change [5].

Among various factors responsible for low yield, weed infestation and their management is one of the important factors. Weed competes with crop plants for water, nutrients, space and solar radiation resulting in reduction of yield by 20 to 50% [6]. In order to sustain global agriculture food production, the importance of protecting arable crops against negative yield effect from weeds is well recognized. The prevailing climatic and edaphic conditions are highly favorable for luxuriant growth of numerous species of weeds which offer a keen competition with wheat crop. Shaban *et al*., [7] reported that reduction in wheat yield due to the broad leaf weed competition were 27.5 and 19.2%, whereas due to grass weed were 43.7 and 33.2%, respectively, in both seasons, which indicates that annual grasses weeds were more aggressive.

Hand or manual weeding though very effective and commonly adopted in Bangladesh is expensive, tedious, time consuming and often become uneconomic for the purpose of cultivation. Furthermore, labor shortage in our agriculture is alarming. Chemical weed control is an important alternative as it is easier and cheaper than hand weeding. Herbicide have shown to be beneficial and very effective means of controlling weeds in wheat because they are quite effective and efficient [8]. In contrast, chemical methods lead to environmental pollution and negative impact on public health [9]. However, herbicide selectivity and application dose may reduce the pollution in some extent. This valuable issue needs to be examined in weed management practices that help keeping lower weed population and better control.

Pendimethalin is a selective pre-emergence herbicide belonging to dinitroaniline group with mode of action of mitosis inhibition [10] and being developed for the control of annual grassy weeds in cereal crops including wheat and

barley. It was reported that Pendimethalin and sulfosulfuron were recommended as alternative herbicides against isoproturon resistant Phalaris minor. But resistance against these herbicides was also reported [11], necessitating the search for new herbicide molecules. Hence, it is essential to identify suitable combination of pre-emergence and post-emergence herbicide with broadleaf weed herbicides molecules viz. Pendimethalin, isoproturon, metsulfuron-methyl, carfentrazone-ethyl and 2,4-D for managing complex weed flora in wheat. In view of above discussion, the investigation was undertaken to evaluate the varietal difference in respect of growth and yield of wheat along with to assess the effectivity of different weed management practices on wheat crop yield.

2. MATERIALS AND METHODS

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2.1 Location

The field experiment was conducted at the Agronomy experimental field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November to April, 2017-2018. The location of the experimental site is 90º37´ E longitude and 23º77´ N latitude.

2.2 Soil

The soil of the experimental field area belonged to the Modhupur tract (AEZ No. 28). It was commonly a medium high land with non-calcareous dark grey soil, with low organic matter content. The selected experimental plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done under the supervision of Soil Resources Development Institute (SRDI), Dhaka [12]. The pH value of the soil was 5.7.

2.3 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (kharif Season) and scanty rainfall during the rest period of the year [13]. The Rabi season (October to March) is characterized by moderately low temperature and plenty of sunshine from November to February [12].

2.4 Treatments

The experiment consisted of two factors as mentioned below:

a) Factor A: Varieties (3)

- $V_{1=}$ BARI Gom-28
- $V_{2=}$ BARI Gom-29
- III.$V_{3=}$ BARI Gom-30

b) Factor B: Weed control (5)

- W_0 = No weeding (Control)
- W_1 = Two hand weeding at 20 DAS and 40 DAS
- W_2 = Panida 33EC (Pendimethalin) @ 2000 ml ha^{-1} at 5 DAS (pre-emergence)
- W_3 =Afinity 50.75WP (Isoproturon) @ 1500 g ha^{-1} at 25 DAS (post-emergence)
- W_4 = Panida 33EC (Pendimethalin) @ 2000 ml ha^{-1} at 5 DAS + Afinity 50.75WP (Isoproturon) @ 1500 g ha^{-1} at 25 DAS

2.5 Design and Layout

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 3.50 m x 2.50 m and total numbers of plots were 45. There were 15 treatment combinations. Each block was divided into 15 unit plots and the treatments were assigned in the unit plots at random. Variety was placed along the main plot and treatments were placed along the sub plot. Layout of the experiment was done on November 10, 2017 with inter plot spacing of 0.50 m and inter block spacing of 1 m.

2.6 Fertilizer Application

All the fertilizers were applied at the rate of BARI recommended dose as 220 kg ha^{-1} Urea, 150 kg ha^{-1} TSP, 50 kg ha^{-1} MOP, 120 kg ha^{-1} Gypsum

[14]. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade.

2.7 Plant Protection Measures

There were negligible infestations of insect-pests during the crop growth period. The experimental crop was not infected with any disease and no fungicide was used. Mole cricket and cutworm attacked the crop during the early growing stages of seedlings. Spraying Diazinon 60EC controlled these insects was done at optimum doses. The insecticide was sprayed three times at seven days interval.

2.8 Collection of Data

2.8.1 Weed parameters

The data on weed infestation as well as population were collected from each unit plot at 20 days interval up to 100 DAS. A plant quadrate of 1.0 m^2 was placed at three different spots of 8.75 m^2 of the plot. The middle quadrate was remained undisturbed for yield contributing data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

2.8.2 Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 80^0c. After drying, weight of each species was taken and expressed to g m^{-2}.

2.8.3 Weed control efficiency (%)

According to Saraswat and Mishra, [15] weed control efficiency was calculated with the following formula:

$$\text{Weed control efficiently (E\%)} = \frac{(D - DWT)}{(D)} \times 100$$

Where,

D = Dry weight of weeds in un-weeded treatment
DWT = Dry weight of weeds in weed control treatment.

2.8.4 Crop growth parameters

Growth variables data were collected on Plant height (cm) at 20 days interval up to harvest, Dry matter weight of plant at 20 days interval including partitioning of different parts, Crop Growth Rate (g m^{-2} day^{-1}), Relative Growth Rate (g m^{-2} day^{-1}), Leaf area index and Grain yield (t ha^{-1}).

2.9 Statistical Analysis

The recorded data were subjected to statistical analysis. Analysis of variance was done following two factor split plot design with the help of computer package MSTAT-C. The mean differences among the treatments were adjusted by Least significant difference (LSD) at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Different Weed Species Observed in the Experimental Field

It was a general observation that conditions favorable for growing wheat were also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Nine weed species belonging to seven families were found to infest the experimental crop. Local name, common name, morphological type, scientific name, and family of the weed species have been presented in Table 1. The density and dry weight of different weeds varied considerably in various weed control treatments. The most important weeds of the experimental plot were *Cynodon dactylon, Cyperus rotundus, Echinochloa colonum, Eleusine indica, Chenopodium album, Alternanthera philoxeroides, Brassica kaber, Heliotropium indicum, Vicia sativa* etc. Among the nine species three were grasses, one sedge, and five were broad leaved (Table 1). Hossain *et al*. [16] reported that dominant weed species in the experimental wheat field were *Eleusine indica, Cynodon dactylon, Echinochloa colonum, Parapholis strigosa setaria glauca, Digitaria spp., Chenopodium album, Blumea lacera, Enydra fluctuans* etc. The present result varied a little bit and this might be due to location and seasonal variation.

Table 1. Weed species found in the experimental plots in wheat

SL No.	Local name	Common name	Types	Scientific name	Family
1	Durba	Bermuda grass	Grass	*Cynodon dactylon*	Poaceae
2	Mutha	Nutsedge	Sedge	*Cyperus rotundus*	Cyperaceae
3	Choto shama	Jungle rice	Grass	*Echinochloa colonum*	Poaceae
4	Chapra	Indian goose grass	Grass	*Eleusine indica*	Poaceae
5	Bathua	Lambsquarter	Broad leaf	*Chenopodium album*	Chenopodiaceae
6	Malanch	Alligator weed	Broad leaf	*Alternanthera philoxeroides*	Amaranthaceae
7	Ban sarisha	Wild mustard	Broad leaf	*Brassica kaber*	Brassicaceae
8	Hatishur	Wild clary	Broad leaf	*Heliotropium indicum*	Boraginaceae
9	Ban masur	Wild lentil	Broad leaf	*Vicia sativa*	Fabaceae

3.2 Weed Population

Weed competes with another plants/weed for their existence. In this experiment, several weed species were found to dominate the field (Table 1). This might be due to crop-weed competition, weed-weed competition or allelopathic effect. However, occurrence of weed in the crop field mainly depends on various environmental factors (climate, relative humidity, rainfall etc.) and abiotic factors (soil types, topography of land etc.).

3.2.1 Effect of variety

There was significant variation observed on weed population for varietal variation and number of weed except at 80 DAS (Fig. 1). It was observed that the weed population increased from 20 and 40 DAS throughout the growing season. At 20 DAS, among three varieties BARI Gom-30 (V_3) plot showed higher number of weed population (29.69) which was statistically similar with BARI Gom-28 (V_1) (28.48), whereas, BARI Gom-28 (V_2) showed lower number of weed population (25.60) which was statistically similar with BARI Gom-28 (V_1). In case of 40 DAS higher number of weed population (49.93) was found at BARI Gom-28 (V_1) which was statistically similar with BARI Gom-29 (V_2) and lowest weed population (41.67) in BARI Gom-30 (V_3) which was also statistically similar with BARI Gom-29 (V_9).Highest weed population (49.93) was found in BARI Gom-29 (V_2) which was statistically similar with BARI Gom-28 (V_1) and lower (44.13) one in BARI Gom-30 (V_3) which was statistically similar with BARI Gom-28 (V_1). Numerically higher (30.73) and lower (27.60) weed population was found in BARI Gom-28 (V_1) and BARI Gom-30 (V_3) respectively at 80 DAS. Dissimilar result found by Sultana *et al*., [17] who revealed that number of weed did not varied with variety rather it influenced by weeding regime.

3.2.2 Effect of weed control treatments

Weed control treatments had significant variation on the weed population of the experimental wheat field (Fig. 2). It was observed that the weed population was highest in case of no weed control measures were taken. But, in case of hand weeding (W_1) treatment weed population reduced almost by two-third than that of the control plot in 40, 60 and 80 DAS. At 20,40 and 80 DAS Panida 33EC (W_2) showed lower number of weed population (21.36, 27.33 and 19.56 respectively) and it indicated that effectiveness to control of weed as pre-emergence which was statistically similar with combine treatment Panida 33EC+Afinity 50.75WP (W_4). At 60 DAS lower number of weed population was recorded at W_4 (Panida 33EC+Afinity 50.75WP). This result was agreement with Kaur *et al.,* [18] that Pendimethalin (3.75 L/ha) was found effective to control weed population.

