# EVALUATION OF DIFFERENT WEED MANAGEMENT PRACTICES FOR MAXIMUM GROWTH AND YIELD OF WHEAT VARIETIES

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**DECEMBER, 2017**

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*A Thesis*
*Submitted to the Faculty of Agriculture,*
*Sher-e-Bangla Agricultural University, Dhaka,*
*in partial fulfilment of the requirements*
*for the degree of*

**MASTER OF SCIENCE**

**IN**

**AGRONOMY**

**SEMESTER: JULY-DECEMBER, 2017**

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# *CERTIFICATE*

*This is to certify that the thesis entitled **"EVALUATION OF DIFFERENT WEED MANAGEMENT PRACTICES FOR MAXIMUM GROWTH AND YIELD OF WHEAT VARIETIES"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **MD. GOLAM MOSTAFA,** Registration. No. **12-04924** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

*I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.*

Dated:

Dhaka, Bangladesh

**(Prof. Dr. Md. Fazlul Karim)**
**Supervisor**

DEDICATED TO

MY

BELOVED PARENTS

## ACKNOWLEDGEMENT

Alhamdulillah, all praises are due to the almighty **Allah Rabbul Al-Amin** for His kindness and infinite mercy in all the endeavors the author to let him successfully completed the research work and the thesis leading to Master of Science.

The author would like to express his heartfelt gratitude and most sincere appreciations to his Supervisor **Prof. Dr. Md. Fazlul Karim**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-Supervisor **Prof. Dr. H. M. M. Tariq Hossain,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author expresses his deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author wishes to extend his special thanks to Md. Ahsan Habib, Md. Rashed Bin-Hafiz and Shiuli Paul for their help during experimentation. Special thanks to all other friends for their support and encouragement to complete this study.
The author is deeply indebted to his parents, brothers, sisters and other relatives for their moral support, encouragement and love with cordial understanding.

Finally, the author appreciates the assistance rendered by the staff members of the Department of Agronomy, Sher-e-Bangla Agricultural University Farm, Dhaka, who have helped him during the period of study.

***The Author***

# EVALUATION OF DIFFERENT WEED MANAGEMENT PRACTICES FOR MAXIMUM GROWTH AND YIELD OF WHEAT VARIETIES


## ABSTRACT

A field experiment was conducted in medium fertile soil at Sher-e-Bangla Agricultural University (90º37´ E longitude and 23º77´ N latitude), 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 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, Ieliotropium indicum, Vicia sativa.* Results reveled that BARI Gom-30 contributed the highest grain yield 3.01 t $ha^{-1}$. 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 t $ha^{-1}$ 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 as the benefit cost ratio was 1.41. 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.

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| | | |
|---|---|---|
| % | = | Percent |
| µg | = | Micro gram |
| $^0$C | = | Degree Celsius |
| AEZ | = | Agro-Ecological Zone |
| AIS | = | Agriculture Information Service |
| B:C | = | Benefit Cost ratio |
| BARI | = | Bangladesh Agricultural Research Institute |
| BBS | = | Bangladesh Bureau of Statistics |
| cm | = | Centi-meter |
| CV% | = | Percentage of coefficient of variance |
| cv. | = | Cultivar |
| DAS | = | Days after sowing |
| DF | = | Degree of freedom |
| EC | = | Emulsifiable Concentrate |
| *et al.* | = | And others |
| etc. | = | Etcetera |
| FAO | = | Food and Agricultural Organization |
| g | = | Gram |
| $ha^{-1}$ | = | Per hectare |
| HI | = | Harvest Index |
| hr | = | Hour |
| Kg | = | Kilogram |
| LAI | = | Leaf area index |
| LSD | = | Least significant difference |
| LSD | = | Least Significant Difference |
| m | = | Meter |
| Max | = | Maximum |
| Min | = | Minimum |
| mm | = | Millimeter |
| MP | = | Muriate of Potash |
| N | = | Nitrogen |
| No. | = | Number |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| NS | = | Non-significant |
| ppm | = | Parts per million |
| RCBD | = | Randomized complete block design |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources and Development Institute |
| T | = | Ton |
| TSP | = | Triple Super Phosphate |
| *viz.* | = | Videlicet (namely) |
| WCE | = | Weed Control Efficiency |
| WP | = | Wettable Powder |
| Wt. | = | Weight |

# Chapter I

# Introduction

# Chapter I

## 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 (FAO, 2016), and 757.52 million tons (Statista, 2018) making it the third most produced cereal after maize and rice.

According to USDA (2018) 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. (USDA,2018).

By considering annual production Wheat is the third important cereal after rice and maize in Bangladesh (BBS, 2018) 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 (BBS, 2018).

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 (www.cimmyt.org.net)

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% (Bhan,1998). 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.* (2009) 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.

The low temperature during winter season favors germination and growth of important weeds like *Chenopodium sp*. (Hirano *et al*., 1993). Some other scientists observed that the broadleaf weeds were predominant in wheat field. Number of weed species in wheat field varied from country to country and up to 45% weed species have been reported in Pakistan (Qureshi and Bhatti, 2001), 33% in Iran (Buczek *et al*., 2011), 90 % in India (Rao, 2000) and 73% in Bangladesh (Begum *et al*., 2003). Besides other crops weed is a major problem for maximizing higher yields of wheat and unchecked weed growth reduces crop yield up to 57% (Singh *et al*., 1997). Moreover, weeds are alternate hosts to insects, pathogenic fungi and nematodes such as common broad-leaved weeds for Fusarium, wild grasses and grassy weeds for wheat streak mosaic virus and its vector and wheat curl mite (Ito *et al*., 2012). Weeds are one of the major constraints and weed control is the key factor in increasing yield of wheat (Shehzad *et al*., 2012).

In a wheat field, variety of weeds grown are generally classified into three groups namely, grasses, sedges and broadleaf weeds according to their morphological character. Monocot and Dicot weeds include *Phalaris minor, Avena fatua, Polypogon monspliensis, Cyperus rotundus* and *Cynodon dactylon.* In Bangladesh the traditional and conventional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Usually two or more hand weeding are normally done for growing a wheat crop depending upon the nature of weeds, their intensity of infestation and the crop grown. However, hand weeding is highly labor-intensive (as much as 90 person/days/ ha) (Roder, 2001).

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 (Azad *et al*., 1997). In contrast, chemical methods lead to environmental pollution and negative impact on public health (Phuong *et al*., 2005). 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 new selective both pre-emergence and post-emergence herbicide belonging to dinitroaniline group with mode of action of mitosis inhibition (Hoffer *et al*., 2006) and being developed for the control of annual grassy weeds in cereal crops including wheat and barley. Pendimethalin controls grassy weeds as well as against broad leaf weeds.

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 (Dhawan *et al*., 2009), 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.

Therefore, the need was felt to study the effect of different herbicides along or combination to control weeds in wheat, and to boost up the productivity. In view of above disscusion, the present investigation is undertaken with the following objectives:

**Objectives:**

1. To evaluate the varietal difference in respect of growth and yield of wheat.

2. To assess the effectivity of different weed management practices in wheat field

3. Assessment of combine effect of variety and weed managements regarding yield improvement of wheat crop.

4.To evaluate the economic performance of wheat varieties under different weed management practices.

# Chapter II

# Review of literature

# Chapter II

# Review of Literature

## 2.1 Biology of wheat

*Triticum* is a genus of the family *Graminae (Poaceae)* commonly known as the grass family and of the cultivated wheats, common wheat, *T. aestivum*, is economically by far the most important.

*T. aestivum L.* as described by Lersten (1987), which is a mid-tall annual or winter annual grass with flat leaf blades and a terminal floral spike consisting of perfect flowers. The vegetative stage of the plant is characterized by tillers bearing axillary leafy culms. Culms comprise five to seven nodes with three to four foliage leaves in itself.

wheat bears the uppermost or flag leaf, subtends the inflorescence. Each culm produces a composite spike or inflorescence, the basic unit of which is termed the spikelet. Spikelets are born on a main axis, or rachis, and are separated by short internodes, each spikelet is a condensed reproductive shoot consisting of two subtending sterile bracts or glumes. The glumes enclose two to five florets which are born on a short rachilla (Kirby, 2002).

Wheat florets contain three stamens with large anthers and the pistil which consists of a single ovary, with a single ovule, two styles, and two branching plumose stigmas at the end of each style. *T. aestivum* L. is hexaploid (AABBDD) with a total of 42 chromosomes (2n=42, six times seven chromosomes).

The cultivation of wheat began with wild einkorn and emmer (Cook and Veseth, 1991). The earliest plant breeding efforts with these wheats probably gave rise to plants with heads that did not shatter to facilitate harvest. Also, hull-less types were selected by early farmers for ease of threshing. In terms of plant adaptation, hexaploid (6n) wheat cultivation was adapted to cool climates due to the contribution of winter hardiness traits present on the "D" genome. However, wheat plants were further adapted for cultivation in different environments via flowering behavior. Spring wheat is planted in locations with severe winters which flowers in the same year yielding grain in about 90 days. Generally winter wheat is grown in locations with less severe winters. Winter wheat will only head after it has received a cold treatment (vernalization) and is therefore, planted in the fall and harvested in the spring of the following year. Wheat varieties were adapted for cultivation in dry climates through the introduction of dwarf traits resulting in small plants that required less water yet produced good grain yield which may severely affected by weed infestation. Modern wheat cultivars have been developed to resist various weeds and diseases such as rusts and smuts. In addition to weed and disease resistance, wheat breeding also focuses on increasing overall grain yield as well as grain quality (starch and protein) (CFIA, 2018).

Modern wheat breeding programs focus on the improvement of agronomic and grain quality traits with capability of resistance to weeds. Agronomic traits include weed resistance, winter hardiness, drought tolerance, disease and insect resistance, straw strength, plant height, resistance to shattering, grain yield, and harvest ability. Grain quality traits include seed colour, shape, test weight, protein concentration and type, starch concentration and type, and flour performance (Knott, 1987).

In consequence, During the domestication of modern wheat, key traits were modified that benefited early farmers but eliminated the ability of the resulting wheat races to survive in the wild. Manipulation of wheat genetics has led to ever increasing gains in yield and grain quality, while decreasing the ability of wheat to survive in the wild. In fact, after hundreds of years of cultivation in North America and throughout the world, there have been no reports of wheat becoming an invasive pest viz weed, insects and microorganisms (CFIA, 2018).

## 2.2 Weed flora in wheat crop

Weed flora form integral part of each and every agrophytocoensis. Thus, their interference with crop is natural. Because of their high competitive ability and allelopathic influence, weed cause an irreversible damage to crops in term of growth and yield. Knowledge on the composition of weed flora in a particular crop and their correct identity are necessary to formulate effective measures for their management and control. Sufficient sunshine and favourable temperature with adequate irrigation and nutrients in rabi season provide a very congenial conditions for rapid growth of various weed species over the country. Weeding at early stages of crop growth in wheat cultivation is a very important practice because heavy infestation of weeds hampers the crop growth as well as greater reduction in wheat yield.

Slow growth of wheat plants during early growth stage provide favourable conditions for the growth of various weed species at the time of germination and also subsequent growth periods. Hence, an attempt has been made to review the literature pertaining to weed flora observed in the wheat field at various locations under different agro-ecological situations in our country.

The major weed flora in wheat observed by Kamrozzaman *et al.* (2015) consisted of *Chenopodium album* (Bathua shak), *Portulaca oleracea*(nunia), *Oxalis europea* (amrul), *Rumex maritius* (bon palong), *Cyperus rotundus*(mutha), *Cynodon dactylon*(durba), and *Digitaria sanguinalis* (bisha grass).

Field experiment was conducted at Hisar (Haryana) on sandy loam soil. Balyan *et al.* (1999) investigated that experimental field was infested with the natural populations of grass weeds viz., *Phalaris minor* and *Avena ludoviciana* and broad leaf weeds viz., *Chenopodium album, Lathirus aphaca, Vicia sativa, Convolvulus arvensis and Fumaria parviflora.*

**2.3 Yield losses caused by weed in wheat**

Weeds constitute a major limiting factor in successful crop production and cause enormous yield losses which, however, depend upon nature and intensity of the weed flora, duration of crop-weed competition, various soil factors and agro-climatic conditions prevailing under a particular agro-ecological zone (AEZ).

On-farm experiments were carried out by Karim (1987) reported that weed plays a crucial role lowering the ultimate yield 33% in Bangladesh. Most of the weed competition in that the critical period of crop weed competition.

In India, among total annual losses of agricultural produce from various pests, weed account for 45 percent, insects 25 percent, diseases 20 percent and other pest 5 percent (Rao, 2001).

Panwar *et al.* (1995) while working on a sandy loam soil at Hisar (Haryana) found that the grain yield of wheat was reduced from 52.1 to 54.2% when plots were weedy for the whole season during both years.

Result of an experiment conducted at G. B. Pant University of Agri & Tech., Pantnagar in 1989 to 1991 revealed that grain yield of wheat was reduced to the extent of 51.2% under unweeded control (Kumar and Singh, 1996).

Weeds cause yield reduction upto 15-50 percent depending upon the weed density and weed species (Jat *et al*., 2003).

The field experiment was carried out during the winter seasons of 1994-95 and 1995-96 at Jabalpur (MP) by Dixit and Bhan (1997) and reported that the presence of weeds for whole seasons reduced the potential yield of wheat by 40.1 and 38.9% in the respective year.

An experiment was conducted at IARI, New Delhi during winter seasons of 1998-99 and 1999-2000 on sandy loam soil by Pandey and Verma (2004). They recoded about 35% reduction in average grain yield due to weed competition.

Singh and Singh (2005) executed experiment at Pantnagar (Uttaranchal) during winter seasons of 2002-2005. They reported that on an average there was more than 66% reduction in the grain yield of wheat due to mixed population of weeds in weedy plots.

### 2.4 Critical period of crop-weed competition

Weeds that germinate along with crop are enormous damaging than the later emerging weeds. There is a period of time (time span) before and after which presence of weeds does not cause any appreciable reduction in crop yield, as irrecoverable loss has been done. Hence, establishing the critical period of crop weed competition is essential to develop economical and effective weed control measures.

Results of an experiment carried out at Anand (Gujarat) in India, on crop-weed competition in wheat revealed that the critical period of crop weed competition ranged between 30 to 45 DAS (Anonymous, 1994).

Saraswat and Mishra (1998) found that the critical period of crop weed competition varies from 30-45 DAS of wheat crop.

Chopra *et al.* (1999) while working on sandy loam soil to find out the critical period of competition between weeds and wheat crop, during the rabi seasons at Agriculture Farm, Meerut noted that the 6.28, 8.09, 20.93 and 24.96% reduction in seed yield, when weeds were allowed to compete with the crop for initial period of 15, 30, 45 and 60 days and removed thereafter, respectively.

Khan *et al.* (2002) carried out a field experiment at Peshawar (Pakistan) during the rabi season of 2000-01 and found that weed competition for the first 42 days did not reduced significantly the yield of wheat. However, when weeds were allowed to compete beyond 42 days, that is up to 56 days or longer, a significant reduction in yield was observed. A weed free period up to 45 days or more resulted in a grain yield statistically similar to season long weed free conditions. Therefore, the critical period of weed crop competition was determined as the period between 42 and 56 days after sowing in wheat life cycle.

### 2.5 Effect of variety

Variety itself is the genetical factor which contributes a lot for producing yield and yield components. Different researcher reported the effect of wheat varieties on yield contributing component and grain yield. Some available information and literature related to the effect of variety on the yield of wheat are discussed below.

Variety is an important factor which influences the plant population per unit area, availability of sunlight, nutrient competition, photosynthesis, respiration etc. which ultimately influence the growth and development of the wheat crops. In agronomic point of view, weed management for modern wheat cultivation has become an important issue. Considering the above points, available literature was reviewed under different variety and weed control of wheat.

An experiment was conducted by Sultana *et al.* (2012) at Agronomy Field Laboratory of Rajshahi University to evaluate the effect of variety and weeding regime on yield and yield components of wheat. Four varieties viz. Prodip -$V_1$, Gourab -$V_2$, Shatabdi -$V_3$, Bijoy -$V_4$ and five weeding treatments. The results indicated 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. The highest grain yield (5.09 t $ha^{-1}$) was obtained in Weed free ($W_1$) followed by $W_3$ (Two hand weeding) (4.89 t $ha^{-1}$) and the lowest grain yield (4.13 t $ha^{-1}$) was obtained in no weeding treatment ($W_0$). The highest grain yield (5.64 t $ha^{-1}$) was obtained from the combination of Prodip and weed free treatment ($V_1W_1$) and the lowest (3.57 t $ha^{-1}$) was obtained from the combination between Shatabdi and no weeding treatment ($V_4W_0$).

### 2.6 Effect of weed management

Weed is one of the most limiting factors for successful wheat production. Among various cultural practices, weed control plays a vital role in the production and yield of wheat through controlling the weeds as well as make the environment favorable for wheat production. To assess the present study attempts have been made to incorporate some of the important findings of different scientists and research workers in this country and elsewhere of the world.

#### 2.6.1 Effect on weed population and weed biomass

Singh and Saha (2001) observed that pendimethalin @ 1 kg $ha^{-1}$ at pre-emergence, isoproturon @ 1.5 kg $ha^{-1}$ at post-emergence, 2,4-D @ 1.5 kg $ha^{-1}$ at post-emergence, combination of pendimethalin 0.5 kg $ha^{-1}$ pre-emergence + isoproturon 1 kg $ha^{-1}$ post-emergence and pendimethalin 0.5 kg $ha^{-1}$ pre-emergence + 2,4-D 1 kg $ha^{-1}$ post-emergence recorded significantly lower weed biomass and weed index and higher weed control efficiency over weedy check treatment.

Nayak *et al.* (2003) executed a field trial during rabi 1998-99 on clayey soil. Results revealed that the weed biomass was minimum under hand weeding and was at par with 2,4-D (0.5 kg $ha^{-1}$) alone and in combination with metsulfuron methyl were applied. Furthermore, weed control efficiency was maximum (94.15%) in hand weeding closely followed by 2,4-D 0.5 kg $ha^{-1}$ + metsulfuron methyl 4 g $ha^{-1}$(90.98%) and 2,4-D 0.5 kg $ha^{-1}$ (89.90%). Again, post-emergence application of metsulfuron methyl at 3 to 5 g $ha^{-1}$ and 2,4-D 0.75 kg $ha^{-1}$ gave excellent control of broad leaved weeds species than farmers practices and weedy check at Kota (Rajasthan).

A field experiment was carried out by by Prasad *et al*. (2005) at Varanasi (UP) in India during rabi seasons of 2000-01 and 2001-02 on sandy clay loam soil. The results indicated that post-emergence application of isoproturon + 2,4-D (1 + 0.5 kg ha$^{-1}$) significantly reduced the population and dry matter production of weeds over weedy check.

Chahal *et al.* (2003) reported that application of clodinafop (60 g ha$^{-1}$) reduced the population and dry matter accumulation of *Phalaris minor* by 92.5% and 90.6%, respectively and hence resulted 53.9% higher grain yield over unweeded check.

Kumar *et al.* (2003) conducted a field experiment during 1996-97 and 1997-98 and concluded that application of sulfosulfuron significantly controlled all the weed species and reduces their dry weight over weedy check. The maximum response was recorded at lowest level, i.e., 20 g ha$^{-1}$.

Tomar *et al.* (2004) reported that all the weed management treatments significantly decreased the dry matter production of weeds over the unweeded control. Application of isoguard 1 kg ha$^{-1}$ gave the maximum yield (4348 kg ha$^{-1}$.) and next best treatments were clodinofop 60 g ha$^{-1}$ + metribuzin 150 g ha$^{-1}$ (4298 kg ha$^{-1}$), sulfosulfuron 25 g ha$^{-1}$ (4167 kg ha$^{-1}$) and metribuzin 250 g ha$^{-1}$ resulting in higher W.C.E.(87.8 - 94.3%).

Gopinath *et al.* (2007) reported that all herbicides provided significant control of weeds compared to weedy check. Pendimethalin at 2000 g ha$^{-1}$ and sulfosulfuron at 33 g ha being at par with each other recorded significantly lower weed dry weight compared to tank mix spray of isoproturon (750 g ha$^{-1}$) + 2, 4 –D (500 g ha$^{-1}$) and weedy check.

Kaur *et al.* (2018) conducted a field experiment with 8 treatments *viz,* Weed free, Weedy check, Pendimethalin 2.5L ha$^{-1}$, Pendimethalin 3.75 L ha$^{-1}$, Clodinofop 400 g ha$^{-1}$, Sulfosulfuron 32.5g ha$^{-1}$, Pinoxaden 1000 ml ha$^{-1}$, Atlantis 400 g ha$^{-1}$ and replicated thrice.

Sharma and Sharma (1997) carried out field experiment at Bajaura (Kullu) in India during winter season of 1993-94 and 1994-95 for the control of complex weed flora in wheat. It was reported that post-emergence application of metsulfuron methyl 4 g $ha^{-1}$ was found very effective against all the broad leaf weeds, however it's combination with isoproturon (1.25 kg $ha^{-1}$) most effectively controlled all the weeds and gave higher yield over rest of the weed management practices. Sole application of metsulfuron methyl up to 8 g $ha^{-1}$ as post-emergence were found effective against broad leaved weeds (Balyan *et al*., 1999, Chopra *et al*., 2001 and Sardana *et al*., 2001) and even its combination with isoproturon for the control of all the weeds (Sardana *et al*., 2001 and Singh and Singh, 2002) under various agro-ecological situations in India.

Field experiments were conducted at Pusa (Bihar) in India during the rabi season of 1989-90 and 1990-91 by Pandey *et al.* (1997). The results revealed that pendimethalin 1 kg $ha^{-1}$ and isoproturon 1 kg $ha^{-1}$ recorded significantly lower weed number and weed dry biomass and recorded maximum weed control efficiency over weedy check. Hence, effectiveness of pendimethalin at 1 kg $ha^{-1}$ as pre-emergence application wheat crop is well documented in later studies (Jain *et al*., 1998, Chopra *et al*., 2001and Singh and Singh, 2004).

### 2.6.2 Effect on weed control efficiency

A field experiment was conducted by Mustari *et al.(*2014) at the experimental farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, found that Carfentrazone-ethyl performed the best in terms of weed control efficiency (79.68%), while Pendimethalin performed the worst (52.74%). Carfentrazone-ethyl + Isoproteuron contributed to the highest tillers per unit area (226.3 $m^{-2}$) and the highest total dry matter (1342 g $m^{-2}$). The study revealed that, combined ingredient herbicide Carfentrazone-ethyl + Isoproteuron as well as Carfentrazone-ethyl alone might used at field level due to their better weed control efficiency.

Studies conducted by Singh *et al*. (1994) at Jabalpur in India during 1990-91 on weed control in wheat revealed that the pre-emergence application of isoproturon 1 kg $ha^{-1}$ had 95.12% weed control efficiency which was almost equal to hand weeding (93.85%) treatment. Isoproturon @ 1 kg $ha^{-1}$ pre or postemergence controlled almost all the annual monocot and dicot weeds.

An experiment was conducted by Bhan and Dixit (1998), in wheat crop at National Research Center for Weed Science, Maharjpur Jabalpur (M.P.) in India. They noted that the pre-emergence pendimethalin application was not as effective as isoproturon. The greatest weed control efficiency was recorded with 1.0 kg $ha^{-1}$ isoproturon applied just before irrigation. Pre-irrigation 1.0 kg/ha isoproturon had a weed control efficiency almost 80 percent. However, effectiveness of isoproturon has been reported particularly against grassy weeds where its problem is severe (Balyan *et al*., 1999 and Singh and Singh, 2002).

Zahoor *et al.* (2012) observed significant differences among various herbicide application rates. The highest weed control efficiency of 84.97% was recorded in plots where hand weeding was done. It was at par with B. Super at 0.35 kg $ha^{-1}$ (78.02) and MCPA at 0.65 kg $ha^{-1}$ (76.30).

Hossain (2008) found that presence of weed in the crop field was significantly affected by different herbicide application at different rates. He observed that lowest dry weight of weed 12.27 and 7.11 kg ha in the treatment of Sencor 70WG @ 0.60 Kg ha at 20 DAS and 45 DAS respectively and the highest dry weights of weeds were observed in control plots at 20 DAS, 45 DAS.

Hari *et al.* (2006) conducted an experiment during the winter seasons of 200 1/02 and 2002/03 in India, to study the effect of weed control treatments in wheat sown by zero-tillage [no-tillage] method. They recorded significant improve in grain yield with the use of Glyphosate + Sulfosulfuron and Glyphosate + Sulfosuifliron + Metsulfuron (each applied at different lime) during both years.

Kaur *et al.* (2018) reported that the weed control efficiency among the weed control management practices ranged from 61.3 to 100 %. The highest weed control efficiency was found in weed free plots followed by pendimethalin @ 3.75 L /ha (76.9%). Whereas, the lowest result recorded in no weeding treatment.

### 2.6.3 Effect on weed density

Nariyal *et al.* (2007) found that field trial was conducted during rabi season on wheat at G.B. Pant University of Agriculture & Technology, Pantnagar. *Phalaris minor, Chenopodium album, Medicago denticulata, Coronopus didymus, Melilotus indica* and *Rumex acetosella* were the major weed species in the experimental field. All the weed control treatments caused significant reduction in the density and dry weight of total weeds over weedy check at 60 days stage of crop growth. The lowest density and dry weight of weeds were recorded with sulfosulfuron at 25 g ai/ha + surfactant at 1250 ml/ha, which was followed by pinoxaden at 45 or 50 g ai/ha, application of pinaxaden 45 or 50 g ai/ha at 30 days after sowing was very effective for the control of *Phalaris minor*.

Zand *et al*. (2007) observed that metsulfuron methyl plus sulfosulfuron at 36 g a.i./ha is a suitable option for the post-emergence control of broadleaved and grass weeds in wheat. This treatment almost resulted in the highest grain yield at different locations too.

Singh and Singh (2004) investigated an experiment at Jodhpur (Rajasthan) in India during rabi season 1998-99 and 1999-2000. They found that pendimethalin 0.75 kg $ha^{-1}$ integrated with one hand weeding reduced significantly the density of *Chenopodium spp*. as well as other weed species.

Field experiment was tried at Junagadh (Gujarat) in India during winter season of 1993-94 to 1997-98 on Vertisol (Sukhadia *et al.*, 2000). The results showed that all the weed management treatments significantly reduced the weed density and weed dry weight as compared with unweeded control treatment. The lowest dry weight of weeds was observed under pendimethalin 1 kg $ha^{-1}$ preemergence + 1 Hand weeding at 30 DAS and this treatment also registered the highest (93%) weed control efficiency.

Ashrafi *et al*. (2009) reported that minimum weed density/m2 and maximum spikelets/ spike, grain/spike, grain yield, harvest index and net income were found with broad spectrum (grasses + broad leaf) herbicides.

Chhokar *et al*. (2008) reported that post-emergence clodinafop (60 g $ha^{-1}$), fenoxaprop (120 g $ha^{-1}$), pinoxaden + S (30 g $ha^{-1}$ plus 0.5% surfactant), metsulfuron + S (12–

15 g + 625 ml surfactant $ha^{-1}$) and sulfosulfuron + S (25 g $ha^{-1}$ +0.35% surfactant) and pre-emergence fluazolate (150 g $ha^{-1}$) and pendimethalin (1250 g $ha^{-1}$) were very effective in controlling *Phalaris minor* and improving wheat yields.

**2.7.1 Effect on growth characters**

**2.7.1.1 Effect on plant height**

Sultana *et al.* (2012) concluded that the plant height was significantly affected by weeding regime. The longest plant (101.59 cm) was obtained from the weed free treatment, which was statistically similar with one hand weeding treatment. The shortest plant (95.40 cm) was recorded in no weeding (control treatment) treatment.

Acker (2010) carried out an experiment to assess the effect of weed management practices on yield attributes and yield of wheat. The result indicated that higher weeding frequency increased plant height by 20-30% compared to no weed control treatments.

Sultana (2009) proposed that weeding operation had significant effect on plant height of wheat. However, the longest plant height (89.96 cm) at harvest was with $W_2$ (Two weeding at 30 and 60 DAS) and the minimum (87.76 cm) was observed from no weeding ($W_0$) treatment.

Field trial was carried out at Ranchi (Jharkhand) in India on sandy clay loam soil by Singh and Saha (2001).They found that pendimethalin @ 1 kg $ha^{-1}$ pre-emergence, isoproturon @ 1.5 kg $ha^{-1}$ post-emergence, 2,4-D @ 1.5 kg $ha^{-1}$ post-emergence, combination of pendimethalin 0.5 kg $ha^{-1}$ pre-emergence + isoproturon 1 kg $ha^{-1}$ post-emergence and pendimethalin 0.5 kg $ha^{-1}$ pre-emergence + 2,4-D 1 kg $ha^{-1}$ post-emergence recorded significantly taller plants, greater number of effective tillers and fertile spikelets as compared to weedy check. Similarly, Yadav *et al*., (2001) reported that application of pendimethalin @ 2.0 kg $ha^{-1}$ pre-emergence recorded significantly higher number of tillers $plant^{-1}$, grains $ear^{-1}$and test weight over weedy control.

### 2.7.1.2 Effect on total dry matter production

Zahoor *et al.* (2012) executed an experiment to assess the optimum herbicide level in wheat production. The result indicated that, among different herbicide rates, the lowest weed biomass (15.97 $gm^{-2}$) was recorded in hand weeded plots followed by Buctril Super at 0.45 kg $ha^{-1}$, MCPA 0.65 kg $ha^{-1}$ and Buctril Super at 0.25 kg $ha^{-1}$. While the highest values of weed biomass (127.22 $gm^{-2}$) was reported in weedy plots over two years of field study.

Acker (2010) carried out an experiment to assess the effect of weed management practices on yield attributes and yield of wheat and he found that dry matter accumulation of wheat increased by 12-20% than the weedy check.

Sultana (2009) concluded that weeding frequency had significant effect on dry weight of wheat plants. The highest values of dry weight plant-1 (4.60, 9.06, 14.06 and 16.99 g at 30, 60, 90 DAS and at harvest, respectively) and the lowest dry weight plant-1 (3.84, 7.16, 10.77 and 13.60 at 30, 60, 90 DAS and at harvest, respectively) was recorded with $W_0$ (No weeding).

## 2.7.2 Effect on yield contributing characters

### 2.7.2.1 Effect on effective tillers

Sultana *et al*. (2012) reported that the highest number of effective tillers $plant^{-1}$ (4.95) was observed in weed free treatment followed by two hand weeding treatment (4.49) and the lowest number of fertile tillers $plant^{-1}$ (3.27) was produced by no weeding treatment. She found that different duration of crop weed competition had significant effect on effective tillers $m^{-2}$ of wheat. The highest effective tillers $m^{-2}$ (246.70) was with $W_2$ (Two weeding at 30 and 60 DAS) and the lowest spikes $m^{-2}$ (185.40) was observed in with $W_0$ (No weeding).

Sujoy *et al.* (2006) conducted a field experiment to determine different weed management practices in wheat. They proposed that hand weeding at 21 and 35 days after sowing was effective in controlling the weeds in the field and this treatment recorded the highest values for number of effective tillers $m^{-2}$.

For the control of weeds in wheat, a field experiment was conducted at Ludhiana in India during 1994-95 and 1995-96 by Walia *et al*. (1997). They observed that on an average of two years, application of metsulfuron at 10 and 20 g $ha^{-1}$, 2,4-D 0.5 and 0.8 kg $ha^{-1}$ and their combinations recorded significantly higher number of effective tillers over unweeded control treatment. However, application of metsulfuron up to 5 g $ha^{-1}$ has been improved various growth and yield attributes of wheat viz., plant height, effective tillers, number of spikes, number of grains $ear^{-1}$, spike length and test weight at various locations in India were reported by Sardana *et al*., 2001, Sharma and Thakur, 2002, Jat *et al*., 2003 and Singh and Ali, 2004.

Singh and Kundra (2003) reported that fenoxaprop and sulfosulfuron provided effective control of *Phalaris minor* in wheat field. Significantly increase in grain yield of wheat under sulfosulfuron over that under isoproturon was supported by more numbers of effective tillers and other yield contributing characters of wheat.

Hossain (2008) carried out a field trial and observed that the number of tillers $plant^{-1}$ increased with the effectiveness of herbicide treatments. He mentioned that the highest number of tillers $plant^{-1}$ (2.52. 5.89. 6.01 and 6.10) was shown by Sencor 70WG @ 0.40kg $ha^{-1}$ at 30. 60. 90 DAS and at harvest respectively.

**2.7.2.2 Effect on leaf area index**

Pandey and Kumar (2005) conducted a field experiment at Pusa (Bihar) in India during the winter seasons of 2000-01 and 2001-02 on clay loam soil. They reported that hand weeding at 30 DAS, post-emergence application of 2,4-D (SS) 800 g $ha^{-1}$ and isoproturon 750 g $ha^{-1}$ produced significantly higher effective tillers, leaf area index (60 DAS), length of ear and grains per ear over weedy check.

Sheibani and Ghadiri (2012) remarked that the integration of herbicides significantly increased the wheat leaf area index. However, competition between weeds and wheat reduced wheat leaf area index in the weedy check condition.

Bharat *et al.* (2012) proposed that weed control treatments significantly increased dry matter production, LAI, CGR, number of spikes, number of grains/ear and grain as well as straw yield of wheat compared to weedy check. The maximum value of these parameters was recorded in tank-mix application of sulfosulfuron + 2,4-D, fenoxaprop + metribuzin and clodinafop + metsulfuron, Maximum grain yield was recorded in weed free (5.05 t/ha), but the highest B:C ratio was observed with isoproturon + 2,4-D. However, the unchecked weed growth of wheat caused 40.3% reduction in grain yield.

Bhikhubhai R.V. (2006) reported that significantly higher leaf area index was observed under pendimethalin 1 kg $ha^{-1}$ pre-em. + 1 HW and remained at par with rest of the treatments, except treatments isoproturon 0.75 kg $ha^{-1}$ pre-em. + 1 HW and unweeded control.

### 2.7.2.3 Effect on spike length

The field experiment was conducted at Varanasi (UP) during rabi seasons of 2000-01 and 2001-02 on sandy clay loam soil by Prasad *et al.* (2005). They found that post-emergence application of isoproturon + 2,4-D (1 + 0.5 kg $ha^{-1}$) produced significantly higher values of ear heads and grain yield over weedy plots.

Sultana (2009) executed a field experiment and found that significant effect on spike length of wheat due to weed control treatments. She reported that higher duration of crop-weed competition resulted shorter spike, whereas less duration showed longer spike. The result indicated that longest spike (10.29 cm) was with $W_2$ (Two weeding at 30 and 60 DAS) and the shortest spike length (9.45 cm) was record in $W_0$ (No weeding).

A field experiment was executed by Pandey *et al*. (2000) at Pusa (Bihar) in India on clay loam soil. They reported 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 $ha^{-1}$ recorded significantly higher values of plant height, effective tillers, CGR, RGR, ear length, test weight than weedy check.

Hossain (2008) recorded that the highest spike lengths (7.25, 12.12 and 12.47 cm) from the treatment of Sencor 70WG @ 0.40 kg ha-1 at 60 DAS, 90 DAS and at harvest respectively. He reported that a gradual trend of increased length of spike was found in all the herbicides with increased rate of application in compare to the control plots of wheat.

### 2.7.2.4 Effect on spikelets spike$^{-1}$

Singh and Singh (1996) executed an experiment at Ghaghraghat in India and concluded that the herbicidal treatments produced higher yield attributes like spikelets ear$^{-1}$, ear length, effective tiller plant$^{-1}$ and 1000 grain weight than weedy check.

Singh and Singh (2004) investigated a field experiment at Jodhpur (Rajasthan) In India during winter seasons of 1998-99 and 1999-2000.They observed that pre-emergence application of pendimethalin at 0.75 kg ha$^{-1}$ supplemented by one hand weeding or 2,4-D 0.5 kg ha$^{-1}$ at 30 DAS gave significantly higher spikes m$^{-2}$, grains spike$^{-1}$, 1000 grain weight due to better weed control.