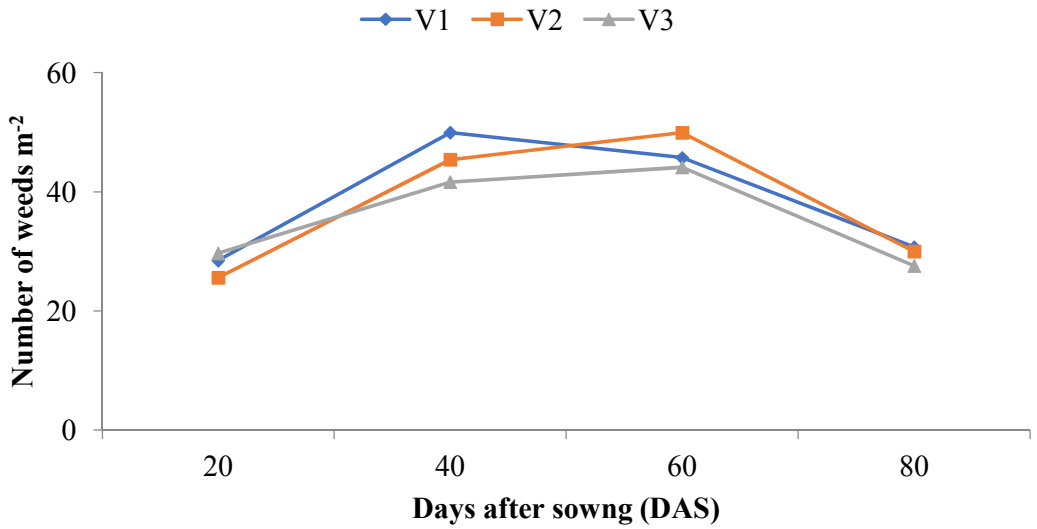

Fig. 1. Effect of variety on the number of weeds on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.79, 7.00, 5.14 and NS at 20, 40, 60 and 80 DAS, respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

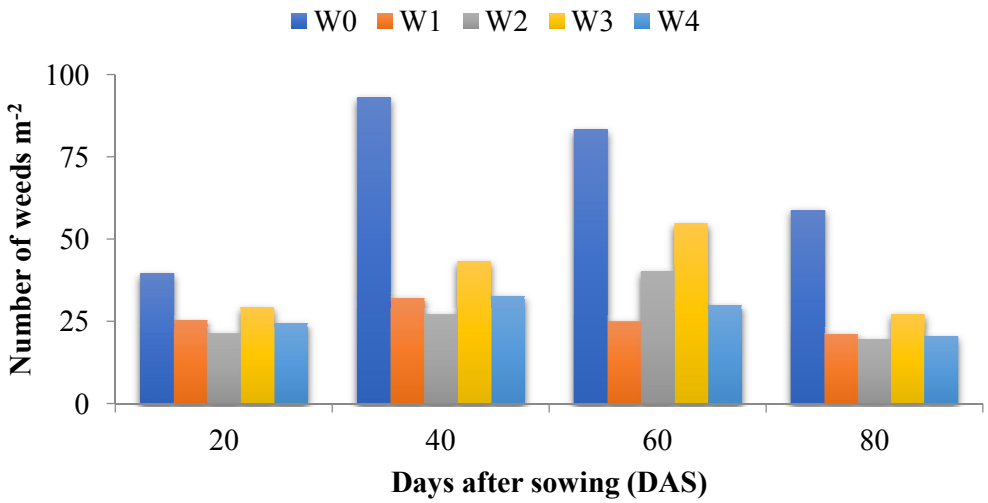

Fig. 2. Effect of different weed managements on the number of weeds on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.26, 5.45, 4.85 and 3.48 at 20, 40, 60 and 80 DAS, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

3.2.3 Combined effect of variety and weed control treatment

For variety and weed management combination, significant variation was observed for weed density throughout the growing period shown in Table 2. At 20 DAS, the highest weed population (42.67 m^{-2}) was recorded from the combination of BARI Gom-30 and no weeding (V_2W_0) which was statistically similar with V_1W_0 and V_3W_0. The lowest weed population (19.67 m^{-2}) was recorded from combination of BARI Gom-30 and panida 33EC (V_2W_2) which was statistically similar to V_1W_2, V_1W_4, V_2W_1, V_2W_4, V_3W_1 and V_3W_2. At 40 DAS, the highest weed population (96.67 m^{-2}) was observed from combination of BARI Gom-30 and no weeding (V_2W_0) which was statistically similar with V_1W_0 and V_3W_0. The lowest weed population (19.00 m^{-2}) was recorded from the combination of BARI Gom-30 and panida 33EC (V_2W_2) which was statistically similar to V_1W_1, V_2W_4 and V_3W_4.Highest weed population (86.00 m^{-2}) was observed from the combinations of BARI Gom-30 and no weeding (V_2W_0) at 60 DAS which was statistically similar with V_1W_0 and V_3W_0. The lowest weed population (21.67 m^{-2}) was observed from the combinations of BARI Gom-29 and two hand weeding (V_2W_1) which was statistically similar with V_1W_1, V_1W_4, V_2W_1, V_3W_1, V_3W_2 and V_3W_4. Finally, at 80 DAS, the highest weed population (62.00 m^{-2}) was observed under the combinations of BARI Gom-28 and no weeding (V_1W_0) which was statistically similar with V_2W_0 and V_3W_0.Minimum weed population (14.33 m^{-2}) was observed from the combinations of BARI Gom-30 and panida 33EC (V_2W_2) which was statistically similar to V_1W_4, V_2W_2 and V_3W_1.

3.3 Weed Biomass

3.3.1 Effect of variety

Significant variation was observed on weed biomass for varietal variation (Fig. 3). The highest weed biomass (122.5 g m^{-2}) was recorded from BARI Gom-28 (V_1) which was statistically similar with BARI Gom-29 (V_2) and lowest weed biomass (98.83 g m^{-2}) recorded from BARI Gom-29 (V_2).

3.3.2 Effect of weed control treatments

Significant variation was observed on weed biomass for different weed control treatments shown in Fig. 4. The highest weed biomass (147.8 gm^{-2}) was recorded from no weeding treatment (W_0) and the lowest weed biomass (75.34 gm^{-2}) was recorded from Panida 33EC+ Afinity 50.75WP(W_4). Second better control over weed performed two hands weeding (W_1) treatment resulted weed biomass (98.48 gm^{-2}) finally. This result supports the findings of Tomar *et al.,* [19], and Singh and Saha, [20].

Table 2. Combined effect of variety and different weed managements on the number of weeds on wheat fields

Treatment combinations	Weeds m^{-2} (no.) at different days after sowing (DAS)			
	20	**40**	**60**	**80**
V_1W_0	38.67 ab	89.33 a	83.67 a	62.00 a
V_1W_1	27.67 d-f	24.00 fg	26.00 f	20.67 d-g
V_1W_2	22.09 f-h	28.67 ef	39.67 d	26.67 b-d
V_1W_3	29.67 de	60.00 b	53.33 bc	28.00 bc
V_1W_4	24.33 e-h	47.67 c	26.00 f	16.33 gh
V_2W_0	37.00 bc	93.00 a	80.00 a	56.67 a
V_2W_1	24.00 f-h	42.67 cd	21.67 f	24.33 b-e
V_2W_2	19.67 h	34.33 de	51.00 c	17.67 f-h
V_2W_3	25.33 e-g	29.33 ef	61.00 b	29.67 b
V_2W_4	22.00 gh	27.67 e-g	36.00 de	21.67 d-g
V_3W_0	42.67 a	96.67 a	86.00 a	58.00 a
V_3W_1	24.12 e-h	29.67 ef	27.33 f	18.67 e-h
V_3W_2	22.33 f-h	19.00 g	30.00 ef	14.33 h
V_3W_3	32.67 cd	40.33 cd	49.67 c	24.00 b-e
V_3W_4	26.67 e-g	22.67 fg	27.67 ef	23.00 c-f
LSD $_{(0.05)}$	5.65	9.44	8.41	6.02
CV (%)	12.00	12.27	10.71	12.14

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4= Panida 33EC+Afinity 50.75WP V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

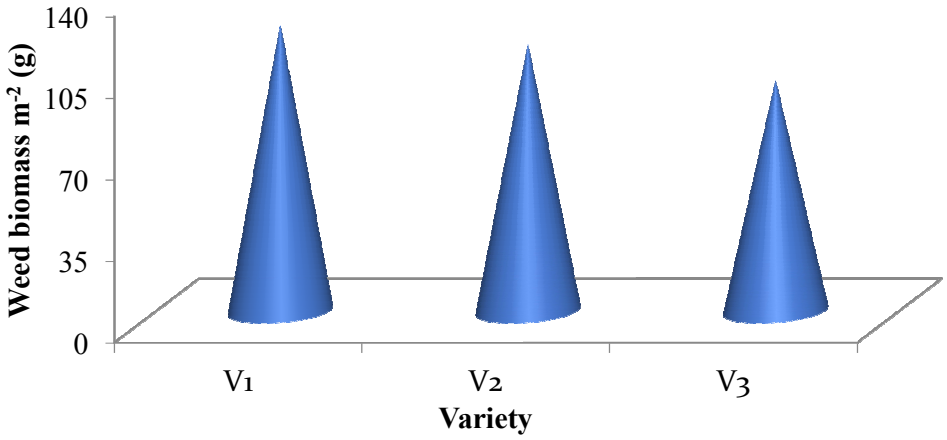

Fig. 3. Effect of variety on the weed biomass m^{-2} (g) in wheat field (LSD $_{(0.05)}$ = 9.14)
V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.3.3 Combined effect of variety and weed control treatment

Significant variation was observed for weed biomass under different variety and weed management combinations (Fig. 5). The highest weed biomass (157.3 g m^{-2}) was observed from BARI Gom-28 (V_1) and no weeding combination (V_1W_0), which was statistically similar with V_2W_0, and V_3W_0 and the lowest weed biomass (57.61 g m^{-2}) was recorded from BARI Gom-30 (V_3) and Panida 33EC + Afinity 50.75WP (V_3W_4). Second least dry matter accumulation weed was found in the combination BARI Gom-29 and Panida 33EC + Afinity 50.75WP (V_2W_4) which was statistically similar with V_1W_4, V_2W_1, V_3W_1 and V_3W_2. Dissimilar result was found by Mustari et al., [21] that pendimethalin performed worst in some wheat varieties in combined.

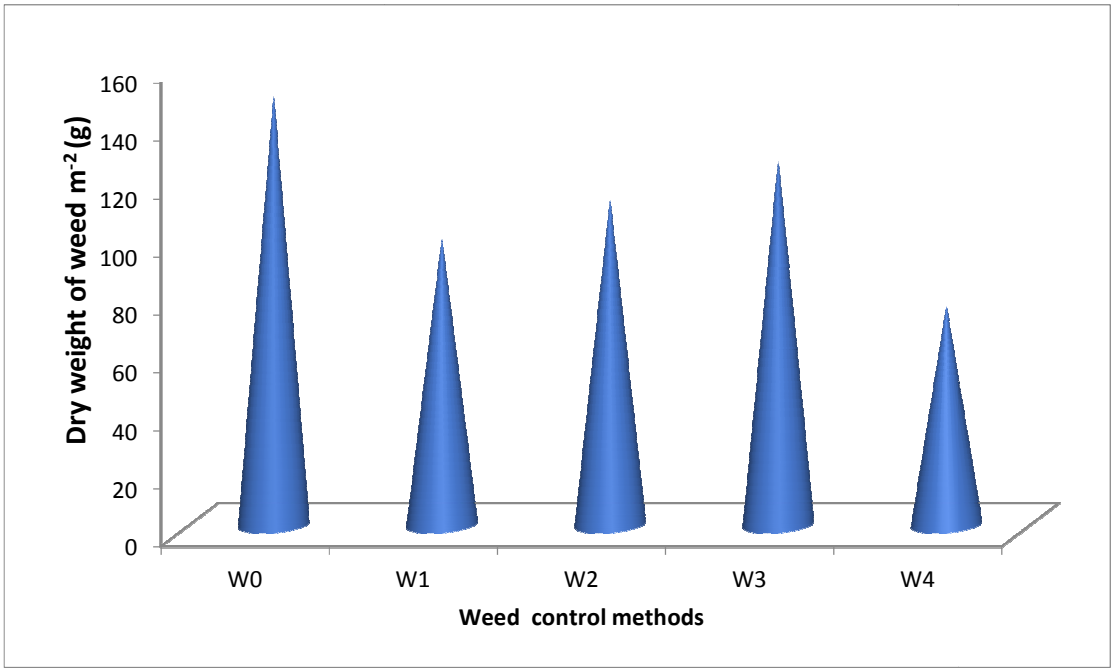

Fig. 4. Effect of different weed managements on the weed biomass m^{-2} (g) in wheat field (LSD (0.05) = 12.18)