Sultana (2012) observed that the highest number of spikelets spike$^{-1}$ (39.19) was with $W_2$ (Two weeding at 30 and 60 DAS) and the lowest number of spikelets spike-1(25.81) was recorded with $W_0$ (No weeding) treatments. Chahal *et al.* (1986) also observed that variety differed in the number of total spikelets spike$^{-1}$.

Hossain (2008) reported that number of spikelets spike$^{-1}$ increased with types of herbicides and then doses of application. There was no significant effect among the said parameter at 60 DAS but at 90 DAS and at harvest it varied significantly. The highest values of spikelets spike$^{-1}$ (5.98 and 6.08 cm) were recorded in Sencor 70WG @ 0.40 kg ha$^{-1}$ at 90 DAS and at harvest, respectively.

### 2.7.2.5 Effect on filled grains spike$^{-1}$

Acker (2010) carried out an experiment to find out the effect of weed management practices on yield attributes and yield of wheat. He reported that the grains spike$^{-1}$ increased by 8-12% due to higher weed control frequencies and the weedy check produced the lowest filled grain spike$^{-1}$.

Sultana (2009) mentioned that significant effect on number of filled grains spike$^{-1}$ was found with weeding at different days after sowing of wheat. She reported that the highest number of filled grains spike$^{-1}$(32.94) was with $W_2$ (Two weeding at 30 and 60 DAS) where the lowest (23.98) was with $W_0$ (no weeding).

Sujoy *et al.* (2006) conducted a field experiment to assess different weed management practices in wheat. They reported that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field. And it produced the highest number of filled grain spike$^{-1}$ of wheat.

### 2.7.2.6 Effect of weight of 1000 grain

Sultana *et al.* (2012) conducted an experiment and found that the highest 1000-grain weight was measured in weed free treatment whereas the lowest (47.30g) was measured in

no weeding treatment. However, two hand weeding treatment was statistically similar to weed free condition in producing 1000-grain weight of wheat.

Kaur *et al.* (2018) conducted a field experiment with 8 treatments *viz,* Weed-free, Weedy check, Pendimethalin 2.5L ha$^{-1}$, Pendimethalin 3.75 L ha$^{-1}$, Clodinofop 400 g ha$^{-1}$, Sulfosulfuron 32.5 g ha$^{-1}$, Pinoxaden 1000 ml ha$^{-1}$, Atlantis 400 g ha$^{-1}$and replicated thrice. Results revealed that Pendimethalin (3.75 L ha$^{-1}$) was found effective to control weed population and produced higher number of effective tillers, 1000 grain weight and enhanced the yield upto 43.1% over weedy check.

Sultana (2009) found that the highest 1000 grains weight (45.44 g) was with treatment $W_2$

(Two weeding at 30 and 60 DAS) and the lowest 1000 grains weight (43.21 g) was observed with $W_0$ (no weeding).

### 2.7.2.7 Effect on grain yield

A field experiment was conducted by Mustari *et al.* (2014) at the experimental farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, found that Carfentrazone-ethyl + Isoproteuron also contributed to the highest grain yield of 3.56 t ha$^{-1}$ with the highest harvest index (HI) of 0.42. Carfentrazone-ethyl + Isoproteuron accompanied by one hand weeding also contributed to statistically identical grain yield of 3.33 t ha$^{-1}$. Single ingredient Carfentrazone-ethyl alone and when accompanied with one hand weeding also contributed to statistically similar grain yields of 3.26 t ha$^{-1}$ and 3.46 t ha$^{-1}$, respectively. The study revealed that, combined ingredient herbicide Carfentrazone-ethyl + Isoproteuron as well as Carfentrazone-ethyl alone might used at field level due to their better weed control efficiency, favourable effect on crop growth and development and higher grain yield.

Zahoor *et al.* (2012) found that the data pertaining to grain yield as influenced by various herbicide application rates showed significant effect among different treatments. They indicated that the highest grain yield of 2678 kg $ha^{-1}$ was recorded with the application of Buctril super 0.45 kg $ha^{-1}$.

Sultana *et al*. (2012) investigated that the grain yield of wheat was significantly varied by weeding regime. The highest grain yield (5.09 t $ha^{-1}$) was obtained from weed free treatment followed by two hand weeding treatment (4.89t $ha^{-1}$). The lowest grain yield (4.13t $ha^{-1}$) was produced by no weeding treatment.

Sultana (2009) found that the highest grain yield (3.74 t $ha^{-1}$) was with $W_2$ (Two weeding at 30 and 60 DAS). On the other hand the lowest grain yield (2.57 t $ha^{-1}$) was observed with $W_0$ (no weeding).

Dodamani and Das (2013) conducted an experiment to evaluate and compare the interference of common lambsquarters (CL) in response to Nitrogen with that of natural weed infestations, and to determine its economic threshold (ET) in wheat.

A field experiment was executed for three consecutive years (186-87 to 1988-89) to study the effect of weed control methods on wheat at Majhera (U.P.) in India. Singh (1997) recorded that all the weed control treatments significantly increased the grain yield over the weedy check. The percentage increase in grain yield over unweeded control was 42.2, 23.2 and 8.2 under 2 hand weeding (25 and 45 DAS), isoproturon 1.5 kg $ha^{-1}$ and 2 mechanical hoeing (25 and 45 DAS), respectively. Similar results were found out by Nayak *et al*. (2003).

Banga *et al*. (2003) concluded that the sulfosulfuron at 25 g/ha being superior to its lower doses (15 and 20 g/ha) provided 87% control of *Avena ludoviciana, Phalaris minor* and *Rumex retroflex* in wheat resulting in yield and yield attributing characters statistically similar to weed free.

Azad (1997) reported that the unweeded control had gave significantly less grain and straw yields than hand weeding and pre and post-emergence application of isoproturon.

Field studies for the control of weeds in wheat were conducted in 1994-95 and 1995-96 at CCS, HAU, Regional Research Station, Karnal on a clay loam soils by Singh *et al*. (1998). The result indicated that during both the years the minimum grain yield (4280, 3267 kg $ha^{-1}$) were recorded under weedy check which were significantly lower than weed free and herbicide treated plots.

Sujoy *et al.* (2006) conducted a field experiment to assess different weed management practices in wheat. They reported that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field. And it produced the highest values of grain yield compared to other weed control treatments.

Shah and Habibullah (2005) investigated that the chemical weed control as the best weed control methods except hand weeding. The highest grain yield of 3.80 t kg $ha^{-1}$ was recorded with chemical weed control followed by hand hoeing (3.70 t kg $ha^{-1}$)

Jarwar and Arain (2005) executed an experiment in Pakistan to assess the effect of post emergence chemical weed control on weed density and grain yield of wheat during rabi seasons of 200 1-02 and 2002-03. The result indicated that maximum wheat grain yield of 3285.71 and 3071.42 kg $ha^{-1}$ was also obtained in Topik 15 WP at 250 g $ha^{-1}$ during both years.

Smeia *et al*. (2005) found out that predominant weeds in the field were *Chenopodium album, Anagallis arvensis, Parthenium hvsterophorus, Vicia hirsuta* and *Phalaris minor*.They recorded that, next to weed-free plots, lower weed population was recorded in the Isoproturon+2,4-I) treatment followed by Isoproturon at 1000 g $ha^{-1}$. After 80 days, next to weedfree plots, maximum plant dry weights were observed in the plots treated with Sulfosulfuron at 30 g $ha^{-1}$. The highest growth and yield of wheat was recorded with Sulfosulfuron at 30 g $ha^{-1}$.

Iffat (2010) proposed that maximum yield losses of 76% in wheat variety Inqalab 91 were caused by *P. annua* followed by 75% by *C. didymus* whereas other weeds caused 60-70% yield losses. Therefore, in case of wheat variety Punjab 96, maximum yield reduction of 55% was caused by *R. dentatus* followed by *P. minor* (28%), *M denticulate*, *C. album* (23%) and *C. didymus* (10%).

Acker (2010) carried out an experiment to determine the effect of weed management practices on yield attributes and yield of wheat. He concluded that the highest yield components and yields of wheat were recorded under three weeding at 15, 35 and 60 DAS than two weeding at 15 and 35 DAS. However, the yield increase was 4.48 and 8.52% higher under three weeding at 15, 35 and 60 DAS.

Sardana *et al*. (2001) found that higher grain yield with tank mix application of isoproturon+2, 4-D at 940+500 g/ha (51.6 q/ha) followed by metribuzin at 175 g/ha (50.3 q/ha). Application of 2,4D at 500 g/ha, metribuzin at 125 and 225 g/ha, metsulfuron at 4 g/ha alone and isoproturon at 940 g/ha+ metsulfuron at 4 g/ha produced lower but statistically similar grain yield as compared to isoproturon at 940 g/ha + 2,4-D at 500 g/ha and metribuzin at 175 g/ha.

Singh *et al.* (2002a) found that weed infestation during the crop period causes more than 53 per cent reduction in grain yield, depending on the weed densities and type of weed species present.

Singh *et al.* (2002b) observed that *Phalaris minor* was controlled effectively by the application of clodinofop – propargyl @ 50 and 60 g/ha PoE. In consequence, isoproturon (500 and 750 g/ha) caused reduction in the density of *Chenopodium album* and *Melilotus alba.*

Ritu Singh (2014), reported that the grain and straw yield was also significantly affected by the different treatments of herbicides showing beneficial effect of medium dose of herbicide on growth and yield of wheat parameters. The medium dose recorded 91.34% and 65.97% increase in grain and straw yield respectively as compared to other two doses. However, again pendimethalin recorded maximum grain yield with 45.05% followed by metsulfuron and 2,4-D with 24.22 and 8.31% respectively.

Walia and Singh (2006) also recorded more than 36% reduction in grain yield due to unchecked growth of weeds. The grain yield was increased significantly due to different herbicidal treatments over weedy check and gave grain yield at par with weed free.

Tripathi *et al.* (2008) found that uncontrolled weeds on an average reduced the grain yield of wheat by more than 46%.

Pandey *et al.* (1997) investigated a field experiment at Pusa (Bihar) in India. According to results they reported that hand weeding and herbicidal weed control treatments gave significantly higher grain and straw yields that the weedy check.

Singh *et al*. (2008) found that the post emergence application of sulfosulfuron (0.025 kg/ha) produced maximum grain yield of wheat which was at par with pre-emergence application of pendimethalin (1.0 kg $ha^{-1}$) and hand hoeing twice.

Verma *et al*. (2008) achieved higher grain yield (2.97 t $ha^{-1}$) with the post emergence application of sulfosulfuron as compared to isoproturon and pendimethalin. Infestation of weed throughout the crop growth period caused 43.63% reduction in grain yield of wheat. Season long weed free environment obtained significantly higher grain yield (3.57 t $ha^{-1}$), yield attributes and nutrient uptake over rest of the weed control measures.

Amin *et al.* (2008) reported that herbicidal treatments increased grain yield as compared with un-weeded and hand weeding treatments.

**2.7.2.8 Effect on straw yield**

A field experiment was executed at Bihar by Pandey *et al.* (2005) on clay loam soil. The result indicated that hand weeding resulted in the maximum increase in grain and straw yields, being significantly higher than that obtained under post emergence application of 2,4-D (SS) 0.8 kg $ha^{-1}$ and isoproturon 0.75 kg $ha^{-1}$ alone but at par with that obtained in mixture of 2,4-D (SS) 0.4 kg $ha^{-1}$ + isoproturon 0.4 kg $ha^{-1}$.

Sultana *et al.* (2012) concluded that the straw yield of wheat varied significantly due to different weeding regime. The maximum straw yield (7.67 t $ha^{-1}$) was measured by weed free treatment and the lowest straw yield (6.45 t $ha^{-1}$) was produced by no weeding treatment.

Kaur *et al.* (2018) concluded that grain and straw yield differed significantly due to different weed control treatments. Weed control treatments performed significantly higher grain and straw yield than weedy check. The higher grain and straw yield was recorded with application of pendimethalin @ 3.75 L $ha^{-1}$ (5.19 and 8.29 t $ha^{-1}$ respectively). On the other hand, lower grain and straw yield was recorded with weedy check (3.63 and 6.77 t $ha^{-1}$ respectively) owing to severe crop weed competition which resulted in reduction in the expression of yield components such as effective tillers per $m^{-2}$ (347.2).

Sultana (2009) observed significant effect on straw yield of wheat due to weeding frequencies at different crop life cycle. She found that the highest straw yield (5.02 t $ha^{-1}$) at harvest was with $W_2$ (Two weeding at 30 and 60 DAS) and the lowest straw yield (4.83 t $ha^{-1}$) was observed with $W_0$ (No weeding).

Sujoy *et al.* (2006) found that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field and it produced the highest straw yield compared to other weed control treatments.

Pandey and Dwivedi (2007) studied that application of sulfosulfuron was found at par with hand weeding treatment for controlling weeds and producing higher grain yield.

Verma *et al.* (2007) reported that application of sulfosulfuron reduced the uptake of nutrient by weeds and significantly increased by crop which resulted in higher grain and straw yield and it was at par with fenoxaprop-p-ethyl and significantly superior over rest of the herbicidal treatments. Weed free treatment established significantly higher yield attributes, grain and straw yield and reduced the nutrient depletion by weeds over rest of the weed control treatments.

Ritu Singh (2014), conducted a field experiment to find out the performance of different herbicides and in this trial the use of pendimethalin @1000 g ai. proved best for wheat field, which may have exerted a positive effect on wheat yield as compared to other herbicides as noticed at harvesting. Metribuzin @ 250 g ai. proved least effective herbicide from the point of view of wheat growth and yield. Hence, metsulfuron methyl, 2,4-D and clodinafop were not so effective as compared to pendimethalin for wheat. Use of NPK showed beneficial with herbicide for wheat growth and yield in this field study.

#### 2.7.2.9 Effect on biological yield

Zahoor *et al*. (2012) found that the mean for different treatments differed significantly for biological yield. Among different application rates, the highest biological yield of 7.2 t ha$^{-1}$ was recorded with the application of Buctril super at 0.45 kg ha$^{-1}$ and the lowest biological yield (6.88 t ha$^{-1}$) was recorded in weedy plots.

Sujoy *et al*. (2006) revealed that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field and it produced the highest biological yield compared to other weed control treatments.

#### 2.7.2.10 Effect on harvest index

Sultana (2009) found significant variation as affected by weeding. She found that the highest harvest index (42.19%) was with $W_2$ (Two weeding at 30 and 60 DAS) and the lowest harvest index (34.15%) was observed with $W_0$ (no weeding).

Hossain (2008) concluded that harvest index was significantly affected by different herbicide application at different rates. He reported that the highest harvest index (46.69%) in the treatment of Sencor 70WG @ 0.40 kg ha$^{-1}$ and the lowest in control plots (no weed control).

Sujoy *et al*. (2006) found that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field which produced the highest harvest index compared to other weed control treatments.

### 2.8.1 Effect on cost benefit ratio

Zahoor *et al*. (2012) mentioned that the weed control treatments provided higher monetary returns than the weedy check treatment. They concluded that Buctril super at 0.45 kg ha$^{-1}$ was the most economical treatment with the highest benefit cost ratio (1.52) that was followed by Buctril super at 0.35 kg ha$^{-1}$ (1.46) and MCPA at 0.65 kg ha$^{-1}$ in agro-climatic conditions of Rawalpindi, Pakistan.

Hossain (2008) found the the highest benefit cost ratio (1.50) from Sencor 70WG at rate of 0.40 kg $ha^{-1}$ and the lowest benefit cost ratios from the control (no weed control).

A field experiment was carried out at Pusa (Bihar) in India by Pandey *et al*. (2005). They recorded that net return under hand weeding, post-emergence application of 2,4-D (SS) 0.8 kg $ha^{-1}$, isoproturon 0.75 kg $ha^{-1}$ alone and 2,4-D (SS) 0.4 kg $ha^{-1}$ + isoproturon 0.4 kg $ha^{-1}$ being at par among themselves significantly excelled the weedy check.

Dhiman and Rohitashav (2006) conducted a field experiment to evaluate the economics of different establishment methods (conventional tillage, zero tillage, strip till drill and bed planting) and weed management practices (hand weeding at 30 and 50 days after sowing (DAS). They found that Strip till drill + Isoproturon and zero tillage + Isoproturon recorded the highest benefit cost ratios of 2.09 and 2.05 respectively.

Jain *et al.* (2007) reported that maximum benefit cost ratio was obtained with zero tillage along with application of pre-emergence herbicide followed by 2,4-D.

Jat *et al.* (2004) investigated a field experiment at Udaipur (Rajasthan). They observed that maximum benefit cost ratio (3.60) was found from isoproturon (0.75 kg $ha^{-1}$ at 30 DAS) followed by pendimethalin 1 kg $ha^{-1}$ as pre-emergence (3.15).

Sharma and Singh (2011) observed that mechanical weeding twice at 15 and 30 DAS proved the most effective treatment in reducing weeds dry weight which was at par with sulfosulfuron 25 g/ha and gave significantly higher grain yield and NPK uptake by wheat than weedy check. Mechanical weeding at 15 and 30 DAS registered the highest (35.4 - 45.1%) increase in grain yield over weedy check, but highest net return (27,620–32,224 kg/ha) and benefit : cost ratio (1.79–1.89) was obtained with sulfosulfuron (25 g/ha).

An investigation was executed by during the winter season 1997-98 and 1998-99 at Morena (MP) on sandy loam soil. The results indicated that application of pendimethalin @ 2.0 kg $ha^{-1}$ pre-emergence recorded significantly higher net return over weedy control (Yadav *et al*., 2001).

# Chapter III

# Materials and Methods

# Chapter III

## MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analysis.

### 3.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November to April, 2017-2018. The location of the experimental site has been shown in Appendix I.

### 3.2 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-calcarious dark grey soil, slightly acidic in reaction 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. The pH value of the soil was 5.7. The physical and chemical properties of the experimental field soil have been shown in Appendix II.

### 3.3 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 (Biswas, 1987). The rabi season (October to March) is characterized by moderately low temperature and plenty of sunshine from November to February (SRDI, 1991). The detailed meteorological data in respect of air temperature, relative humidity, total precipitation and soil temperature recorded by the weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka during the period of study have been presented in Appendix III.

### 3.4 Treatments

The experiment consisted of two factors as mentioned below:

a) Factor A: Varieties (3)

I. $V_{1=}$ BARI Gom-28

II. $V_{2=}$ BARI Gom-29

III. $V_{3=}$ BARI Gom-30

b) Factor B: Weed control (5)

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

### 3.5 Plant materials and features

Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur so far released 32 wheat varieties. Among them wheat cultivar BARI Gom -28, BARI Gom -29 and BARI Gom-30 were used as plant materials for the present study. These varieties are recommended for commercial cultivation in Bangladesh during rabi season. The features of these three varieties are presented below:

**BARI Gom-28:** BARI Gom-28 is one of the recommended varieties for commercial cultivation in Bangladesh. The variety is semi-dwarf in height 95-100 cm with high yield potential as released in 2012. The grain yield ranges from 4.0-5.5 t $ha^{-1}$ under optimum management. It requires 55-60 days to heading and 102-108 days to mature, Flag leaf straight, glum of lower portion of spikelet shoulder medium broad and indented, lip tall (>12.1 mm) and spine has present in lip. Spike is medium with 45-50 grains per spike.

Grains are amber white in color, bright and medium in size (1000-grain weight 43-48 g). The variety is tolerant to terminal heat stress giving 15-20% higher yield and 10 days early than BARI Gom -21 (Shatabdi). The variety is tolerant to leaf rust and leaf spot disease (blight). The variety is suitable for growing both in optimum and late seeding condition. (Krishi Projukti Hatboi, 2017)

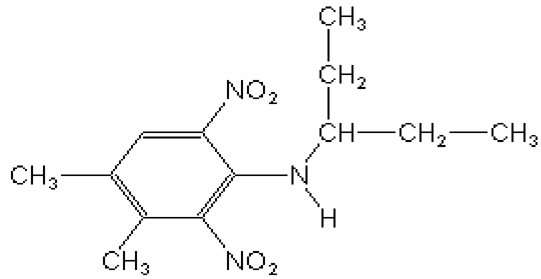
**BARI Gom-29:** BARI Gom-29 is another recommended variety for commercial cultivation in Bangladesh. The variety is semi-dwarf in height 95-100 cm with high yield potential as released in 2014. The grain yield ranges from 4.0-5 t $ha^{-1}$ under optimum management. It requires 55-60 days to heading and 102-108 days to mature, Tiller straight in seedling, plant deep green, very few hair present in upper node of culm. Flag leaf straight, glum of lower portion of spikelet shoulder medium broad and indented, lip tall (>12.1 mm) and spine has present in lip. Spike is medium with 45-50 grains per spike. Grains are amber white in color, bright and medium in size (1000 grain weight 44-48 g). The variety is tolerant to leaf rust and leaf blight. (Krishi projukti hatboi, 2017)

**BARI Gom-30:** BARI Gom -30 is one of update high yielding recommended varieties for commercial cultivation in Bangladesh released by Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI) in 2014. Most important features of the variety are short duration, plant height 95-100 cm. Number of tiller/plant 4-5, 55-60 days require for spike initiation, crop duration 102-108 days, spike broad, grain/spike 45-50, grain white, bright and medium, 1000 grain weight 44-48 g, tiller straight in seedling, plant deep green, very few hair presents in upper node of culm. Flag leaf straight, glum of lower portion of spikelet shoulder medium broad and indented, lip tall (>12.1 mm) and spine has present in lip. The grain yield ranges from 4.0-5.5 t $ha^{-1}$ under optimum management This variety tolerant to leaf rust and leaf spot disease (blight) and heat tolerant too. (Krishi Projukti Hatboi, 2017)

### 3.6 Properties of herbicides

#### (a) Pendimethalin

**Chemical name**: 3,4-Dimethyl-2,6-dinitro-*N*-pentan-3-yl-aniline




**PENDIMETHALIN**

**Trade name And Manufactures:** Panida 33 EC (Auto Crop Care Limited), Monsoon 330 EC ( Alpha Agro Limited), Fist 33 EC ( United Phosphorus Bangladesh Ltd) ,Pendulum 330 EC (ACI Formulations Limited), Tough 30 EC (MAP Agro Industries Limited)

**Mode of Action:** Pendimethalin does not inhibit seed germination but rather inhibit early seedling growth shortly after seed germination. This is caused by the disruption of cell division in certain plant. It inhibits both cell division and cell elongation in shoot and root meristem of susceptible weed species. Hence, growth is inhibited directly following absorption through shoot and hypocotyls (Shakya N. 2016).

**Uses:** Pendimethalin is a dinitroaniline group herbicide, can controls annual grasses and certain broad leaf weeds in many crops. It is applied pre-emergence, early post emergence and pre-plant incorporated depending on the crop even after ecology. As it has lower volatility, it does not require soil incorporation with adequate rainfall or overhead irrigation because of. Certain crops like rice, wheat, cotton, soybean, groundnut, peas and sunflower can physiologically tolerate to pendimethalin, so pre-plant incorporation or pre-emergence may also be used here. However, crops like wheat, rice, maize, seeded onion and carrots tolerate pendimethalin because the seeds are placed below herbicide layer, where only pre-emergence spray is used.

**(b) Isoproturon**

**Chemical name:** N-(4-isopropyl phenyl)-N, N-diethyl urea.


**Trade name and Manufactures**: Affinity 50.75 WP (FMC Chemical International AG)

**Mode of Action:** This is both pre and post-emergence selective herbicide. It function principally by absorption through the roots and leaves. (Shakya N., 2016).

**Uses:** Isoproturon is a versatile herbicide for the control of annual grass weeds, particularly, wild oat (*Avena fatua*) and canary grass (*Phalaris minor*) in wheat. Besides, it will also controls some broad leaf weeds like *Anagallis, Melilotus, Convolvulus* and *Chenopodium spp*. This is active on the susceptible weeds, both as pre and post-emergence treatments. It is very generally applied as spray treatments, 30-35 days after sowing of winter grains, soon after the first irrigation of the crop. The annual grasses at this stage are young and tends to be susceptible to isoproturon. Its optimum rates are 0.75- 1.0 kg $ha^{-1}$ on medium soils and up to 1.5 kg $ha^{-1}$ in the heavy soils.

### 3.7 Land preparation

The land of the experimental field was first opened on November 5, 2017 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce an optimum tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg $ha^{-1}$ to protect young plants from the attack of mole cricket, ants, and cutworms. The experimental field was then divided into unit plots and prepared before seed sowing.

### 3.8 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.

### 3.9 Fertilizer application

All the fertilizers were applied at the rate of BARI recommended dose as 150 kg $ha^{-1}$ TSP, 50 kg $ha^{-1}$ MOP, 120 kg $ha^{-1}$ Gypsum (BARI, 2011). Fertilizers other than nitrogen were given during final land preparation. 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.

### 3.10 Seed treatment

Seeds were treated with Vitavex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease. Furadan @1.2 kg $ha^{-1}$ was also used against wireworm and mole cricket.

### 3.11 Seed sowing

Seeds were sown on November 14, 2017 continuously in 20 cm apart rows opened by specially made iron hand tine followed by light irrigation on row. The seed rate was 120 kg $ha^{-1}$. After sowing, the seeds were covered with soil and slightly pressed by hands.

### 3.12 Intercultural operations

The following intercultural operations were done for ensuring the normal growth and development of the crop.

#### 3.12.1 Thinning

Emergence of seedling was completed within 10 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 15 days of sowing which is done to remove unhealthy and lineless seedlings. The second thinning was done 15 days after first thinning keeping one or two or three healthy seedlings in each hill according to the treatment.

### 3.12.2 Weeding

Weeding was done as per the experiment treatment.

### 3.12.3 Irrigation and drainage

The experimental plots required three irrigations during the crop growth season and sometimes drainages were done at the time of heavy irrigation. The first irrigation was done at 20 DAS, crown root initiation stage. Second irrigation was provided at 50 DAS which is the maximum tillering stage of wheat and the last irrigation was done a 72 DAS, grain filling stage. Proper drainage system was also made for draining out excess water.

### 3.12.4 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.

### 3.12.5 General observations of the experimental field

Regular observations were carried out to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

## 3.13 Harvest and post-harvest operation

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. Harvesting of all three varieties were done 1$^{st}$ and 2$^{nd}$ March, 2018 as thevarieties are almost synchronize with their maturity. From the centre of each plot 1 $m^2$ was harvested to assess yield of individual treatment and converted into ton $ha^{-1}$. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned properly. The grain and straw weights for each experimental plot were recorded after proper drying in sun. Before harvesting, ten hills were selected randomly outside the sample area of each plot and cut at the ground level for collecting data on yield contributing characters.

### 3.14 Collection of data

#### 3.14.1 Weed parameters

**Weed population**

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.

**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 $80^0$c. After drying, weight of each species was taken and expressed to g $m^{-2}$.

**Weed control efficiency (%)**

According to Sawant and Jadav (1985) weed control efficiency was calculated with the following formula:

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

Where,

D = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

### 3.14.2 Crop growth parameters

a) Plant height (cm) at 20 days interval up to harvest.
b) Dry matter weight of plant at 20 days interval including partitioning of different parts.
c) Crop Growth Rate (g $m^{-2}$ $day^{-1}$)
d) Relative Growth Rate (g $m^{-2}$ $day^{-1}$)
e) Leaf area index

### 3.14.3 Yield Contributing Characters

a. Length of spike (cm)
b. Number of spikelets $spike^{-1}$ (no.)
c. Number of grains $spike^{-1}$ (no.)
d. Weight of 1000 grains (g)

### 3.14.4 Yield Characters

a. Grain yield (t $ha^{-1}$)

b. Straw yield (t $ha^{-1}$)

c. Biological yield (t $ha^{-1}$)

d. Harvest index (%)

### 3.15 Procedure of sampling for growth study during the crop growth period

**Plant height**

The height of the wheat plants was recorded from 20 days after sowing (DAS) at 20 days interval up to harvest, beginning from the ground level up to tip of the flag leaf was measured as height of the plant. The average height of ten plants was considered as the height of the plant for each plot.

**Number of tillers $m^{-2}$**

Total tiller number was taken from 20 DAS at 20 days interval up to 100 DAS. The average number of tillers of one linear meter was counted and then multiplied with wheat row per meter.

**Total above ground dry matter weight (g $plant^{-1}$)**

The total dry matter production was calculated from the summation of dry matter weight of shoots and the weight was expressed in g $plant^{-1}$.

**Crop growth rate (g $m^{-2}$ $day^{-1}$)**

Crop growth rate was calculated by using the following standard formula (Radford, 1967 and Hunt, 1978) as shown below:

$$\mathrm{CGR} = \frac{\mathrm{W2} - \mathrm{W1}}{\mathrm{T2} - \mathrm{T1}}\,\mathrm{g\ m} - 1\ \mathrm{day} - 1$$

Where,

$W_1$= Total plant dry matter at time $T_1$

$W_2$ = Total plant dry matter at time $T_2$

**Relative growth rate (g $m^{-2}$ $day^{-1}$)**

Relative growth rate was calculated by using the following formula (Radford,1967) as shown below:

$$\mathrm{RGR} = \frac{\mathrm{LnW2} - \mathrm{LnW1}}{\mathrm{T2} - \mathrm{T1}}\ \mathrm{g\ m} - 1\ \mathrm{day} - 1$$

Where,

$W_1$ = Total plant dry matter at time $T_1$

$W_2$ = Total plant dry matter at time $T_2$

**3.16 Procedure of data collection for yield and yield components**

For assessing yield parameters except the grain and straw yields data were collected from 10 randomly selected hills from each plots. For yield measurement, an area of 1.0 $m^2$ from center of each plot was harvested.

**Spike length**

The length of spike was measured by using a meter scale. The measurement was taken from the base to tip of the spike. Average length of spike was taken from ten randomly selected spikes from inner row plants of each plot. Data was recorded at harvest time. Mean data was expressed in centimeter (cm).

**Spikelets spike$^{-1}$**

Data on the number of spikelets spike$^{-1}$ was counted. Ten spike bearing plants were randomly selected and the average data were collected from inner rows of each plot except harvest area during the time of harvesting.

**Filled grains spike$^{-1}$**

The total number of filled grains from randomly selected 10 spikes were counted and average of which gave the number of filled grains spike$^{-1}$. Grain having food material inside were considered as filled grain.

**Weight of 1000 grains**

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 10 plants of each plot and were sun dried properly at 14% moisture content and weight by using an electric balance.

**Grain and straw yield**

An area of 1.0 $m^2$ was harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

**Biological yield**

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

**Harvest index**

According to Gardner *et al*. (1985), harvest index is the relationship between grain yield and biological yield.

It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{biological yield}} x\ 10$$

**3.17 Economic analysis**

From beginning to ending of the experiment, individual cost data on all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production. The rates of different items in wheat were given in Appendix xii.

**Input cost**

Input costs were divided into two parts. These were as follows:

**A. Non-material cost (labor)**

The human labor was obtained from adult male laborers. Eight working hours of a laborer was considered as a man day. The mechanical labor came from the tractor. A period of eight working hours of a tractor was taken to be tractor a day.

**B. Material cost**

The seed of wheat varieties BARI Gom -28, BARI Gom -29 and BARI Gom -30, was purchased from BARI Headquarter @ Tk.120 per kg. Chemical fertilizers e.g. Prilled urea, Urea super granules, TSP, MP, Gypsum and Zinc sulphate were bought from the authorized dealer at Savar, Dhaka. Irrigation was done from the existing facilities of irrigation system of the Sher-e-Bangla Agricultural University field. Herbicides, fungicide and insecticide were bought from the respective dealers at local market.

**Overhead cost**

The interest on input cost was calculated for 6 months @ Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank. The value of land varies from place to place and also from year to year. In this study, the value of land was taken Tk. 200000 per hectare. The interest on the value of land was calculated @ 12.5% per year for 2 months for nursery and 4 months for main field.

**Miscellaneous overhead cost**

It was arbitrarily taken to be 5% of the total running capital. Total cost of production has been given in Appendix XIII.

**Gross return**

Gross return from wheat cultivation (Tk. $ha^{-1}$) = Value of grain (Tk $ha^{-1}$) + Value of straw (Tk $ha^{-1}$).

**Net return**

Net return was calculated by using the following formula:

Net return (Tk. $ha^{-1}$) = Gross return (Tk. $ha^{-1}$) – Total cost of production (Tk. $ha^{-1}$)

**Benefit cost ratio (BCR)**

Benefit cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:Benefit cost ratio (BCR) $= \frac{\text{Gross return}}{\text{cost of production}}$

**3.18 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.

# Chapter IV

# Results and Discussion

# Chapter IV

# RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from a study to investigate the influence of different methods of weed control on the growth, development and yield of wheat varieties cv. BARI Gom-28, BARI Gom-29 and BARI Gom-30. The results of the weed parameters, crop growth and yield characters and economic evaluation of the production of the crop as tested have been presented and discussed in this chapter.

## 4.1 Different weed species observed in the experimental field:

It is a general observation that conditions favorable for growing wheat are 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*. (2010) 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 |

## 4.2 Weed population

Weed competes with another weed plants 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 (chemical secretion of one plant that inhibit the growth of other plants) of one plant to others. 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.).

### 4.2.1 Effect of Variety

There was significant variation observed on weed population for varietal variation and number of weed except at 80 DAS (Fig. 1 and Appendix IV). 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*. (2009) who reveled that number of weed did not varied with variety rather it influenced by weeding regime.

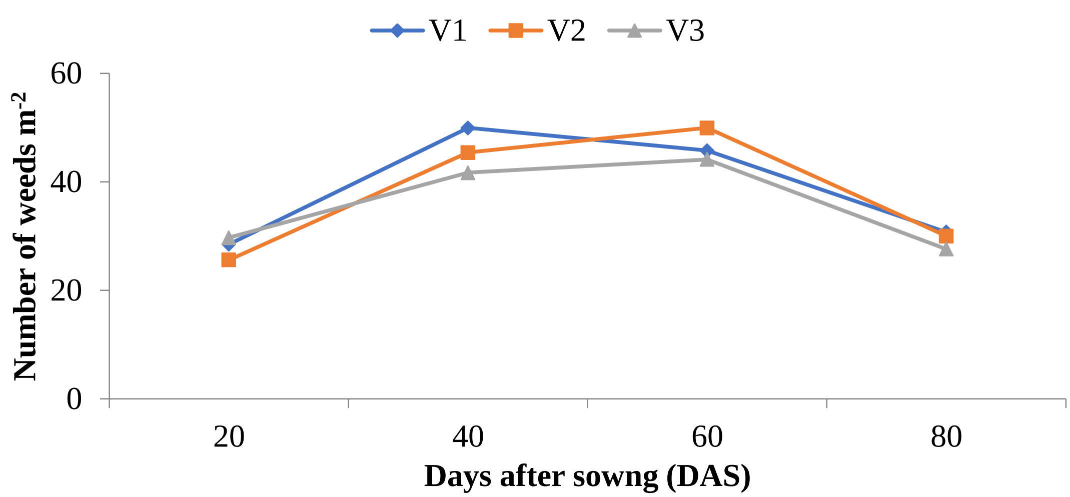



**Figure 1. Effect of variety on the number of weeds on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.79, 7.00, 5.14 and NS at 20, 40, 60 and 80 DAS, respectively)**

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

### 4.2.2 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. Thus, the control ($W_0$) recorded the highest number of weeds per plots. 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.* (2018) that Pendimethalin (3.75 L/ha) was found effective to control weed population.