W_0= No weeding, W_1= Two hand weeding, W_2= Panida 33EC, W_3= Afinity 50.75 WP, W_4= Panida 33EC+Afinity 50.75 WP

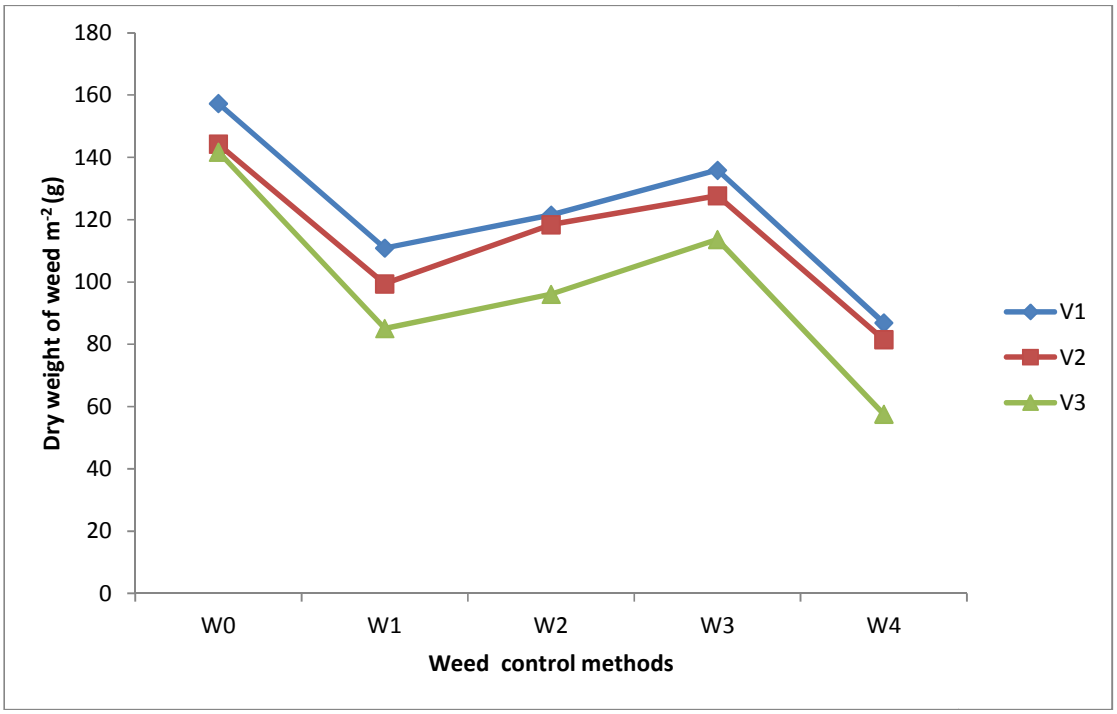

Fig. 5. Combined effect of variety and different weed managements on the Weed biomass m^{-2} (g) in wheat field (LSD (0.05) = 21.10)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.4 Weed Control Efficiency

3.4.1 Effect of variety

Significant variation was observed for weed control efficiency due to varietal variation which was recorded at 20 and 60 DAS shown in Fig. 6. At 20, BARI Gom-29 (V_2) recorded the highest weed control efficiency (30.72 %) which was statistically similar with BARI Gom-30 (V_3) (30.72%) and the lowest weed control efficiency (26.06%) was recorded from BARI Gom-28 (V_1). Hence, similar result was found that higher and lower efficiency (56.50% and 44.02% in BARI Gom-30 and BARI Gom-28 respectively) whose both were statistically similar with other one. In consequence, Sultana *et al*. [17] observed that weed control efficiency significantly varies in different varieties.

3.4.2 Effect of weed control treatments

For different weed management treatments, significant variation was observed in case of weed control efficiency (Fig. 7). Both 20 and 40 DAS, Panida 33EC + Afinity 50.75 WP (W_4) treatment scored the highest weed control efficiency (45.46% and 70.36% at 20 and 40 DAS respectively) and the lowest weed control efficiency (0.00% and 0.00%) were observed under no weeding treatment (W_0). The treatments showed lower efficiency which might be due to emergence of some new weed species at later stages. This result was in agreement with the findings of Kaur *et al.,* [18], and Zahoor *et al.,* [22].

3.4.3 Combined effect of variety and weed control treatments

Significant variation was observed for weed control efficiency under different variety and weed control treatment combinations (Table 3). Both 20 and 40 DAS, the highest weed control efficiency (46.89% and 79.90% 20 and 40 DAS respectively) was recorded form combinations of BARI Gom-30 (V_3) and panida 33EC (V_3W_2), which was statistically similar (46.53% and 76.22% at 20 and 40 DAS respectively) with V_3W_4. The lowest weed control efficiency (0.00%) was observed under all the varieties (BARI Gom-28 (V_1), BARI Gom-29 (V_2), and BARI Gom-30 (V_3) and no weeding treatment combinations (V_1W_0, V_2W_0 and V_3W_0).

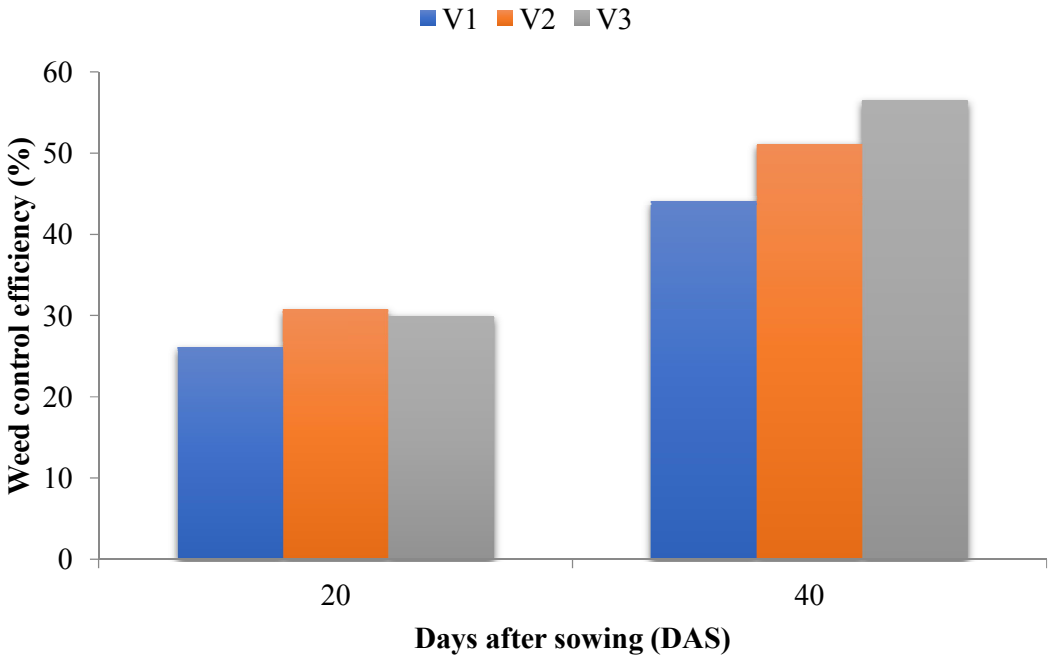

Fig. 6. Effect of variety on the weed control efficiency on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.24 and 7.44 at 20 and 40DAS, respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

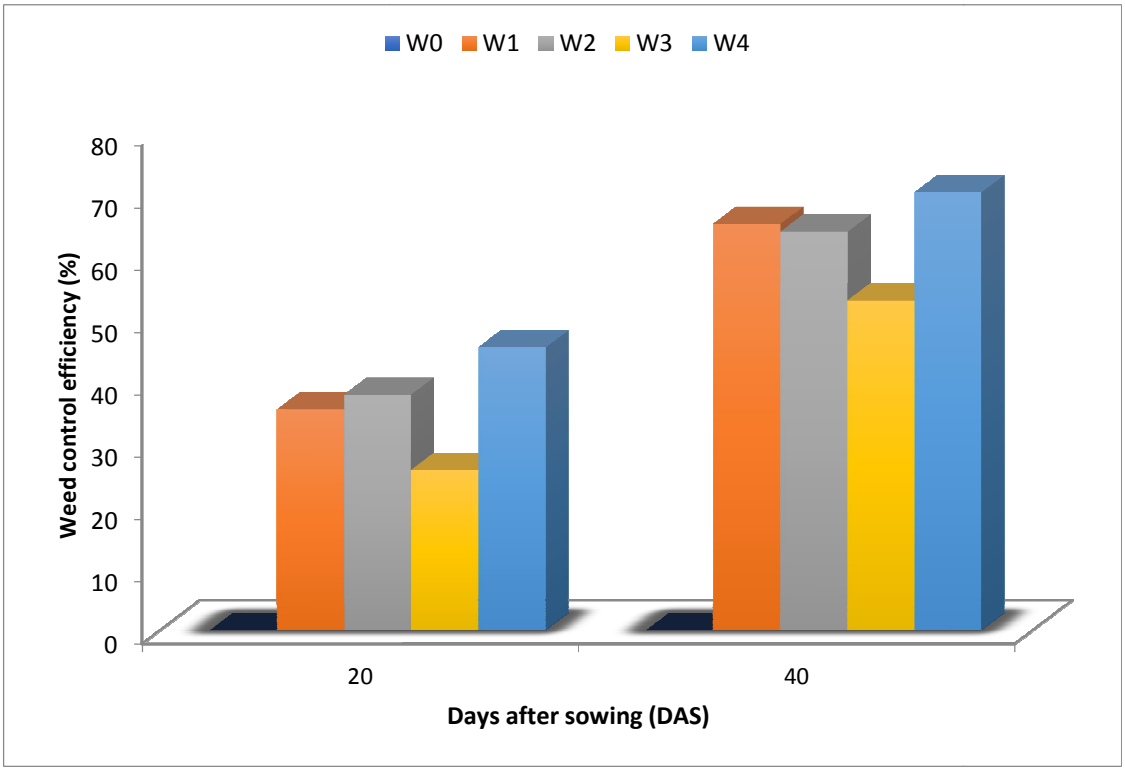

Fig. 7. Effect of different weed managements on the weed control efficiency on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.55 and 4.45 at 20 and 40 DAS, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2= Panida 33 EC, W_3= Afinity 50.75 WP, W_4= Panida 33 EC + Afinity 50.75 WP

Table 3. Combined effect of variety and different weed managements on the number of weeds on wheat fields

Treatment combinations	Weed control efficiency (%) at different days after sowing (DAS)	
	20	**40**
V_1W_0	0.00 h	0.00 i
V_1W_1	28.14 fg	73.11 a-c
V_1W_2	42.96 a-c	67.98 cd
V_1W_3	22.79 g	33.02 h
V_1W_4	36.42 de	45.99 g
V_2W_0	0.00 h	0.00 i
V_2W_1	35.28 de	54.01 f
V_2W_2	36.84 c-e	63.22 de
V_2W_3	31.46 ef	68.40 cd
V_2W_4	40.33 b-d	69.93 b-d
V_3W_0	0.00 h	0.00 i
V_3W_1	43.03 ab	68.74 b-d
V_3W_2	46.89 a	79.90 a
V_3W_3	23.04 g	57.63 ef
V_3W_4	46.53 a	76.22 ab
LSD $_{(0.05)}$	6.14	7.71
CV (%)	12.61	9.05

W_0= No weeding, W_1= Two hand weeding, W_2= Panida 33 EC, W_3= Afinity 50.75 WP, W_4= Panida 33 EC +Afinity 50.75 WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.5 Plant Height

3.5.1 Effect of variety

Plant height varied significantly due to varietal variation throughout the going period (Fig. 8). At 20 DAS, BARI Gom-30 (V_3) scored the highest plant height (23.88 cm) which was statistically similar (22.99 cm) with BARI Gom-29 (V_2). The lowest plant height (22.90 cm) was observed in BARI Gom-28 (V_1) which is statistically similar (22.99 cm) with BARI Gom-29 (V_2). At 40 DAS, BARI Gom-30 (V_3) was recorded the tallest plant (51.43 cm) and BARI Gom-28 (V_1) was recorded the lowest plant height (48.03 cm). In case of 60 DAS, the highest plant height (76.93 cm) was recorded, BARI Gom-30 (V_3)which was statistically similar (22.99 cm) with BARI Gom-29 (V_2), whether the lowest plant height (62.64 cm) was recorded from BARI Gom-28 (V_1).According to 80 DAS and at harvest plant height are not varied significantly but numerically the highest (83.35 cm and 88.47 cm) and lowest plant height (78.88 cm and 82.31 cm) were recorded respectively which are not statistically similar from each other. This result was in agreement with Sultana *et al.,* [17] who described that plant height varies significantly among varieties.

3.5.2 Effect of weed control treatment

There was significant variation observed for plant height due to different weed control treatments (Fig. 9). Throughout the growing period, Panida 33EC (W_2) scored the highest plant height (23.60, 53.30, 75.85, 82.80 and 87.23 cm at 20, 40, 60, 80 DAS and at harvest) while no weeding treatment (W_0) attained the lowest (22.61, 45.73, 65.15, 78.42 and 80.87 cm at 20, 40, 60, 80 DAS and at harvest) plant height. The results were in agreement with the findings of Sultana *et al.* (2012) who found that the highest plant height was observed in completely weed free condition throughout the crop growth period with chemical weed control method and next in two hand weeding treatment whereas lowest value was observed in no weeding treatment. The results were in consistent with the findings of Acker, [22] and Sultana, [17]. The reduction in plant height of wheat plant due to weed competition was also reported by Pandey *et al*., [23].

3.5.3 Combined effect of variety and weed control treatments

Plant height was significantly affected by the combined effect of variety and weed control shown in Table 4. At 20 DAS, highest plant height (25.08 cm) was recorded from the combination of BARI Gom-30 and two hand weeding (V_3W_1) which was statistically similar with V_1W_1, V_1W_2, V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_2, V_2W_4, V_3W_0, V_3W_2, V_3W_3 and V_3W_4 and the lowest (21.40 cm) was obtained from BARI Gom-28 and no weeding combination (V_1W_0) which was statistically similar with V_1W_1, V_1W_2, V_1W_4, V_2W_0, V_2W_1, V_2W_2, V_2W_3, V_2W_4,V_3W_0,V_3W_3 and V_3W_4. Combination of BARI Gom-30 and Panida 33EC (V_3W_2) scored the highest plant height (55.92 cm) at 40 DAS which was statistically similar with V_1W_1, V_1W_2, V_2W_1, V_2W_2, V_2W_3, V_2W_4, V_3W_1, V_3W_4 and V_3W_4.

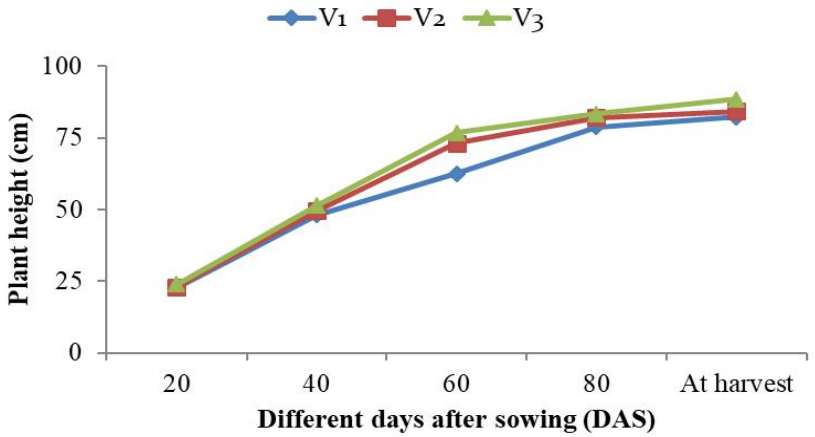

Fig. 8. Effect of variety on the plant height of wheat at different days after sowing (LSD $_{(0.05)}$ =0.95, 1.33, 6.43, NS AND NS at 20, 40, 60, 80 DAS and harvest, respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

On the other hand, the lowest plant height (43.41 cm) was recorded from the combination of BARI Gom-28 and no weeding combination (V_1W_0) which was statistically similar to V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_3, V_2W_4, V_3W_0, V_3W_3 and V_3W_4. At 60 DAS highest plant height (80.27cm) was recorded from the combinations of BARI Gom-30 and Panida 33EC (V_3W_2) which was statistically similar to V_1W_1, V_1W_2, V_2W_0, V_2W_1, V_2W_2, V_2W_3, V_2W_4, V_3W_0, V_3W_1, V_3W_3 and V_3W_4. The lowest plant height was recorded from the combinations of BARI Gom-28 and no weeding combination (V_1W_0) (51.77) which was statistically similar to V_1W_3. The plant height at 80 DAS was non-significant, hence, the highest plant height (86.13cm) was found in combination with BARI Gom-30 and Panida 33EC (V_3W_2), while the lowest one (75.87 cm) was recorded from BARI Gom-28 and no weeding combination (V_1W_0). At harvest, BARI Gom-30 and two hands weeding (V_3W_1) treatment combination achieved the highest plant height (93.33 cm) which was statistically similar with V_1W_1, V_1W_2, V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_2, V_2W_3, V_2W_4, V_3W_0, V_3W_2 and V_3W_4. The lowest plant height (77.57 cm) was recorded from the combinations of BARI Gom-28 and no weeding combination (V_1W_0) which was statistically similar with V_1W_1, V_1W_2, V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_2, V_2W_3, V_2W_4, V_3W_0, V_3W_3 and V_3W_4.

3.6 Leaf Area Index

3.6.1 Effect of variety

Leaf area index of wheat increased significantly due to various type of wheat cultivar at different days after sowing (Fig. 10). BARI Gom-30(V_3) showed exponential highest result throughout the growing stage. The highest (0.23) leaf area index was obtained from BARI Gom-30 (V_3) which was statistically par with BARI Gom-29 (V_3) at 40 DAS and the lowest results (0.15) found in BARI Gom-28 (V_1). At 60 DAS, the highest leaf area index (0.78) was recorded from the BARI Gom-30(V_3) and lowest leaf area index (0.61) which was similar to BARI Gom-29 (V_2). In the case of 80 DAS, the highest leaf area index (1.21) recorded in BARI Gom-30 (V_3) and lowest leaf area index (0.97). A Similar result was observed in the research of Mandal *et al*., [24].

3.6.2 Effect of weed control methods

Weed control methods had a significant influence on the leaf area index of wheat at different days after sowing (Fig. 11). The indicated that Pnida 33EC (W_2) showed exponentially the highest Leaf area index, whereas, no weeding treatment showed the lowest result. The highest leaf area index (0.46, 1.94 and 2.46 at 40, 60 and 80 DAS respectively) were obtained from the treatment panida 33EC and the lowest leaf area index (0.42, 1.58 and 2.06 at 40, 60 and 80 DAS respectively) were recorded in control (W_0). Mandal *et al*., [24] concluded that maximum LAI was found from W_3 (1.3) while minimum from W_0 (0.9) which was similar with the findings and significantly higher leaf area index was observed under pendimethalin 1 kg ha^{-1} pre-em.+1 HW (T_1) by Bhikhubhai, [25].

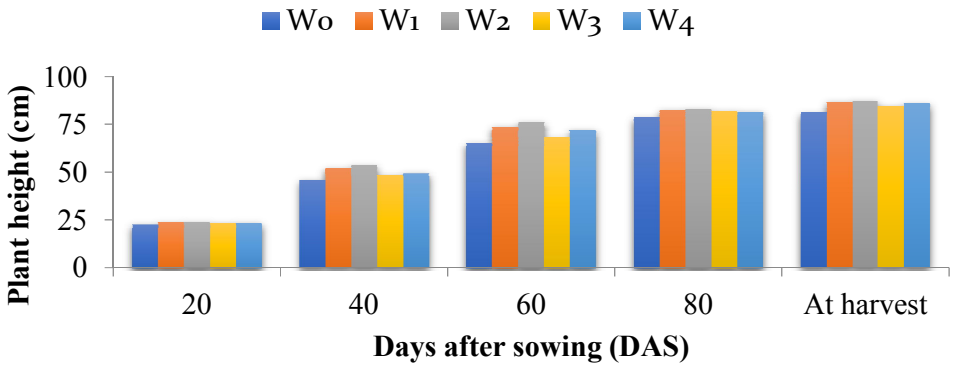

Fig. 9. Effect of different weed managements on the plant height of wheat at different days after sowing (LSD $_{(0.05)}$ = NS, 4.62, 7.30, NS and NS at 20, 40, 60, 80 DAS and harvest, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

Table 4. Combined effect of variety and different weed managements on the plant height of wheat at different days after sowing

Treatment combinations	Plant height (cm) at different days after sowing (DAS)				
	20	40	60	80	At harvest
V_1W_0	21.40 c	43.41 d	51.77 d	75.87	77.57 b
V_1W_1	22.29 a-c	51.46 a-c	68.02 a-c	79.53	84.07 ab
V_1W_2	23.53 a-c	52.32 a-c	70.96 ab	78.07	85.40 ab
V_1W_3	24.99 ab	45.74 cd	57.33 cd	81.00	81.13 ab
V_1W_4	22.31 a-c	47.23 b-d	65.11 bc	79.93	83.39 ab
V_2W_0	23.99 a-c	46.15 b-d	69.89 a-c	79.13	79.80 ab
V_2W_1	23.18 a-c	50.31 a-d	74.67 ab	82.07	86.07 ab
V_2W_2	22.39 a-c	51.66 a-c	76.33 ab	84.20	86.23 ab
V_2W_3	21.73 bc	49.65 a-d	71.24 ab	82.47	83.07 ab
V_2W_4	23.67 a-c	50.50 a-d	73.53 ab	82.67	86.13 ab
V_3W_0	22.45 a-c	47.62 b-d	73.80 ab	80.27	85.23 ab
V_3W_1	25.08 a	53.96 ab	78.13 a	85.67	90.33 a
V_3W_2	24.88 ab	55.92 a	80.27 a	86.13	90.07 a
V_3W_3	23.04 a-c	49.28 a-d	75.26 ab	82.33	88.93 ab
V_3W_4	23.94 a-c	50.36 a-d	77.20 ab	82.33	87.80 ab
$LSD_{(0.05)}$	3.30	8.00	12.65	NS	12.34
CV (%)	8.43	9.55	10.59	10.48	8.61