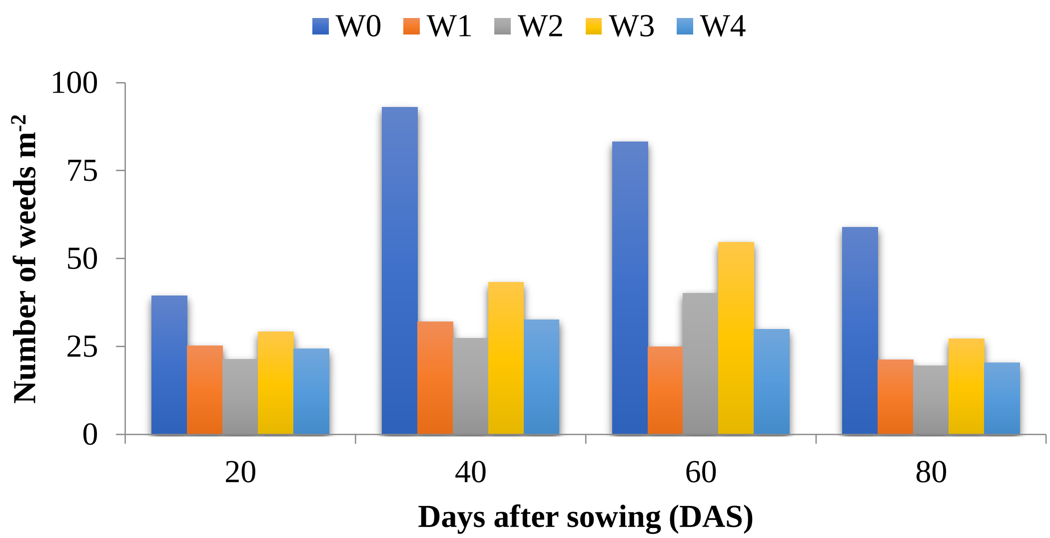



**Figure 2. Effect of different weed managements on the number of weeds on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.26, 5.45, 4.85 and 3.48 at 20, 40, 60 and 80 DAS, respectively)**

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

### 4.2.3 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 $V_3W_0$.

**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**

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 $V_3W_4$. Finaly 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 $V_3W_1$.

### 4.3 Weed biomass

#### 4.3.1 Effect of variety

Significant variation was observed on weed biomass for varietal variation (Fig. 3 and Appendix V). 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 ($V_2$). Similar result found by Singh and Saha (2001) that pendimethalin @ 1 kg $ha^{-1}$ pre-emergence, isoproturon @ 1.5 kg $ha^{-1}$ post-emergence, 2,4-D @ 1.5 kg $ha^{-1}$ post-emergence lower weed biomass and weed index and higher weed control efficiency over weedy check treatment.

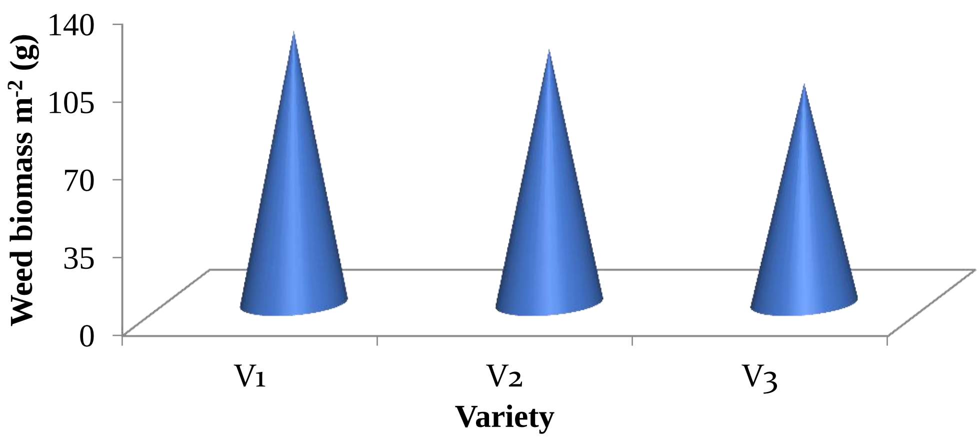



**Figure 3. Effect of variety on the weed biomass $m^{-2}$ (g) in wheat field (LSD $_{(0.05)}$ = 9.14)**

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

### 4.3.2 Effect of weed control treatments

Significant variation was observed on weed biomass for different weed control treatments shown in Figure 4 and Appendix V. The highest weed biomass (147.8 $gm^{-2}$) was recorded from no weeding treatment ($W_0$) and hence the lowest weed biomass (75.34$gm^{-2}$) was recorded from Panida 33EC + Afinity 50.75WP($W_4$).No weeding ($W_1$) showed the highest weed biomass which provided the highest accumulation of weed dry matter per unit area Hence, combine treating Panida 33EC + Afinity 50.75WP ($W_4$)showed the better control over the weed resulting least dry matter accumulation of weed *i.e.*, lowest weed biomass in cases of all weed species. Second better control over weed performed two hand weeding ($W_1$) treatment resulted weed biomass (98.48 $gm^{-2}$) finally. This result was also similar with the findings of Tomar *et al.* (2004), Prasad *et al*. (2005), Nayak *et al*. (2003) and Singh and Saha (2001), but dissimilar result was found by Mustari *et al*. (2014) that pendimethalin performed worst.

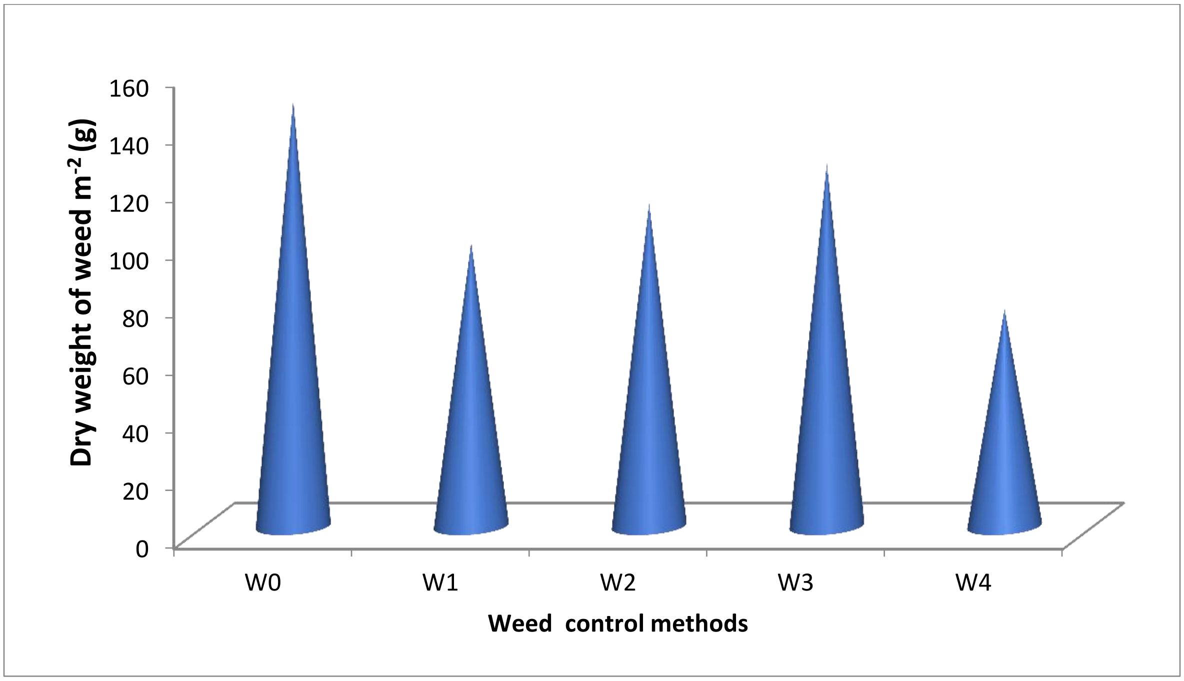



**Figure 4. Effect of different weed managements on the weed biomass $m^{-2}$ (g) in wheat field (LSD (0.05) = 12.18)**

**$W_0$= 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**

### 4.3.3 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*. (2014) that pendimethalin performed worst in some wheat varieties in combined.

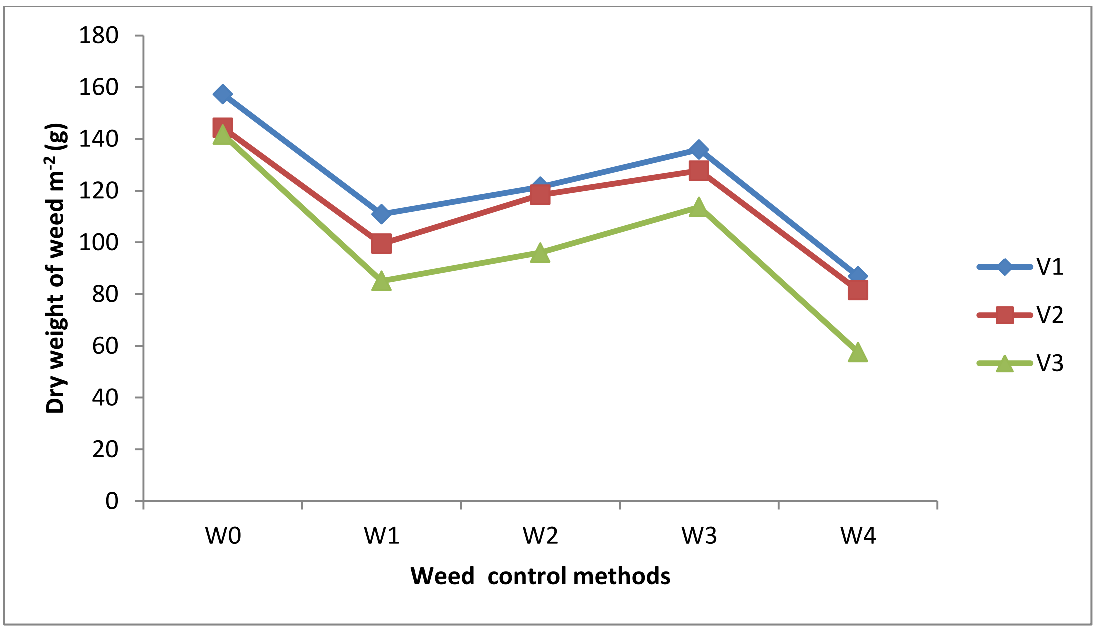



**Figure 5. Combined effect of variety and different weed managements on the Weed biomass $m^{-2}$ (g) in wheat field (LSD (0.05) = 21.10)**

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

### 4.4 Weed control efficiency

### 4.4.1 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 Figure 6 and Appendix V. 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, Khatun *et al*. (2007) observed that weed control efficiency significantly varies in different varieties.

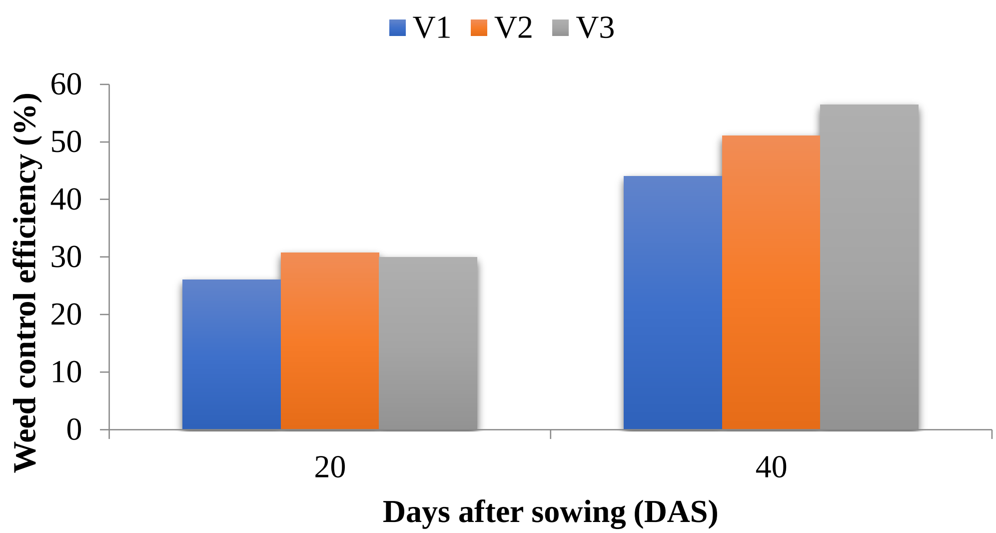



**Figure 6. Effect of variety on the weed control efficiency on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.24 and 7.44 at 20 and 40DAS, respectively)**

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

### 4.4.2 Effect of weed control treatments

For different weed management treatments, significant variation was observed in case of weed control efficiency (Fig. 7 and Appendix V). 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. Second highest weed control efficiency (37.86% and 64.05%) were recorded in case of panida 33 EC ($W_2$) which were statistically similar with $W_1$ (two hand weeding).

This result was in agreement with the findings of Kaur *et al.* (2018), and Zahoor *et al.* (2012). On the other hand, this result was dissimilar with Singh *et al.* (1994) who found that isoproturon 1 kg $ha^{-1}$ had 95.12% weed control efficiency which was almost equal to hand weeding (93.85%) treatment weed control efficiency. Furthermore, dissimilar result was reported by Mustari *et al.* (2014) that Carfentrazone-ethyl performed the best in terms of weed control efficiency (79.68%), while Pendimethalin performed the worst (52.74%).

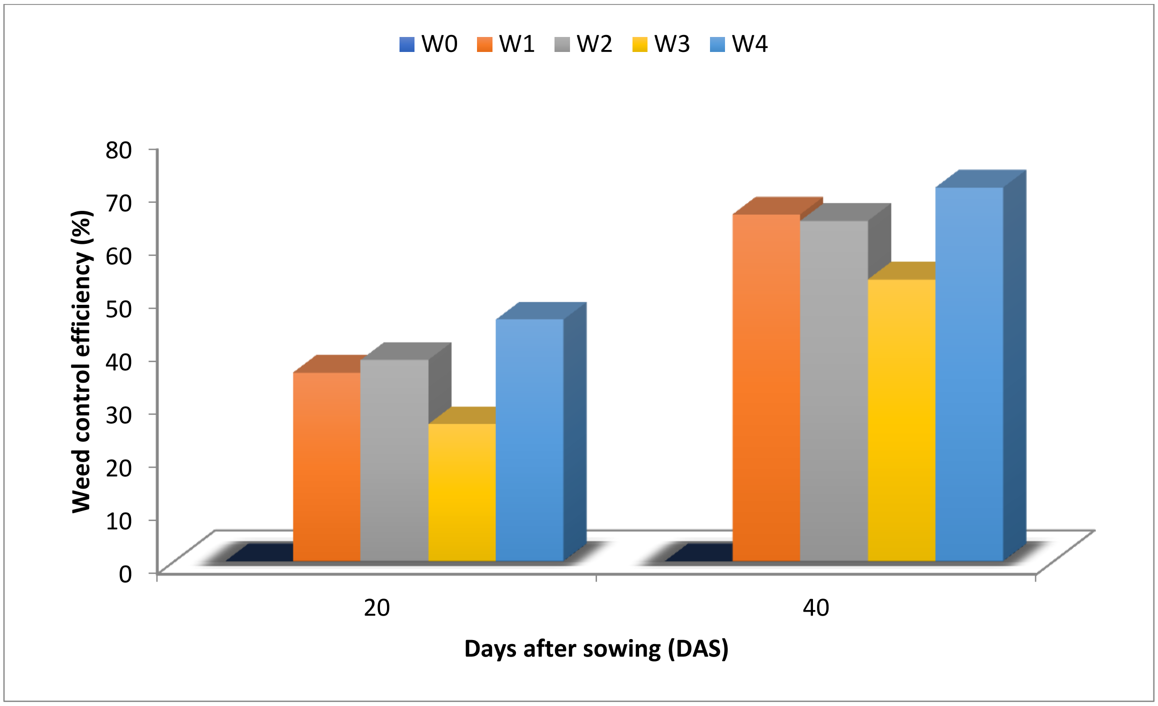



**Figure 7. Effect of different weed managements on the weed control efficiency on wheat field at different days after sowing (LSD $_{(0.05)}$ = 3.55 and 4.45 at 20 and 40 DAS, respectively)**

**$W_0$= 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**

### 4.4.3 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 $V_3W_0$).

**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**

## 4.5 Crop growth parameters

### 4.5.1 Plant height

#### 4.5.1.1 Effect of variety

Plant height varied significantly due to varietal variation throughout the going period (Fig. 8 and Appendix VI). 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.* (2012) who described that plant height varies significantly among varieties.

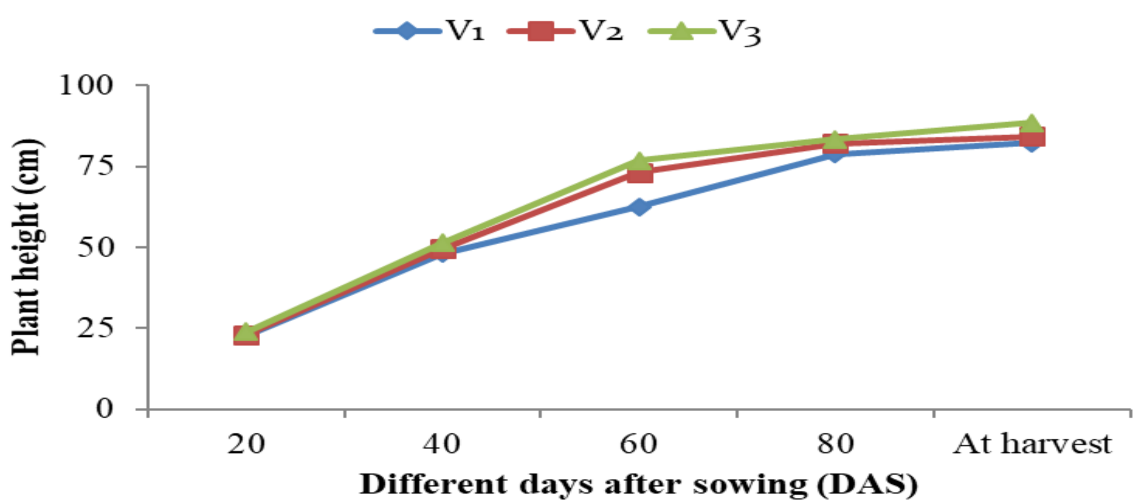



**Figure 8. Effect of variety on the plant height of wheat at different days after sowing (LSD $_{(0.05)}$ =0.95, 1.33, 6.43, NS AND NS at 20, 40, 60, 80 DAS and harvest, respectively)**

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

**4.5.1.2 Effect of weed control treatment**

There was significant variation observed for plant height due to different weed control treatments (Fig. 9 and Appendix VI). 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 consistence with the findings of Acker (2010) and Sultana (2009). The reduction in plant height of wheat plant due to weed competition was also reported by Pandey *et al*. (2002).