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

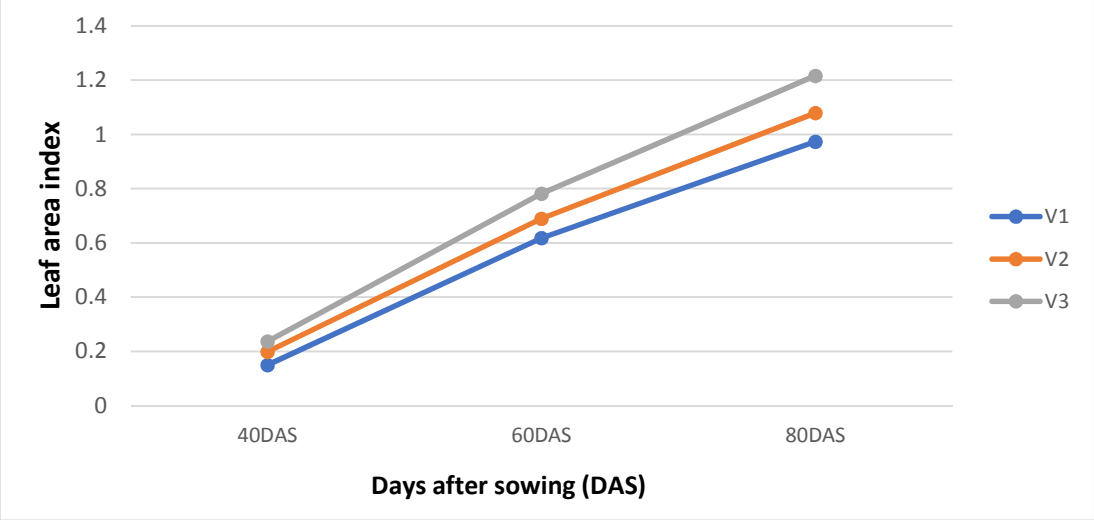

Fig. 10. Effect of variety on the leaf area index of wheat at different days after showing (LSD $_{(0.05)}$ =0.31,0.067 and 0.093 at 40,60 and 80 DAS respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.6.3 Combined effect of variety and weed control treatment

Different treatment combinations variety and weed control method showed significant influence on the leaf area index of wheat at different days after sowing (Table 5). The combination of BARI Gom-30 and Panida 33EC (V_3W_2) reveled the highest leaf area index (2.15 and 2.64) in the case of 40 and 60 DAS respectively. At 80 DAS, the highest leaf area index (3.04) was recorded in combination treatment BARI Gom-30 and two hand weeding (V_3W_2). On the other hand, treatment combination V_1W_0 (BARI Gom-28 and no weeding) showed the lowest leaf area index (1.33, 1.73 and 2.04 at 40, 60 and 80 DAS respectively) throughout the growing season.

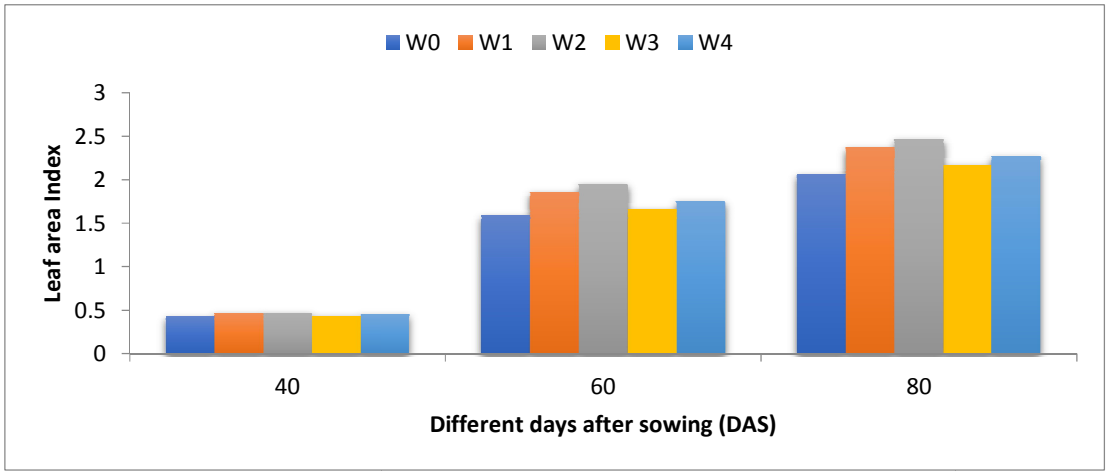

Fig. 11. Effect of different weed managements on the leaf area index of wheat at different days after sowing (LSD $_{(0.05)}$ = 0.052, 0.178 and 0.223 at 40, 60 and 80 DAS, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

Table 5. Combined effect of variety and different weed managements on the Leaf area index (cm^2) in wheat field

Treatment combinations	Leaf area index (cm^2) at different days after sowing (DAS)		
	40	60	80
V_1W_0	1.33 f	1.73 e	2.04 e
V_1W_1	1.67 c-e	2.23 b-d	2.43 b-e
V_1W_2	1.74 b-e	2.31 a-d	2.57 a-d
V_1W_3	1.45 ef	1.93 de	2.15 de
V_1W_4	1.53 d-f	2.08 c-e	2.35 b-e
V_2W_0	1.67 c-e	2.12 c-e	2.18 de
V_2W_1	1.86 -c	2.35 a-c	2.46 b-e
V_2W_2	1.94a-c	2.43 a-c	2.63 a-d
V_2W_3	1.71 c-e	2.20 b-d	2.28 c-e
V_2W_4	1.79 b-d	2.28 a-d	2.39 b-e
V_3W_0	1.74 b-e	2.32 a-d	2.52 b-e
V_3W_1	2.03 ab	2.51 ab	3.04 a
V_3W_2	2.15 a	2.64a	2.81 ab
V_3W_3	1.81 b-d	2.37 a-c	2.69 a-c
V_3W_4	1.93 a-c	2.44 a-c	2.74 a-c
LSD $_{(0.05)}$	3.12	3.89	4.88
CV (%)	10.62	11.51	11.19

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.7 Above Ground Dry Matter Production

3.7.1 Effect of variety

Dry matter is the material that was dried to a certain constant weight. Above ground dry matter (AGDM) production indicates the production potential of a relevant crop. A high AGDM production is the first pre-requisite for high yield. AGDM of roots, leaves, leaf sheath+stem and or panicles of all varieties were measured at 20, 40, 60 DAS and at harvest. It was evident from Fig. 12 that irrespective of treatments AGDM of all the varieties significantly varied at all sampling dates except 20 DAS. Fig. 12 shows that BARI Gom-30 (V_3) achieved the highest dry matter throughout the growing period (0.52, 5.66,9.73 and 12.44 g per plant at 20, 40, 60 and at 80 DAS respectively). Lower amount of dry matter production was observed in BARI Gom-28 (V_1)

throughout the growing period. This may be due to the highest number of tiller mortality. Dissimilar results were reported by Sultana, [26] who stated that cultivar Prodip accumulated a higher amount of vegetative dry matter than the other cultivar.

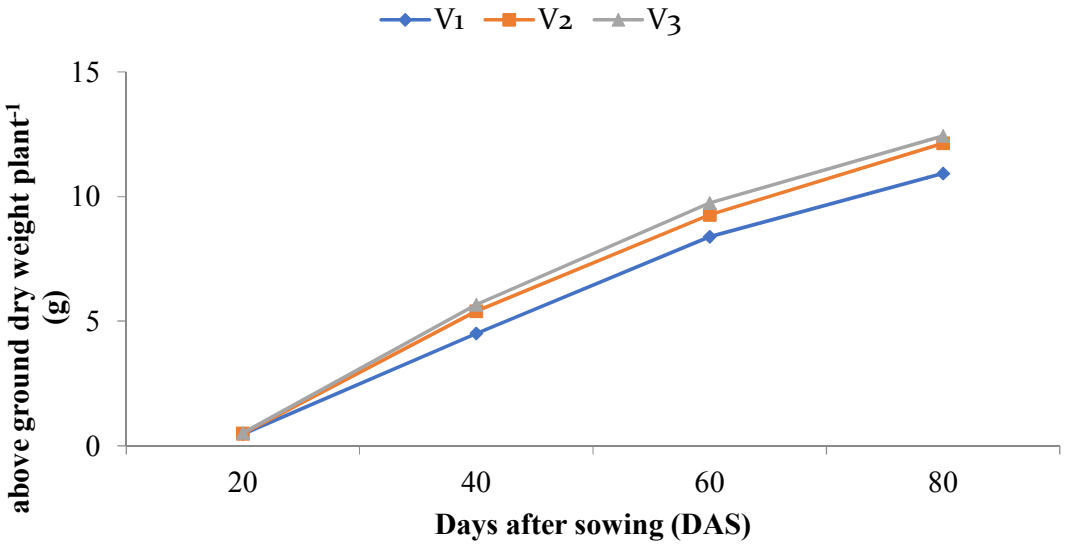

Fig. 12. Effect of variety on the above ground dry weight plant^{-1} of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, 0.55, 0.87 and 1.01 at 20, 40, 60 and 80 DAS, respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

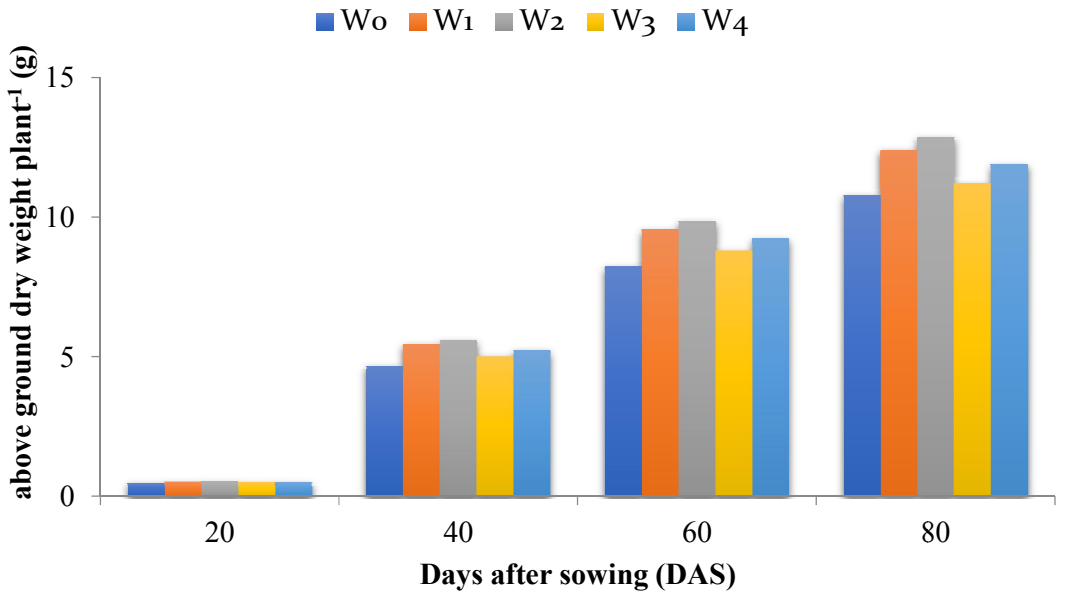

Fig. 13. Effect of different weed managements on the above ground dry weight plant^{-1} of wheat at different days after sowing (LSD $_{(0.05)}$ = 0.04, 0.59, 0.98 and 1.31 at 20, 40, 60 and 80 DAS, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

3.7.2 Effect of weed control treatment

Total dry matter (AGDM) increased exponentially with time. AGDM was significantly influenced by different weed control treatments (Fig. 13). Hence, from the early stages distinct differences were visible among the weed control treatments in AGDM production. The lowest AGDM throughout the growing period was found in un-weeded treatment (W_0). All of the weed control treatments gave statistically similar results from 20 to 80 DAS except Afinity 50.75WP (W_3) were 8.804 (g) and 11.20 (g) at 60 and 80 DAS respectively. Among all the weed control treatments, Panida 33EC (W_2) achieved the highest AGDM (0.5156 g, 5.570 g, 9.84 g and 12.86 g at 20, 40, 60 and at 80 DAS respectively) throughout the growing period. It was reported that weedy check produces minimum AGDM and hand weeding produces higher AGDM followed by Buctril Super at 0.45 kg ha^{-1}, MCPA 0.65 kg ha^{-1} and Buctril Super at 0.25 kg ha^{-1} [27].

3.7.3 Combined effect of variety and weed control treatment

The combined weed control treatments and variety had a significant effect on AGDM production throughout the growing period (Table 6). All the weed control treatments gave higher AGDM over time and gave lower AGDM at no weeding. The treatment combination of BARI Gom-30 and Panida 33EC (V_3W_2) produced the highest AGDM (0.5533 g ,5.933 g, 10.43 g and 13.47 g at 20, 40, 60 and at 80 DAS respectively) throughout the growing period. It might be due to the luxuriant growth of weeds up to harvest in the treatment plot that was controlled by Panida 33EC.

3.8 Crop Growth Rate (CGR)

3.8.1 Effect of variety

Crop growth rate (CGR) is a measure of the increase in size, mass or number of crops over a period of time. The increase further can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to the variety shown in (Fig. 14). At 20-40 DAS, BARI Gom-30 (V_3) scored the highest CGR (12.86 g m^{-2} d^{-1}) which was statistically similar (12.27 g m^{-2} d^{-1}) with BARI Gom-29 (V_2). The lowest CGR (10.10 g m^{-2} d^{-1}) was observed from BARI Gom-28 (V_1). On 40-60 DAS, Crop growth rate (CGR) was non-significantly influenced by different variety but numerically highest CGR (10.20 g m^{-2} d^{-1}) found in BARI Gom-30 (V_3) and lowest CGR (9.682 g m^{-2} d^{-1}) was found in BARI Gom-29 (V_2). In case of 60-80 DAS, the highest CGR (7.244 g m^{-2} d^{-1}) was recorded by BARI Gom-29 (V_2) which was statistically similar (6.755 g m^{-2} d^{-1}) with BARI Gom-30 (V_3). Whether the lowest CGR (6.329 g m^{-2} d^{-1}) was recorded from BARI Gom-28 (V_2) which was statistically similar (6.755 g m^{-2} d^{-1}) with BARI Gom-30 (V_3).

Table 6. Combined effect of variety and different weed managements on total dry matter plant^{-1} of wheat at different days after sowing

Treatment combinations	Above ground dry weight plant^{-1} (g) at different days after sowing (DAS)			
	20	40	60	80
V_1W_0	0.43 c	3.59 d	7.41 d	9.70 d
V_1W_1	0.53ab	4.99 a-c	8.73 a-d	11.55 a-d
V_1W_2	0.49 a-c	5.12 a-c	8.98 a-d	12.06 a-c
V_1W_3	0.44 c	4.27 cd	8.25cd	10.39 cd
V_1W_4	0.45 c	4.57 b-d	8.57 b-d	10.89 b-d
V_2W_0	0.49 a-c	5.01 a-c	8.27 cd	10.99 b-d
V_2W_1	0.50 a-c	5.55 ab	9.59 a-c	12.84 ab
V_2W_2	0.50 a-c	5.66 a	10.11 ab	13.05 ab
V_2W_3	0.46bc	5.32 ab	8.87 a-d	11.35 a-d
V_2W_4	0.47bc	5.43ab	9.48 a-c	12.44 a-c
V_3W_0	0.48 a-c	5.41 ab	9.01 a-d	11.69 a-d
V_3W_1	0.47 bc	5.80 a	10.31 a	12.85 ab
V_3W_2	0.55 a	5.93 a	10.43 a	13.47 a
V_3W_3	0.55 a	5.49 ab	9.30 a-c	11.87 a-d
V_3W_4	0.53 ab	5.67 a	9.65a-c	12.33 a-c
$LSD_{(0.05)}$	0.08	1.03	1.70	2.27
CV (%)	10.12	11.73	11.06	11.38

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

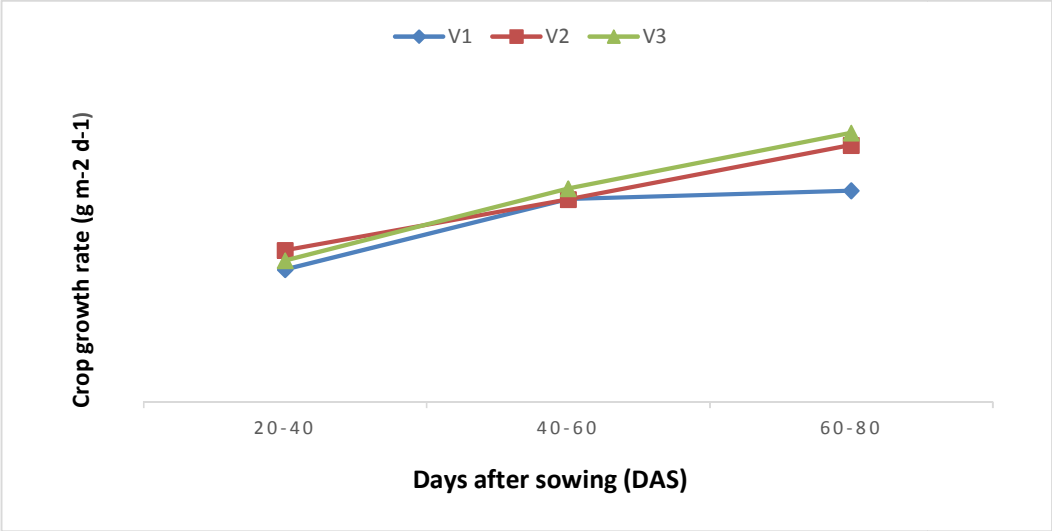

Fig. 14. Effect of variety on the crop growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ = 1.34, NS and 0.61 at 20-40, 40-60 and 60-80 DAS, respectively)
V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

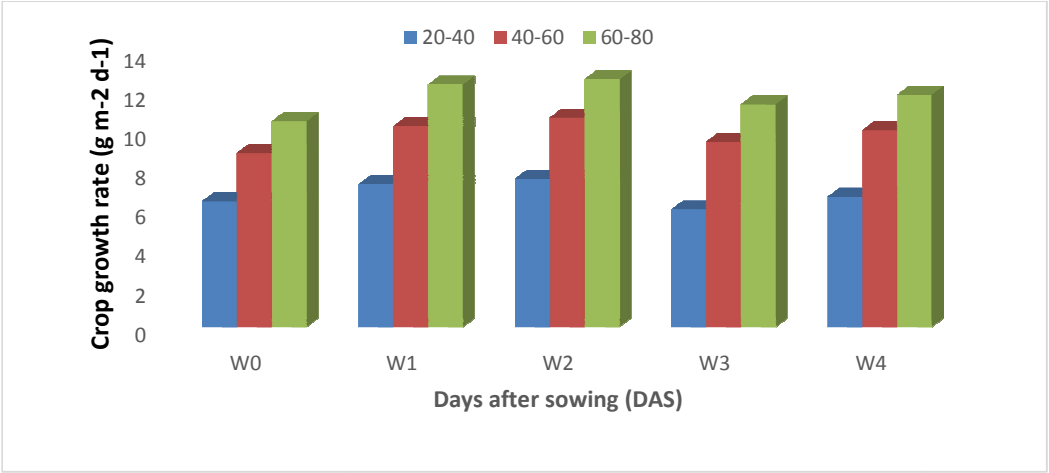

Fig. 15. Effect of different weed managements on the crop growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =1.37, 1.03 and 0.78 at 20-40, 40-60 and 60-80 DAS, respectively)
W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

3.8.2 Effect of weed control treatments

The growth rate of the wheat crop was significantly influenced by different weed control treatments over time (Fig. 15). Unweeded treatment (W_0) showed the lowest CGR throughout the growing period except for 20-40 DAS (5.993 g m^{-2} d^{-1}) which is statistically similar with treatments no weeding (W_1) and Panida 33EC + Afinity 50.75WP (W_4). It revealed that severe weed infestation might hamper the growth and development of wheat plants drastically (Fig. 15). At 20-40 DAS, treatment W_2 (Panida 33CE) gave the highest CGR (7.556 g m^{-2} d^{-1}) which was statistically similar to two hand weeding (W_1) treatment (7.276 g m^{-2} d^{-1}). Even At 60-80DAS, the treatment W_2 (Panida 33CE) gave the highest CGR (12.64 g m^{-2} d^{-1}) which was statistically similar with two hand weeding (W_1). At 40-60 DAS, treatment W_2 gave the highest CGR (10.68 g m^{-2} d^{-1}) which was statistically similar to two hands weeding (W_1) and Panida 33EC + Afinity 50.75WP(W_4Dissimilar result was found by Pandey *et al.* (2000) that weed control

through herbicides *viz*., post-emergence application of isoproturon 1.0 kg ha^{-1}, 2,4-D 0.8 kg ha^{-1} and combination of isoproturon 0.5 kg ha^{-1} + 2,4-D 0.125 kg ha^{-1}gave higher CGR and RGR.

3.8.3 Combined effect of variety and weed control treatment

The combined effect of weed control treatments and variety significantly influenced the CGR throughout the growing period (Table 7). In most of the treatment combinations, CGR increased gradually up to 20-60 DAS and then declined. At the beginning of the crop growth (20-40 DAS) V_3W_1 showed the highest CGR (11.27 g m^{-2} d^{-1}). At 40-60 DAS, V_3W_1 showed the highest CGR (12.86 g m^{-2} d^{-1}). At 60-80 DAS, V_2W_1 gave the highest CGR (8.47 g m^{-2} d^{-1}) among all the treatment combinations. It implied that different weed control treatments effectively controlled the weeds [26].