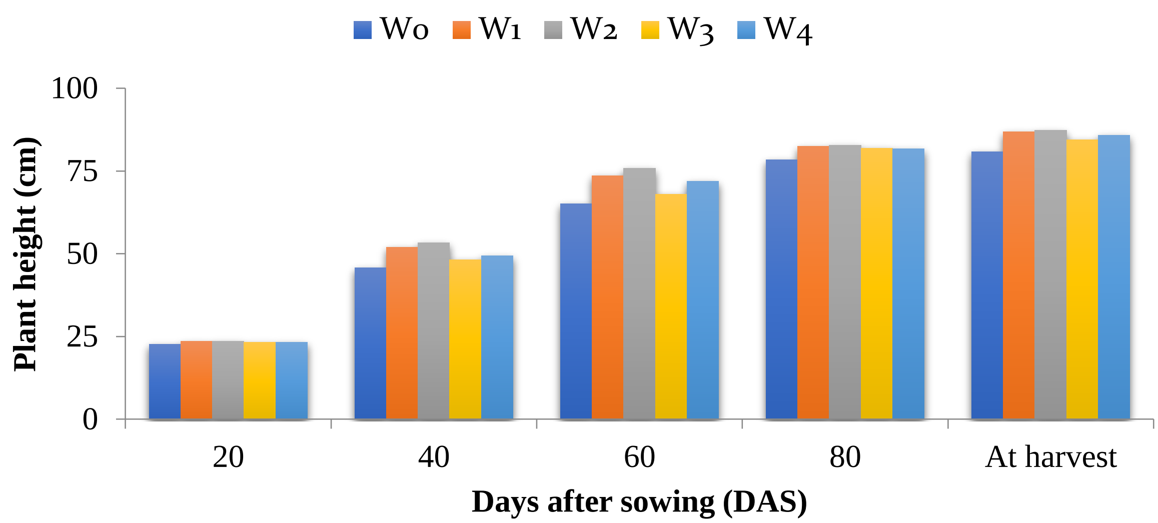



**Figure 9. Effect of different weed managements on the plant height of wheat at different days after sowing (LSD $_{(0.05)}$ = NS, 4.62, 7.30, NS and NS at 20, 40, 60, 80 DAS and harvest, respectively)**

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

#### 4.5.1.3 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 $V_3W_4$. 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 with $V_1W_3$, $V_1W_4$, $V_2W_0$, $V_2W_1$, $V_2W_3$, $V_2W_4$, $V_3W_0$, $V_3W_3$ 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 with $V_1W_1$, $V_1W_2$, $V_2W_0$, $V_2W_1$, $V_2W_2$, $V_2W_3$, $V_2W_4$, $V_3W_0$, $V_3W_1$, $V_3W_3$ 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 with $V_1W_3$.

**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**

The plant height at 80 DAS was non-significant, hence, the highest plant height (86.13cm) was found in combination of 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 hand 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 $V_3W_4$.

### 4.6.2 Leaf area index

#### 4.6.2.1 Effect of variety

Leaf area index of wheat increased significantly due to various type of wheat cultivar at different days after sowing (Fig. 10 and appendix VII). 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 result (0.15) found in BARI Gom-28 ($V_1$).

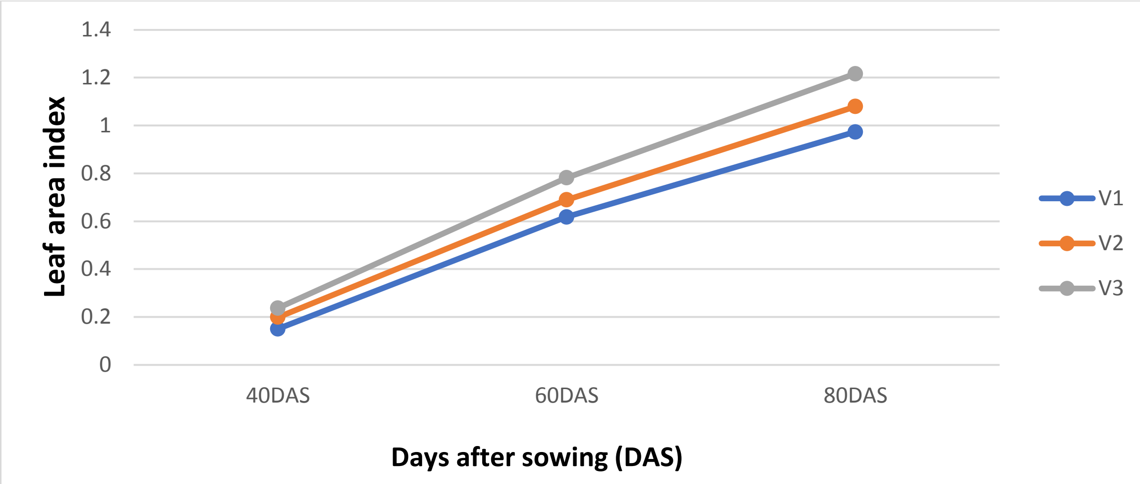



**Figure 10. Effect of variety on the leaf area index of wheat at different days after showing (LSD $_{(0.05)}$ =0.31,0.067 and 0.093 at 40,60 and 80 DAS respectively)**

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

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 with BARI Gom-29 ($V_2$). In case of 80 DAS, highest leaf area index (1.21) recorded in BARI Gom-30 ($V_3$) and lowest leaf area index (0.97). Similar result in a research of Sultana *et al*. (2012).

#### 4.5.2.2 Effect of weed control methods

Weed control methods had significant influence on the leaf area index of wheat at different days after sowing (Fig. 11 and appendix VII). The indicated that Pnida 33EC ($W_2$) showed exponentially highest Leaf area index, whereas, no weeding treatment showed 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 ($W_0$).

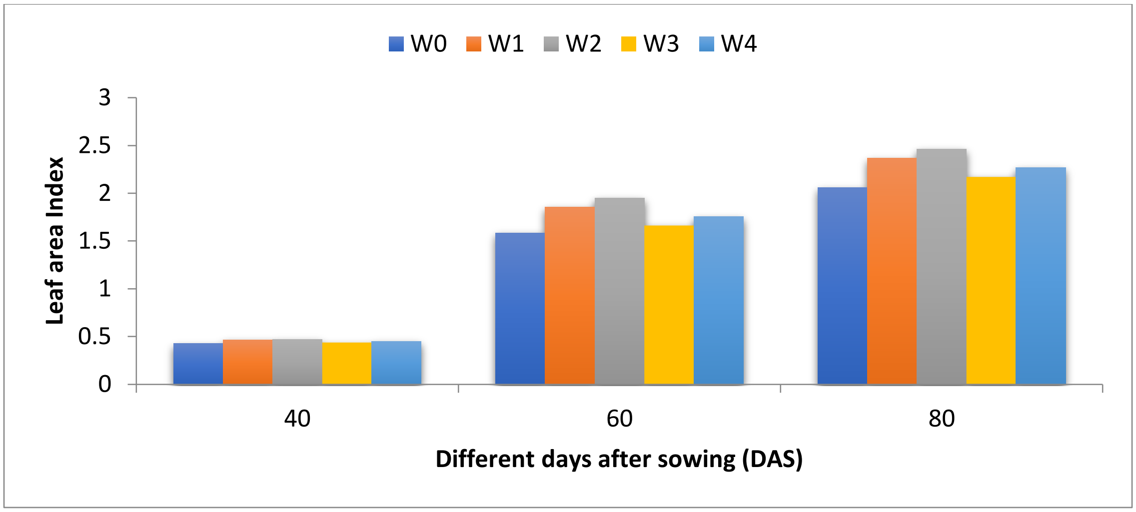



**Figure 11. Effect of different weed managements on the leaf area index of wheat at different days after sowing (LSD $_{(0.05)}$ = 0.052, 0.178 and 0.223 at 40, 60 and 80 DAS, respectively)**

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

Mandal *et al*. (2014) 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, R. V.,2006).

### 4.5.2.3 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 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.

**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 a-c | 2.35 a-c | 2.46 b-e |
| **$V_2W_2$** | 1.94a-c | 2.43 a-c | 2.63a-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**

### 4.5.3 Above ground dry matter production

#### 4.5.3.1 Effect of variety

Dry matter is the material which 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 Figure 12 that irrespective of treatments AGDM of all the varieties significantly varied at all sampling dates except 20 DAS. Figure

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, 60and 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 *et al.* (2006) who stated that cultivar Prodip accumulated higher amount of vegetative dry matter than the other cultivar.

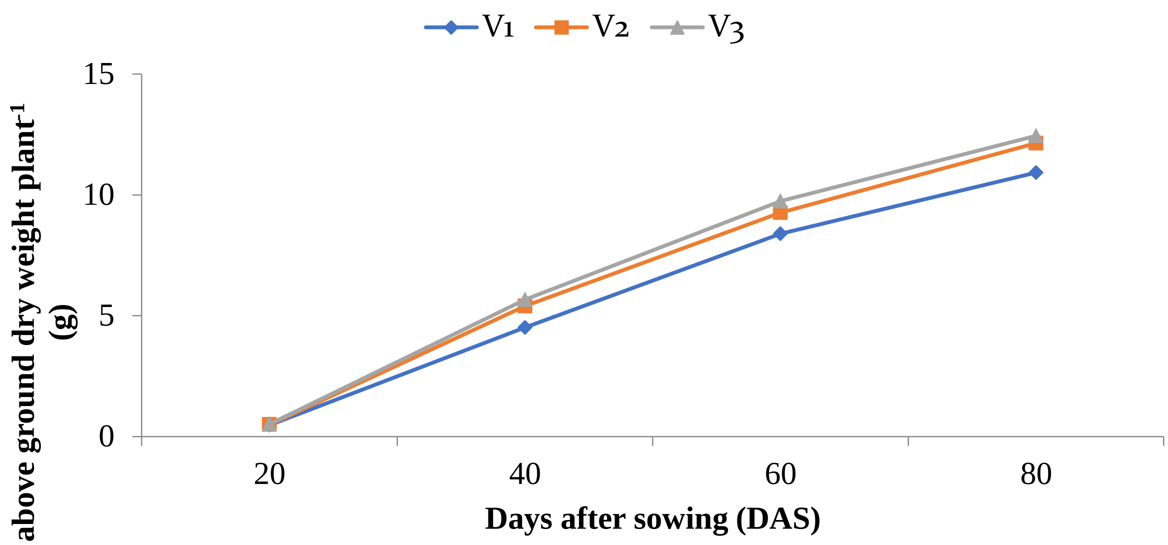



**Figure 12. Effect of variety on the above ground dry weight plant$^{-1}$ of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, 0.55, 0.87 and 1.01 at 20, 40, 60 and 80 DAS, respectively)**

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

### 4.5.3.2 Effect of weed control treatment

Total dry matter (AGDM) increased exponentially with time. AGDM was significantly influenced by different weed control treatments (Fig. 13 and Appendix VIII). 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 unweeded 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 $ha^{-1}$ Zahoor *et al.* (2012).

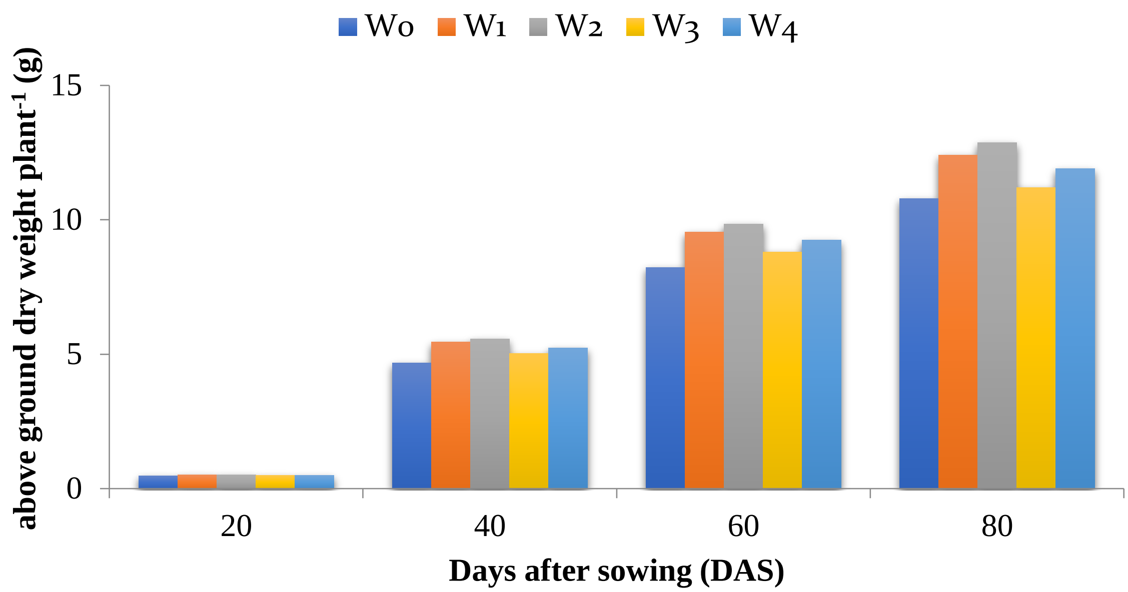



**Figure 13. Effect of different weed managements on the above ground dry weight plant$^{-1}$ of wheat at different days after sowing (LSD $_{(0.05)}$ = 0.04 , 0.59, 0.98 and 1.31 at 20, 40, 60 and 80 DAS, respectively)**

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

### 4.5.3.3 Combined effect of variety and weed control treatment

The combined of weed control treatments and variety had 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 were controlled by Panida 33EC.

**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**

### 4.5.4 Crop growth rate (CGR)

#### 4.5.4.1 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 variety shown in (Fig. 14 and Appendix IX). 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 ($V_3$).

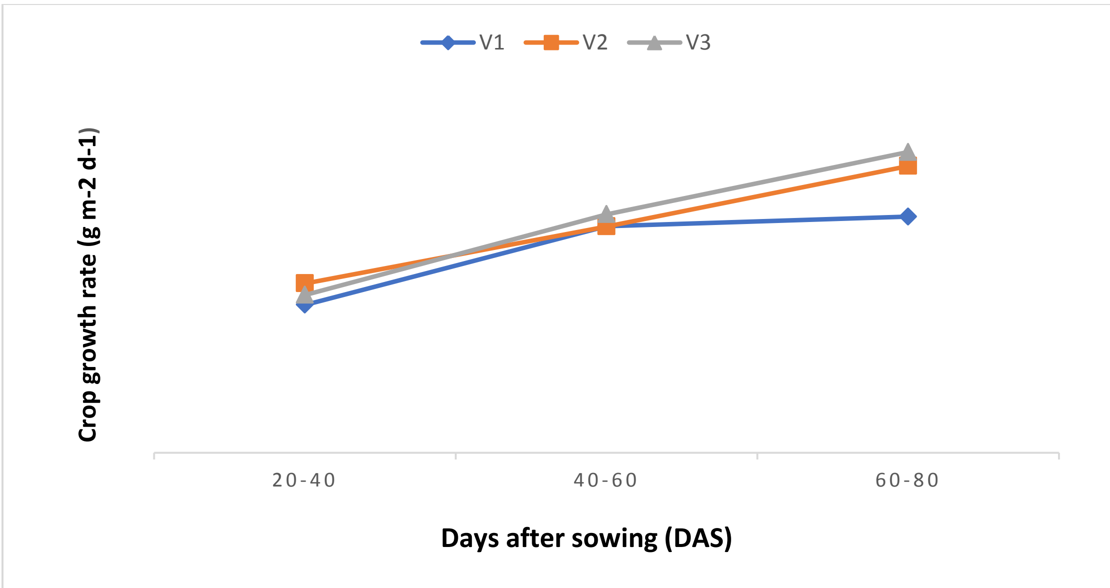



**Figure 14. Effect of variety on the crop growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ = 1.34, NS and 0.61 at 20-40, 40-60 and 60-80 DAS, respectively)**

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

### 4.5.4.2 Effect of weed control treatments

The growth rate of wheat crop was significantly influenced by different weed control treatments over time (Fig. 15 and Appendix IX). Unweeded treatment ($W_0$) showed the lowest CGR throughout the growing period except 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 (Figure 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 with two hand weeding ($W_1$) and Panida 33EC + Afinity 50.75WP($W_4$Dissimilar 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.

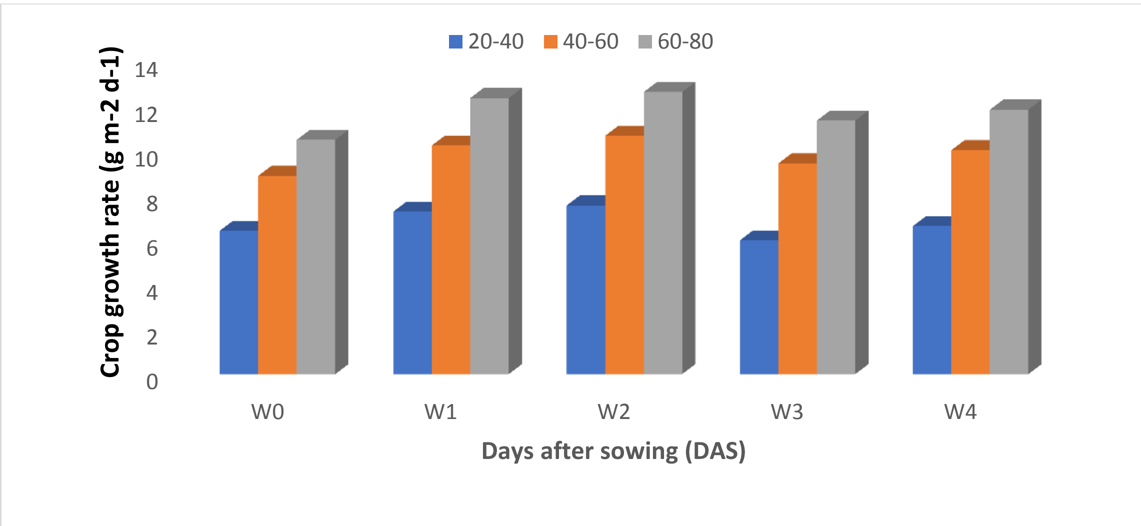



**Figure 15. Effect of different weed managements on the crop growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =1.37, 1.03 and 0.78 at 20-40, 40-60 and 60-80 DAS, respectively)**

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

#### 4.5.4.3 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.

**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**

### 4.5.5 Relative growth rate (RGR)

#### 4.5.5.1 Effect of Variety

Relative growth rate (RGR) is the increase of materials per unit of plant materials per unit of time. RGR of wheat plant varied non-significantly due to variety shown in Figure 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 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 ($V_3$).