3.9 Relative Growth Rate (RGR)

3.9.1 Effect of variety

The relative growth rate (RGR) is the increase in materials per unit of plant materials per unit of time. RGR of wheat plant varied non-significantly due to variety shown in Fig. 16. At 20-40 DAS, BARI Gom-28 (V_1) was recorded the highest RGR (0.03140 g m^{-2} d^{-1}) and BARI Gom-29 (V_2) was recorded the lowest RGR (0.0272 g m^{-2} d^{-1}). On 40-60 DAS, BARI Gom-29 (V_2) scored the highest RGR (0.1203 g m^{-2} d^{-1}) numerically. The lowest RGR (0.1127 g m^{-2} d^{-1}) was observed for BARI Gom-20 (V_1). In the case of 60-80 DAS, the highest RGR (0.01353 g m^{-2} d^{-1}) was recorded from BARI Gom-29 (V_2) whether the lowest RGR (0.0122 g $hill^{-1}$ day^{-1}) was recorded from BARI Gom-30 (V_3).

3.9.2 Effect of weed control treatment

Relative growth rate was non-significantly affected by different weed control treatments throughout the time (Fig. 17). At 20-40 DAS, the highest RGR (0.02944 g m^{-2} d^{-1}) attained by the treatments W_0 (no weeding) and lowest RGR (0.02811 g m^{-2} d^{-1}). Treatment W_1 (Two hand weeding) gave the highest RGR (0.1194 g m^{-2} d^{-1}) at 40-60 DAS, While, W_0 treatment (no weeding) gave lowest RGR (0.1142 g m^{-2} d^{-1}) (Fig. 17). However, the numerical highest value of RGR (0.01367 g m^{-2} d^{-1}) at 60-80 DAS and the lowest RGR (0.01211 g m^{-2} d^{-1}) revealed in treatment W_3 (Afinity 50.75WP). Dissimilar result was found by Pandey *et al.,* [28] that weed control through herbicides *viz*., post-emergence application of soproturon 1.0 kg ha^{-1}, 2,4-D 0.8 kg ha^{-1} and combination of isoproturon 0.5 kg ha^{-1} + 2,4-D 0.125 kg ha^{-1}gave higher CGR and RGR.

Table 7. Combined effect of variety and different weed managements on the crop growth rate of wheat at different days after sowing

Treatment combinations	Crop growth rate (g m^{-2} d^{-1}) at different days after sowing (DAS)		
	20-40	40-60	60-80
V_1W_0	9.49a-c	7.90 d	5.73ef
V_1W_1	9.35 bc	11.15 a-c	7.04 b-e
V_1W_2	9.67 a-c	11.56 a-c	7.71 ab
V_1W_3	9.93 a-c	9.58 cd	5.35 f
V_1W_4	10.03 ab	10.31 bc	5.80ef
V_2W_0	8.16c	11.29 a-c	6.80 b-e
V_2W_1	10.10 ab	12.62 ab	8.47 a
V_2W_2	11.14 a	12.90 a	7.35 a-d
V_2W_3	8.85bc	12.16 ab	6.21 d-f
V_2W_4	10.16 ab	12.39 ab	7.39 a-d
V_3W_0	9.010 bc	12.31 ab	6.72 b-e
V_3W_1	11.27 a	13.34 a	6.32 c-f
V_3W_2	11.24 a	13.45 a	7.60 a-c
V_3W_3	9.54a-c	12.34 ab	6.42 b-f
V_3W_4	9.94 ab	12.86 a	6.72 b-e
$LSD_{(0.05)}$	1.79	2.38	1.36
CV (%)	10.75	12	11.9

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

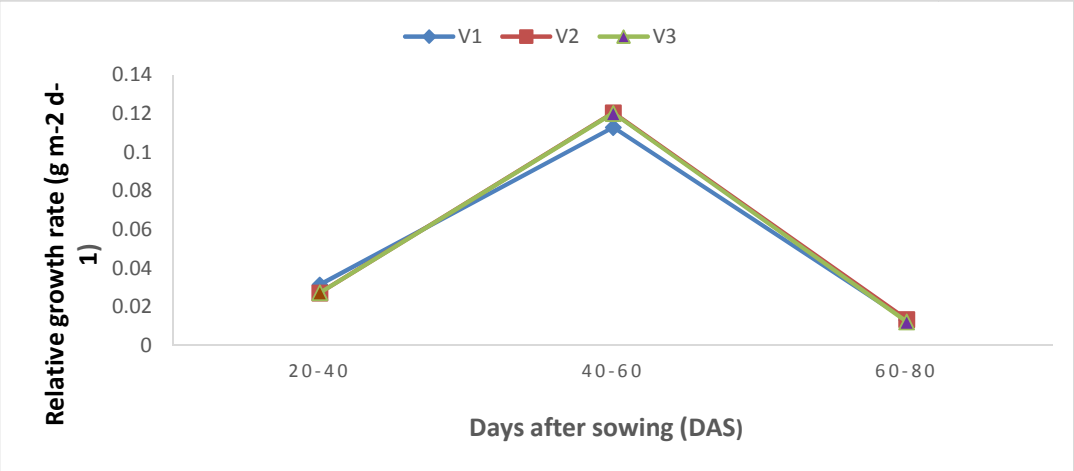

Fig. 16. Effect of variety on the relative growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, NS and NS at 20-40, 40-60 and 60-80 DAS, respectively)

V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

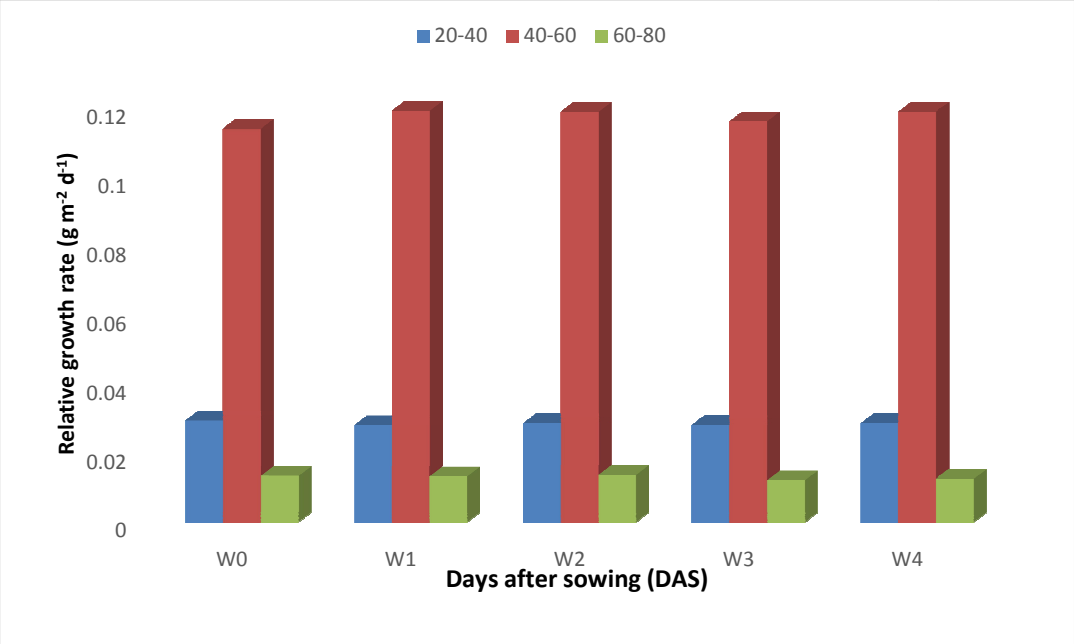

Fig. 17. Effect of different weed managements on the relative growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, NS and NS at 20-40, 40-60 and 60-80 DAS, respectively)

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

3.9.3 Combined effect of variety and weed control treatment

The combined between the weed control treatments and variety non-significantly influenced RGR in all dates of observations shown in Table 8. Numerical value, 20-40 DAS, highest RGR (0.036 g m^{-2} d^{-1}) was found by the treatment V_1W_0. During 40-60 DAS, highest RGR (0.1263 g m^{-2} d^{-1}) was found by the treatment V_3W_1.And during 60-80 DAS, highest RGR (0.01500 g m^{-2} d^{-1}) was observed in the treatment V_1W_2.Numerical lowest value, at 20-40 DAS, RGR (0.025 g m^{-2} d^{-1}) in was found by the

treatment V_2W_0 which was identical to V_2W_3 , during 20 - 40 DAS, RGR (0.1060 g m^{-2} d^{-1}) was found by the treatment V_1W_0. And during 60-80 DAS, RGR (0.01100 g m^{-2} d^{-1}) was observed in the treatment V_3W_1. The high rate of RGR during the period of 40-60 DAS was observed from the results (Table 8). This might be due to the rapid tiller emergence of the crop during this period. A growing organ is consumer of photosynthate and RGR is balanced between sources and sink [18].

Table 8. Combined effect of variety and different weed managements on the relative growth rate of wheat at different days after sowing

Treatment combinations	Relative growth rate (g g^{-1} d^{-1}) at different days after sowing (DAS)		
	20-40	40-60	60-80
V_1W_0	0.036	0.106 b	0.013
V_1W_1	0.028	0.112 ab	0.014
V_1W_2	0.029	0.117 ab	0.015
V_1W_3	0.033	0.112 ab	0.012
V_1W_4	0.031	0.116 ab	0.012
V_2W_0	0.026	0.116 ab	0.014
V_2W_1	0.028	0.120 ab	0.015
V_2W_2	0.029	0.121 ab	0.013
V_2W_3	0.026	0.122 ab	0.012
V_2W_4	0.028	0.122 ab	0.014
V_3W_0	0.026	0.121 ab	0.013
V_3W_1	0.029	0.126 a	0.011
V_3W_2	0.028	0.119 ab	0.013
V_3W_3	0.026	0.115 ab	0.012
V_3W_4	0.027	0.119 ab	0.012
LSD $_{(0.05)}$	NS	0.017	0.02
CV (%)	12.91	10.41	11.68

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

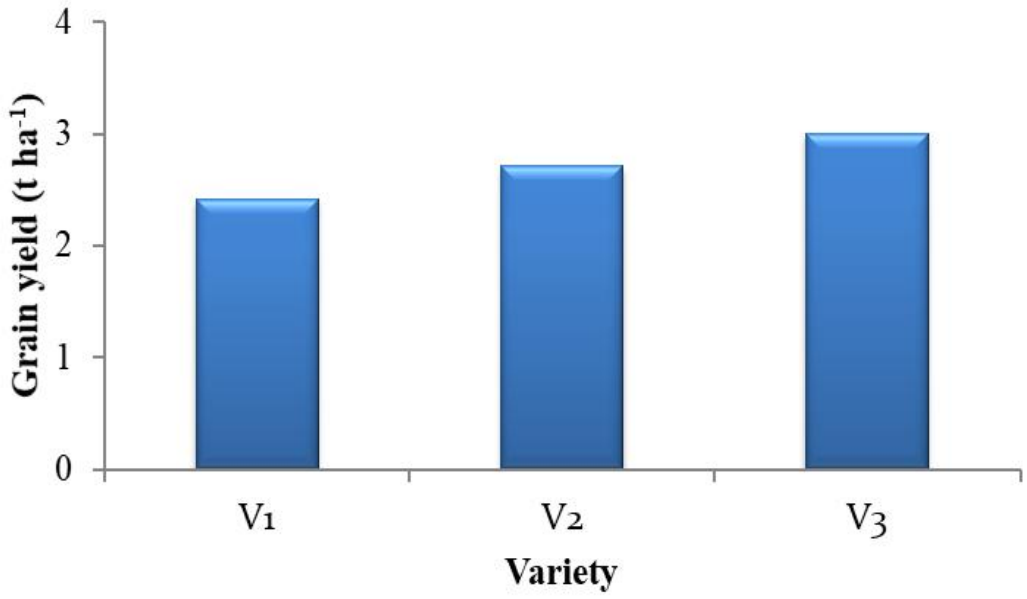

Fig. 18. Effect of variety on the grain yield of wheat (LSD (0.05) =0.08)
V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

3.10 Grain Yield

3.10.1 Effect of variety

Grain yield varied significantly for different varieties shown in Fig. 18. The highest grain yield (3.007 t ha^{-1}) was recorded by BARI Gom-30 (V_3). The second highest grain yield (2.71 t ha^{-1}) was recorded from BARI Gom-29 (V_3). The lowest grain yield (2.416 t ha^{-1}) was recorded from BARI Gom-28 (V_1). This result was similar with Sultana *et al.,* [17] who found that Prodip produced the highest grain yield (5.33 t ha^{-1}) followed by Gourab (4.85 t ha^{-1}), while the lowest grain yield (3.98 t ha^{-1}) was obtained from Shatabdi.

3.10.2 Effect of weed control treatments

Significant variation was observed for grain yield due to different weed control treatments (Fig. 19). The highest grain yield (3.124 t ha^{-1}) was recorded from Panida 33EC (W_2) which was statistically similar with two hand weeding (W_1) and the lowest yield (2.374 t ha^{-1}) was obtained from no weeding treatment (W_0) which was similar with Afinity 50.75WP (W_4). Similar findings were reported by Zahoor *et al.,* [27] that the application of Buctril super gave 0.45 kg ha^{-1} grain yield. Dissimilar results were found by Azad *et. al.,* [8] stated that pre and post-emergence application of isoproturon give higher grain yield rather than weedy check.

3.10.3 Combined effect of variety and weed control treatments

The grain yield varied significantly due to different varietal and weed control treatment combinations (Table 9). The highest grain yield (3.523 t ha^{-1}) was recorded from BARI Gom-30 and Panida 33EC combination (V_3W_2) which was statistically similar to BARI Gom-30 and two hands weeding (V_3W_1), BARI Gom-29 and Panida 33EC (V_2W_2). The lowest grain yield (2.090 t ha^{-1}) was recorded from BARI Gom-28 and no weeding treatment combination (V_1W_0) which was statistically similar to treatment combination V_1W_3, V_1W_4, V_2W_0 and V_2W_3. This result was in agreement with Sultana *et al.,* [17] who reported that the combined effect of variety and the weeding regime had a significant effect on yield and yield contributing characters.

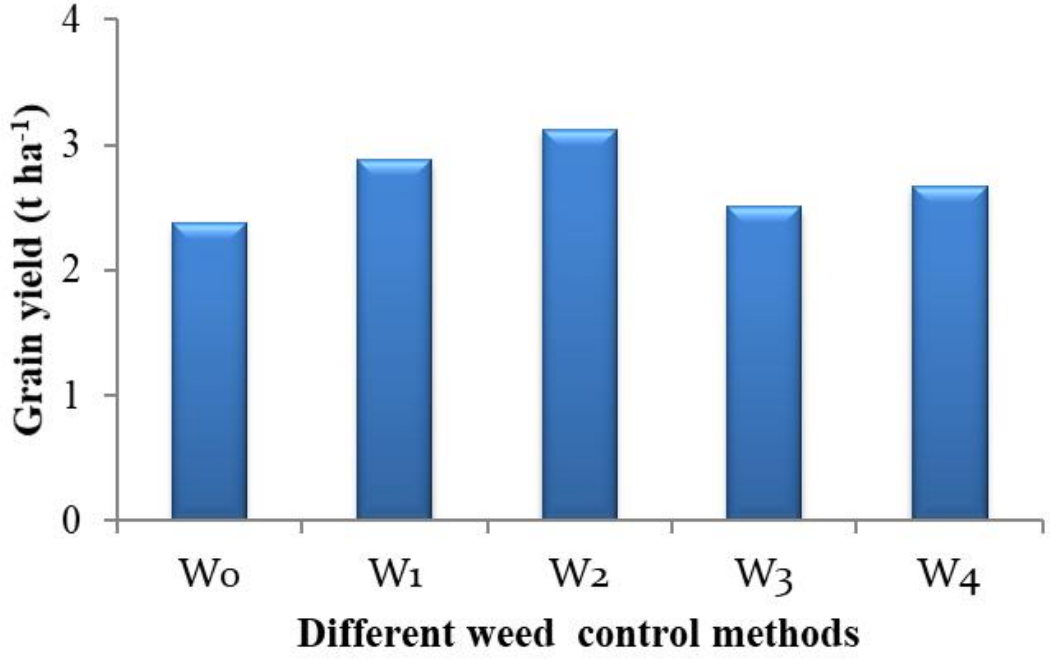

Fig. 19. Effect of different weed managements on the grain yield of wheat (LSD $_{(0.05)}$ =0.27)
W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP

Table 9. Combined effect of variety and different weed managements on the yield characters of wheat

Treatment combinations	Grain yield (t ha^{-1})
V_1W_0	2.09 g
V_1W_1	2.57 d-f
V_1W_2	2.69 d-f
V_1W_3	2.27 fg
V_1W_4	2.46 d-g
V_2W_0	2.43 e-g
V_2W_1	2.79 c-e
V_2W_2	3.16 a-c
V_2W_3	2.54 d-g
V_2W_4	2.64 d-f
V_3W_0	2.60 d-f
V_3W_1	3.29 ab
V_3W_2	3.52 a
V_3W_3	2.70 c-f
V_3W_4	2.92 b-d
LSD $_{(0.05)}$	0.46
CV (%)	10.18

W_0= No weeding, W_1= Two hand weeding, W_2=Panida 33EC, W_3= Afinity 50.75WP, W_4=Panida 33EC+Afinity 50.75WP, V_1=BARI Gom-28, V_2=BARI Gom-29, V_3=BARI Gom-30

4. CONCLUSION

Different weed control treatments and varieties had significant effect on different crop growth parameters along with yield. Based on the results of the present research, the following conclusion can be drawn; BARI Gom-30 was proved superior over other varieties in respect of growth and yield of wheat crop. Panida 33 EC as pre-emergence herbicide was found to be an effective means of controlling weeds from an economic point of view. BARI Gom-30 treated with Panida 33EC at pre-emergence showed the best performance in terms of growth parameters and grain yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO (Food and Agricultural Organization). Statistical Yearbook. Food and Agriculture Organization, Rome, Italy; 2016
2. Available:https://www.statista.com/statistics/263977/world-grain-production-by-type/
3. USDA (United States Department of Agriculture). World agricultural supply and demand estimates, economic research service and foreign agricultural service. 2018;18.
4. BBS (Bangladesh Bureau of Statistics). Yearbook of Agricultural Statistics-2017. Statistics and Informatics Division (SID), Ministry of Planning. Govt, of the peoples Republic of Bangladesh, Dhaka. 2019;78-79.
5. Available:http://www.cimmyt.org/global-wheat-research.
6. Bhan VM. Status of research on weed science and its impact. Presented at seventeenth meeting of the Governing Body of the ICAR, New Delhi;1998.
7. Shaban SA, Soliman S. Yehia ZR, El-Attar MH. Weed competition effect on some Triticum aestivum quality and quantity. CAB Abstracts, Egyptian J. Agron. 2009;31(2):135-147.
8. Azad BS, Singh H, Gupta SC. Effect of plant density, dose of herbicide and time of nitrogen application on weed suppression and its efficiency in wheat (Triticum aestivum L.). Env. Ecol. 1997;15(3):665-668.
9. Phuhong LT, Denich M, Vlek PLG, Balasubramanian V. Suppressing weeds in direct seeded lowland rice: effects of methods and rates of seeding. J. Agron. Crop Sci. 2005;191:185-194.
10. Hoffer U, Muehlebach M, Hole S, Zoschke A. Pinoxaden for broad spectrum grass weed management in cereal crops. J. Plant Disease Protec. 2006;20(5):989-995.

11. Dhawan RS, Punia SS, Singh S, Yadav D, Malik RK. Productivity of wheat (Triticum aestivum) as affected by continuous use of new herbicides for management of little seed canary grass (Phalaris minor). Indian J. Agron. 2009;54(1):58-62.
12. Available:http://www.srdi.gov.bd
13. Biswas PK. A study on the relative merits of mixed cropping under two levels of irrigations. MS Thesis, Dept. Agron. Bangladesh Agric. Univ. Mymensingh. 1987;38-40.
14. Available:http://www.bari.gov.bd/
15. Saraswat VN, Mishra JS. Status of weed management research in wheat. Pestology. 1998;23(5):5-11.
16. Hossain A, Chowdhury MAS, Jahan T, Sarker MAI, Akhter MM. Competitive ability of wheat cultivars against weeds. Bangladesh J. Weed Sci. 2010;1(1):63-70.
17. Sultana MR, Alim MA, Hossain MB, Karmaker S, Islam MS. Effect of Variety and Weed Management Practices on Yield and Yield Attributes of Wheat. J. Environ. Sci. Nail. Resources. 2012;5(2):91-96.
18. Kaur E, Sharma R, Singh ND. Efficacy of Pre-Emergence and Post-Emergence Herbicides on Weed Control and Yield in Wheat. Int. J. Curr. Microbiol. App. Sci. 2018;7(2):883-887.
19. Tomar SS, Jain PC, Paradkar NR. Effect of post-emergence herbicide on weed control in wheat (Triticum aestivum). National symposium on Resource conservation and Agricultural Productivity, Ludhiyana, Punjab. 2004;216-217.
20. Tomar SS, Jain PC, Paradkar NR. Effect of post-emergence herbicide on weed control in wheat (Triticum aestivum). National symposium on Resource conservation and Agricultural Productivity, Ludhiyana, Punjab. 2004;216-217.
21. Mustari S, Bari MN, Islam MR, Karim AJMS. Evaluation of selected herbicides on weed control efficiency and yield of wheat. J. Sci. Foundation. 2014;12(2):27-33.
22. Acker, I. (2010). Grain yield and quality of wheat depending on the level of nitrogen fertilization form applied. Bangladesh Agron. J., 8(2): 129-133.
23. Pandey IB, Sharma SL, Tiwari S, Mishra SS. Economics of tillage and weed-management system for wheat after lowland rice. Indian J. Agron. 2005;50(1):44-47.
24. Mandal MSH, Ali MH, Amin AKMR, Masum SM, Mehraj H. Assessment of different weed control methods on growth and yield of wheat. Int. J. Agron. Agric. Res. 2014;5(5):65-73.
25. Bhikhubhai RV. Efficacy of herbicides in wheat (Triticum aestivum) and assessment of their persistence through bioassay technique, MS thesis, Junagadh Agric. Univ. Junagadh, India; 2006.
26. Sultana S. Influence of nitrogen level and weeding on the performance of wheat. MS Thesis, SAU, Dhaka, Bangladesh; 2009.
27. Zahoor F, Malik MA, Mehmood K, Rasheed M, Ansar R, Hussain M, Kazmi MH, Jamil M. Optimizing herbicide use in wheat (Triticum aestivum) under rain-fed conditions. African J. Agric. Res. 2012;7(35):4858-4866.
28. Pandey IB, Mishra SS, Singh H, Prasad N. Nutrient uptake by wheat and associated weeds as influenced by fertilizer levels and weed management. Indian J. Weed Sci. 2000;32(1 and 2):31-32.

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