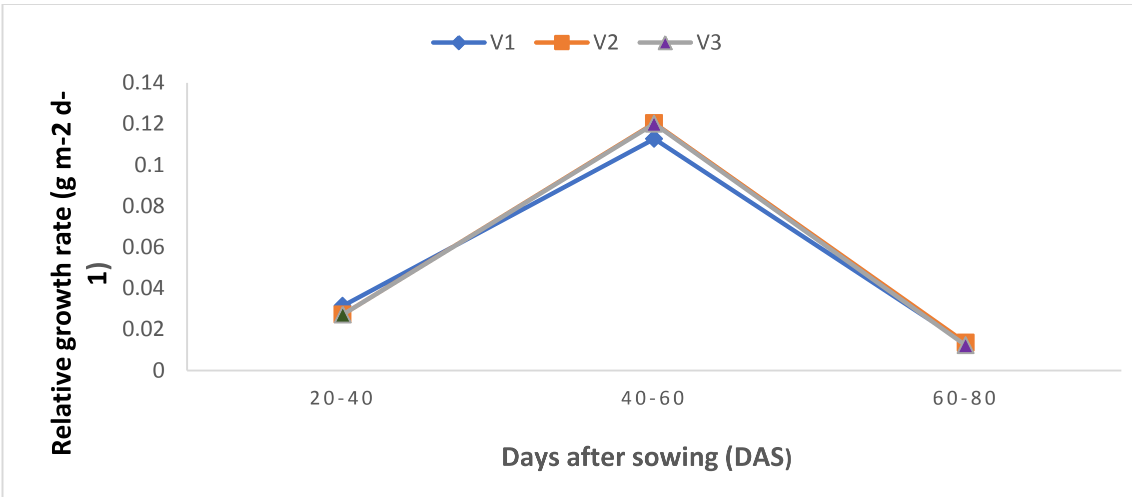



**Figure 16. Effect of variety on the relative growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, NS and NS at 20-40, 40-60 and 60-80 DAS, respectively)**

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

### 4.5.5.2 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, 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.* (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.

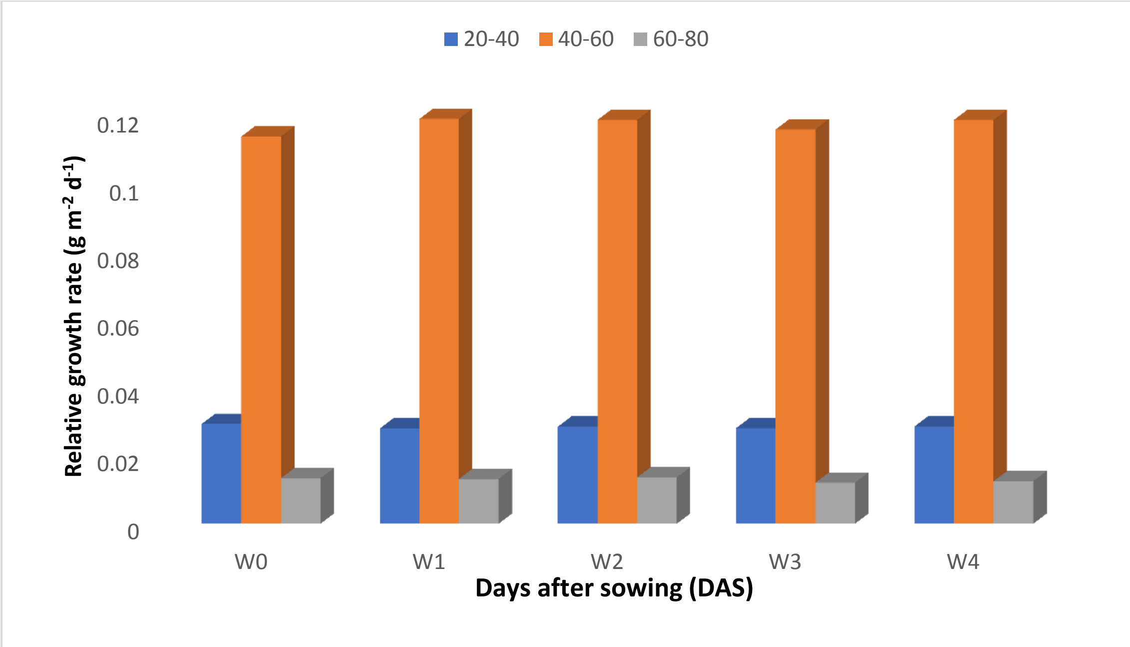



**Figure 17. Effect of different weed managements on the relative growth rate of wheat at different days after sowing (LSD $_{(0.05)}$ =NS, NS and NS at 20-40, 40-60 and 60-80 DAS, respectively)**

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

### 4.5.5.3 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 12). 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 (Khan *et al.* 1981).

**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**

## 4.6 Yield contributing characters

### 4.6.1 Spike length

#### 4.6.1.1 Effect of Variety

The spike length or length of ear head varied significantly due to variety shown in Figure 18. It was observed that BARI Gom-30 ($V_3$) produced significantly longer (16.15cm) spike which was statistically similar with BARI Gom-29 ($V_2$) and again the shortest panicle length (13.8 cm) was measured from BARI Gom-28 ($V_1$) which was statistically similar with BARI Gom-29 ($V_2$). Similar result found that different wheat varieties show different spike length by sultana *et.al.*(2012).

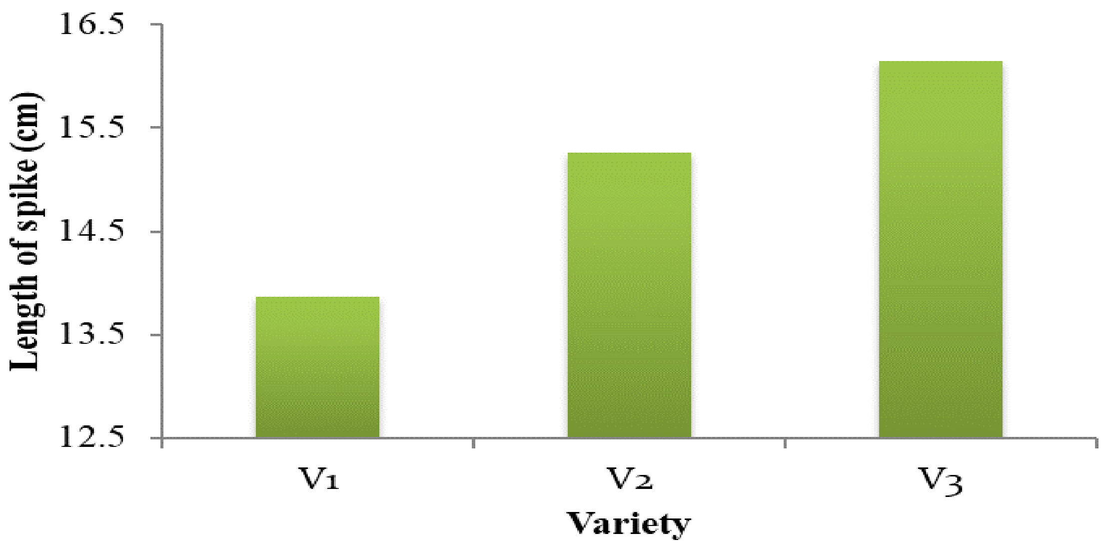



**Figure 18. Effect of variety on the length of spike(cm) of wheat (LSD (0.05) =1.42)**

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

### 4.6.1.2 Effect of weed control treatments

The Spike length varied non-significantly due to weed control treatments shown in Figure 19. But it was observed that numerically longest panicle length (15.77 cm) was recorded at the treatment $W_2$ (Panida 33EC).While the shortest (14.34 cm) spike length was observed from control treatment ($W_0$). Hossain (2008) recorded that a gradual trend of increase length of spike was found in all the herbicides with increased rate of application compared to the control plots of wheat and found the highest spike lengths (7.25, 12.12 and 12.47 cm) from the treatment of Sencor 70WG @ 0.40 kg ha$^{-1}$ at 60 DAS, 90 DAS and at harvest respectively.

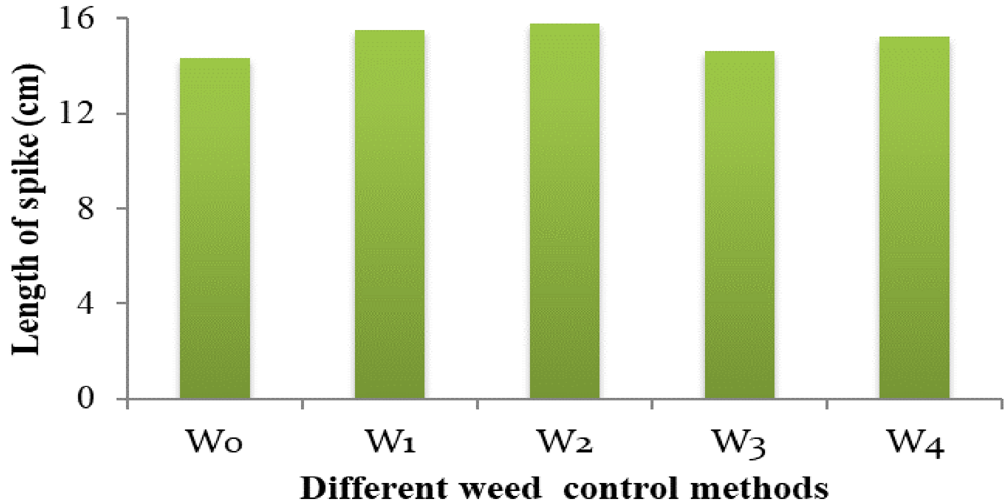



**Figure 19. Effect of different weed managements on the length of spike of wheat (LSD (0.05) =NS)**

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

#### 4.6.1.3 Combined effect of variety and weed control treatments

Spike length was significantly affected by the combined effect of variety and weed control (Table 9). The longest (29.91 cm) panicle was observed from the combination BARI Gom-30 with panida 33EC ($V_3W_2$) which was statistically similar with all other treatment combination except $V_1W_0$ and $V_1W_3$. On the contrary, smallest spike was found in treatment combination $V_1W_0$ (BARI Gom-28 and no hand weeding) which was statistically similar with $V_1W_1$, $V_1W_2$, $V_1W_3$, $V_1W_4$, $V_2W_0$, $V_2W_1$, $V_2W_3$, $V_2W_4$, $V_3W_0$ (table no).

### 4.6.2 Spikelets spike$^{-1}$

#### 4.6.2.1 Effect of variety

The number of spikelets spike$^{-1}$ varied significantly due to Varieties (Fig. 20). It was observed that BARI Gom-30 ($V_3$) produced significantly higher number of spikelets spike$^{-1}$ (14.76) spike which was statistically similar with BARI Gom-29 ($V_2$) and the lowest number of spikelets spike$^{-1}$ (13.22) was measured from BARI Gom-28 ($V_1$) plots which was statistically similar with BARI Gom-29 ($V_2$). Sultana *et al.* (2012) observed that significantly the highest number of spikelets spike$^{-1}$ (20.42) was produced by Prodip which was statistically simillar with Gourab and the lowest (18.19) was produced by Bijoy. Chahal *et al*. (1986) also observed that variety differed in case of the number of spikelets spike$^{-1}$.

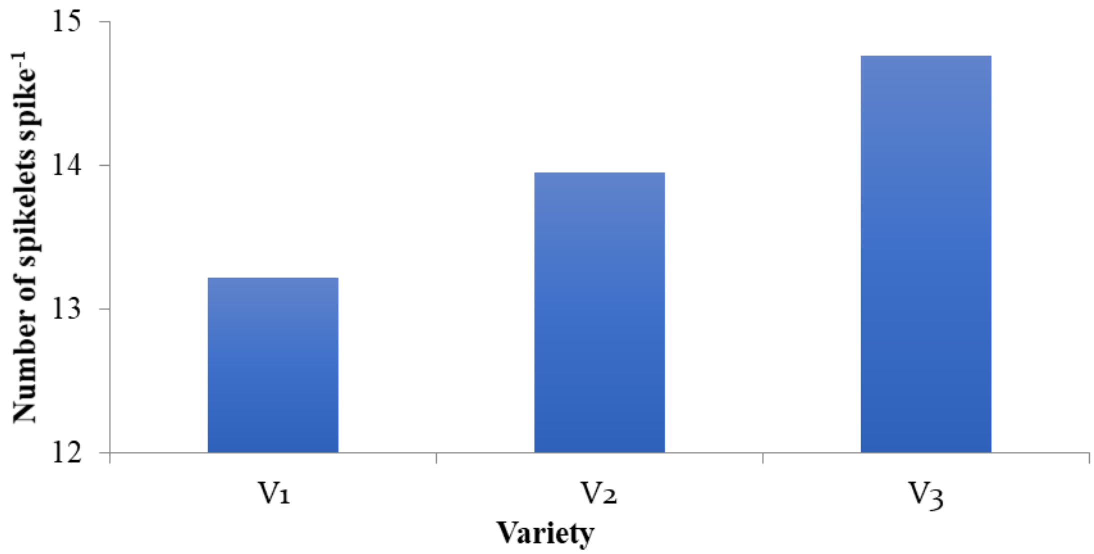



**Figure 20. Effect of variety on the number of spikelets spike$^{-1}$ of wheat (LSD $_{(0.05)}$ =1.34)**

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

#### 4.6.2.2 Effect of weed control treatment

Number of spikelets spike$^{-1}$ also varied significantly due to different weed control methods (fig. 21). It was observed that the number of spikelets spike$^{-1}$ was highest (14.68) in the treatment of panida 33EC ($W_2$) that was also statistically similar with all other treatments except no weeding ($W_0$) which gave the lowest (13.27) number of spikelets spike$^{-1}$. Singh and Singh (2004) investigated the similar result that pre-emergence application of pendimethalin at 0.75 kg ha$^{-1}$ supplemented by one hand weeding or 2,4-D 0.5 kg ha$^{-1}$ at 30 DAS gave significantly higher spikes m$^{-2}$.

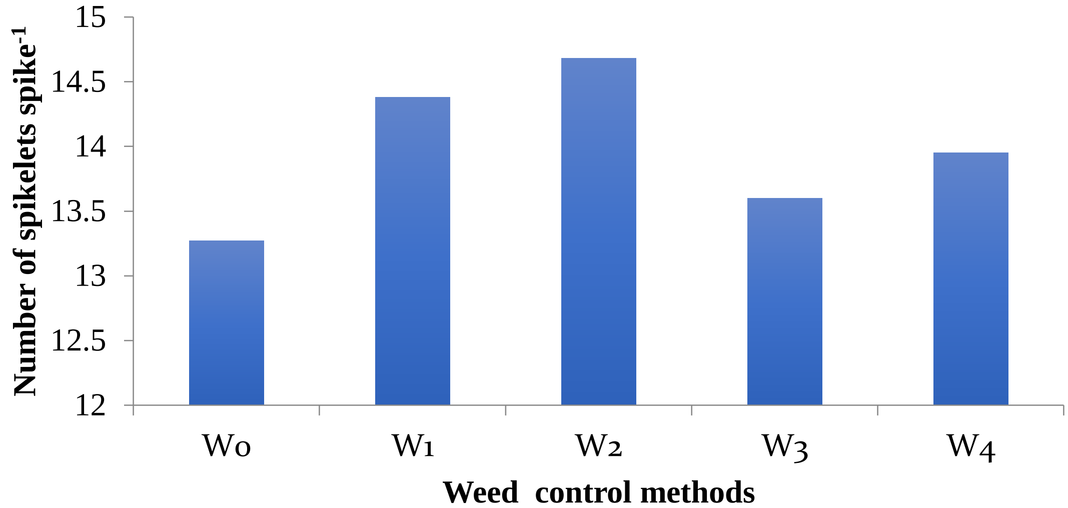



**Figure 21. Effect of different weed managements on the number of spikelets spike$^{-1}$ of wheat (LSD (0.05) =1.39)**

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

### 4.6.2.3 Combined effect of variety and weed control treatment

Different treatment combinations of variety and weed control method produced significant variation in case of number of spikelets spike$^{-1}$ (Table 9). The treatment combination of $V_3W_2$ (BARI Gom-30 with panida 33EC) produced the highest (15.43) number of spikelets spike$^{-1}$ which was statistically similar with all other treatment combination except $V_1W_0$ and $V_1W_3$. However, the lowest (12.40) number of spikelets spike$^{-1}$ was obtained from the treatment combination of $V_1W_0$ which was statistically similar with almost all other treatment combination except highest giving combination BARI Gom-30 with panida 33EC ($V_3W_2$) and BARI Gom-30 and two hand weeding ($V_3W_1$).

### 4.6.3 Grains spike$^{-1}$

### 4.6.3.1 Effect of variety

Significant variation was observed in number of filled grain spike$^{-1}$ due to the effect of variety shown in Figure 22. The highest number filled grain spike$^{-1}$ (42.66) was found in

BARI Gom-30 ($V_3$). The second highest number filled grain spike$^{-1}$ (39.18) was obtained from BARI Gom-29 ($V_2$). The lowest number of filled grain (36.27) was gained from BARI Gom-28 ($V_1$). BARI Gom-30 produced 17.66% more number filled grain than BARI Gom-28 ($V_1$). These results were in agreement with Sultana *et al*. (2012) the highest number of grain spike$^{-1}$ was produced by Prodip which was statistically simillar with Gourab and the lowest value was produced by Bijoy. Shrestha (1988) observed that number of grains spike$^{-1}$ was different for different wheat varieties.

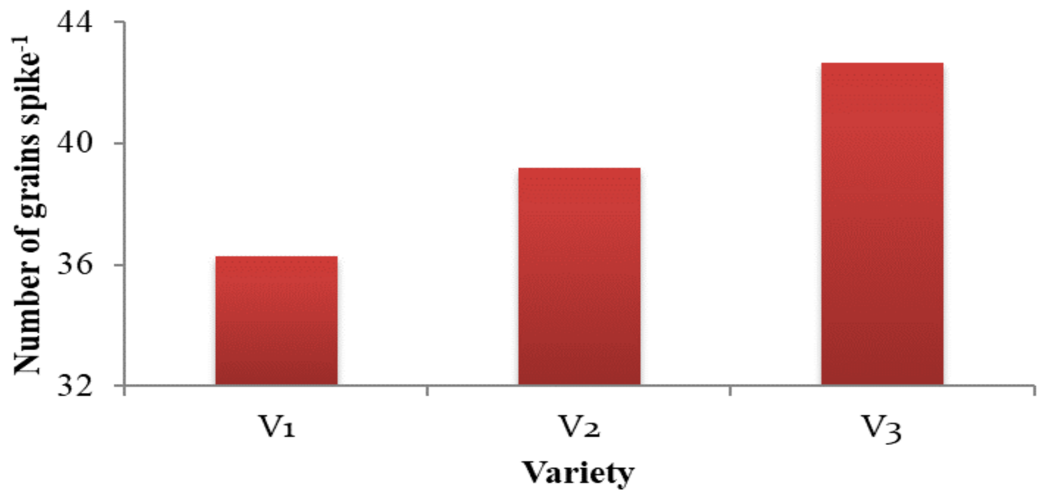



**Figure 22. Effect of variety on the number of grains spike$^{-1}$ of wheat (LSD$_{(0.05)}$ =2.02)**

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

### 4.6.3.2 Effect of weed control treatment

Significant variation was observed in filled grain spike$^{-1}$ due to the influence of weed control (Figure 24). The highest filled grain spike$^{-1}$ (43.02) was obtained from the effect of Panida 33EC ($W_2$) which was statistically similar with the effect of two hand weeding ($W_1$) and combine effect of Panida 33EC and Affinity 50.75WP ($W_4$). The lowest filled grain spike$^{-1}$ (35.69) was obtained from no weeding treated plot ($W_0$) which was statistically similar with the effect of Affinity 50.75WP ($W_3$) Panida 33EC + Affinity 50.75WP ($W_4$). Panida 33EC ($W_2$) gave 20.53% more filled grain spike$^{-1}$ than no weeding ($W_0$). This result supports the findings of Sujoy *et al*. (2006) who showed that application of herbicide contributed mainly increasing the number of grain spike$^{-1}$ and that findings agreement with the findings of Acker (2010).

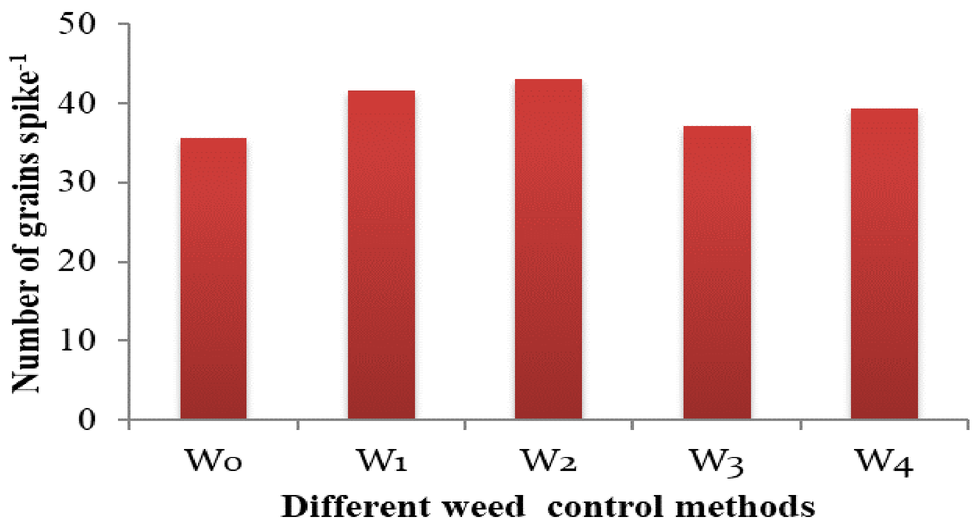



**Figure 23. Effect of different weed managements on the number of grains spike$^{-1}$ of wheat (LSD $_{(0.05)}$ =4.71)**

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

#### 4.6.3.3 Combined effect of variety and weed control treatments

Significant variation was obtained in number of filled grain spike$^{-1}$ due to the combined effect of variety and weed control treatment (Table 9). The highest number filled grain spike$^{-1}$ (47.38) was obtained from the combined effect of BARI Gom-30 with panida 33EC ($V_3W_2$) which was statistically at par with $V_2W_1$, $V_2W_2$, $V_3W_1$, $V_3W_3$, and$V_3W_4$. The lowest filled grain spike$^{-1}$ (32.99) was found from the combined effect of BARI Gom-28 with no weeding ($V_1W_0$) which was statistically similar with all other treatment combination except $V_2W_1$, $V_2W_2$, $V_3W_1$, and $V_3W_4$.

### 4.6.4 1000 grain weight

#### 4.6.4.1 Effect of variety

Weight of 1000 grains showed non-significant variation among the varieties (Figure 24). However, BARI Gom-30 ($V_3$) produced highest 1000 grain weight (50.84 g). The second highest 1000 grain weight (48.95 g) was found in BARI Gom-29 ($V_2$) (Figure 24). The lowest 1000 grain weight (46.82 g) was obtained from BARI Gom-28($V_1$). Similar

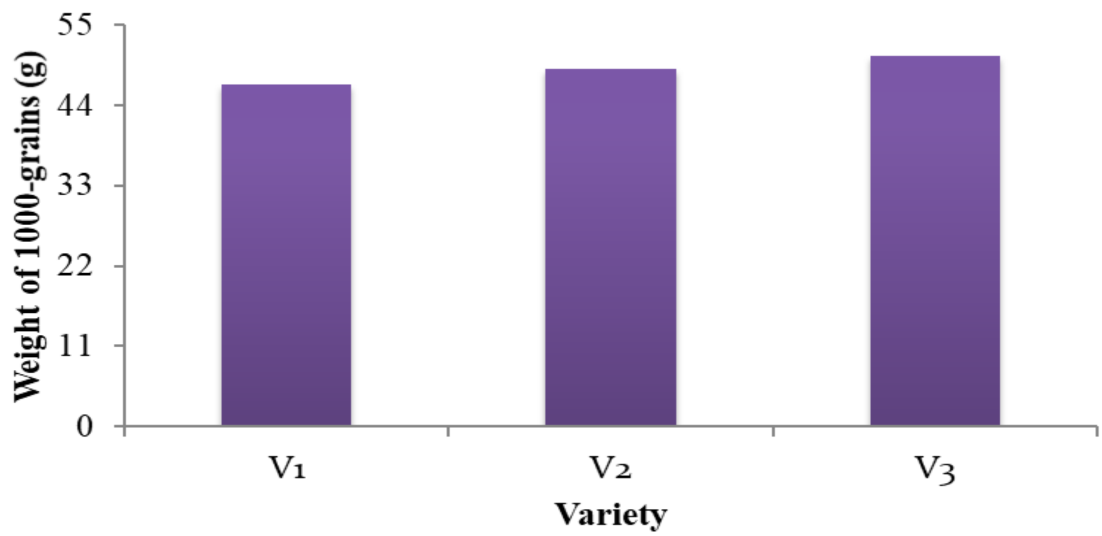



**Figure 24. Effect of variety on the number of weight of 1000-grains of wheat (LSD $_{(0.05)}$ =NS)**

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

findings were reported by Sultana *et al*. (2012) that variety did not differ significantly in respect of 1000-grain weight rather than weight of 1000-grain varied significantly due to weeding regime.

#### 4.6.4.2 Effect of weed control treatment

Effect of weed control method showed significant variation in 1000 grain weight. Panida 33EC ($W_2$) gave the highest 1000 grain weight (51.51 g) which was statistically similar with all other treatments except no weeding($W_0$) (Figure 25). The lowest 1000 grain weight (46.23g) was found from no weeding ($W_0$) which also was statistically similar with all other treatments except highest giving treatment Panida 33EC ($W_2$). This finding was in agreement with Kaur *et al.* (2018) that Pendimethalin (3.75 L/ha) was found effective to control weed population and produced higher number of 1000 grain weight and enhanced the yield upto 43.1% over weedy check.

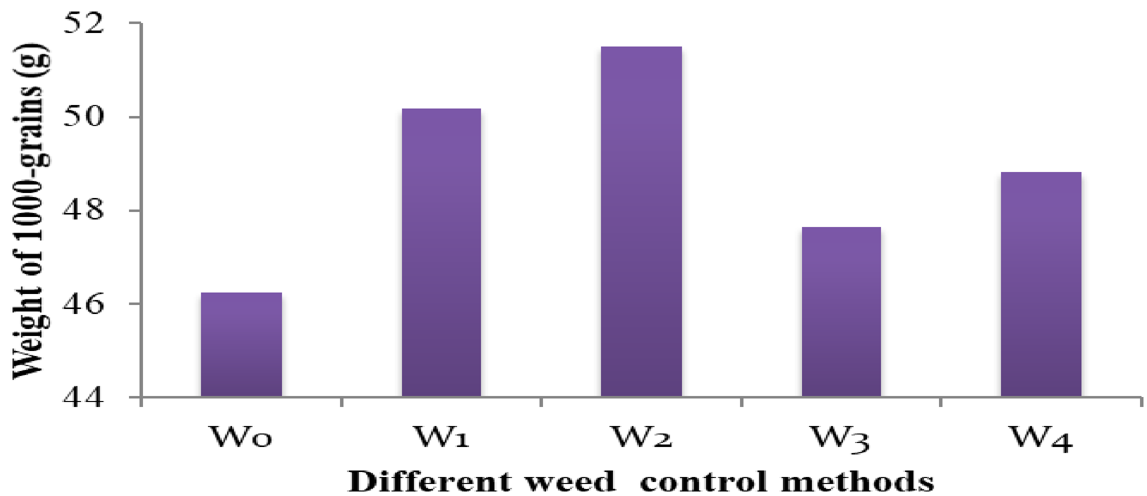



**Figure 25. Effect of different weed managements on the weight of 1000-grains of wheat (LSD $_{(0.05)}$ =4.69)**

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

### 4.6.4.3 Combined effect of variety and weed control treatments

Combined effect of variety and weeding method showed significant variation in 1000 grain weight shown in Table 9. The highest grain weight (53.57g) was found from the combined effect of BARI Gom-30 with panida 33EC ($V_3W_2$) which was statistically similar with all treatment combination except $V_1W_0$ and $V_1W_3$. The lowest grain weight (43.68 g) was found with the combined effect of BARI Gom-28 with no weeding ($V_1W_0$) which was statistically similar with all other treatments except $V_3W_1$(BARI Gom-30 and two hand weeding) and$V_3W_2$ (BARI Gom-30 with panida 33EC). This result supports the findings of Sultana *et. all.* (2012) who reported that weight of 1000 grains varied significantly due to various weed control treatments.

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

| Treatment combinations | Spikelets spike$^{-1}$ | Grains spike$^{-1}$ | Length of spike (cm) | 1000 grain weight (g) |
|---|---|---|---|---|
| $V_1W_0$ | 12.40 c | 32.99 d | 13.20 d | 43.68 c |
| $V_1W_1$ | 13.80 a-c | 37.57 b-d | 14.31 a-d | 48.49 a-c |
| $V_1W_2$ | 13.94 a-c | 39.06 b-d | 14.60 a-d | 49.84 a-c |
| $V_1W_3$ | 12.78 bc | 35.03 cd | 13.31 cd | 45.14 bc |
| $V_1W_4$ | 13.20 a-c | 36.70 cd | 13.93 b-d | 46.97 a-c |
| $V_2W_0$ | 13.22 a-c | 35.76 cd | 14.33 a-d | 46.10 a-c |
| $V_2W_1$ | 14.27 a-c | 41.87 a-c | 15.87 a-d | 50.04 a-c |
| $V_2W_2$ | 14.67 a-c | 42.63 a-c | 16.00 ab | 51.12 a-c |
| $V_2W_3$ | 13.61 a-c | 36.68 cd | 14.63 a-d | 48.28 a-c |
| $V_2W_4$ | 14.00 a-c | 38.93 b-d | 15.46 a-d | 49.20 a-c |
| $V_3W_0$ | 14.20 a-c | 38.30 b-d | 15.49 a-d | 48.91 a-c |
| $V_3W_1$ | 15.07 ab | 45.49 ab | 16.40 ab | 51.97 ab |
| $V_3W_2$ | 15.43 a | 47.38 a | 16.70 a | 53.57 a |
| $V_3W_3$ | 14.41 a-c | 39.57 a-d | 15.93 a-c | 49.51 a-c |
| $V_3W_4$ | 14.67 a-c | 42.53 a-c | 16.23 ab | 50.27 a-c |
| **LSD $_{(0.05)}$** | **2.40** | **8.15** | **2.67** | **8.13** |
| **CV (%)** | **10.21** | **12.29** | **10.50** | **9.87** |

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

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

## 4.7 Yield characters

### 4.7.1 Grain yield

#### 4.7.1.1 Effect of variety

Grain yield varied significantly for different varieties shown in Figure 26 and Appendix XI. 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.* (2012) 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.

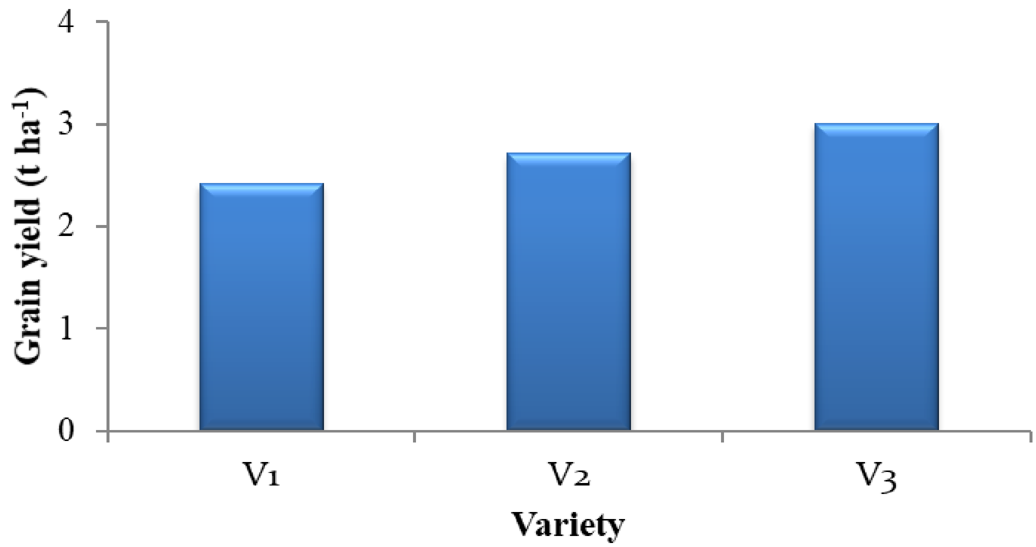



**Figure 26. Effect of variety on the grain yield of wheat (LSD (0.05) =0.08)**

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

### 4.7.1.2 Effect of weed control treatments

Significant variation was observed for grain yield due to different weed control treatments (Fig. 27 and Appendix XI). 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.* (2012) that the application of Buctril super gave 0.45 kg $ha^{-1}$ grain yield. Dissimilar results were found by Azad *et. al.* (2010) stated that pre and post-emergence application of isoproturon give higher grain yield rather than weedy check.

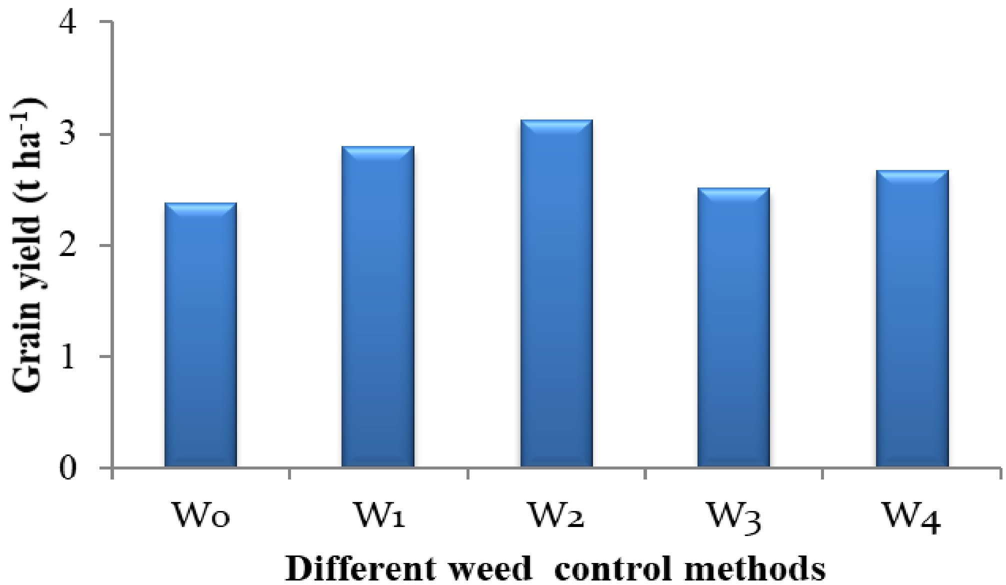



**Figure 27. Effect of different weed managements on the grain yield of wheat (LSD $_{(0.05)}$ =0.27)**

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

### 4.7.1.3 Combined effect of variety and weed control treatments

The grain yield varied significantly due to different varietal and weed control treatment combinations (Table 10). 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 with BARI Gom-30 and two hand 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 with treatment combination $V_1W_3$, $V_1W_4$, $V_2W_0$ and $V_2W_3$. This result was in agreement with Sultana *et al.* (2011) who reported that the combined effect of variety and weeding regime had significant effect on yield and yield contributing characters *viz.* number of fertile spikelets $spike^{-1}$, number of grains $spike^{-1}$ and straw yield in cases of combined of Prodip and completely weed free condition.

### 4.7.2 Straw yield

### 4.7.2.1 Effect of variety

There was significant variation observed for straw yield due to varietal variation (Fig. 28 and Appendix XI). BARI Gom-30 ($V_3$) recorded the highest straw yield (3.814tha$^{-1}$) which was statistically similar with BARI Gom-29 ($V_2$) and the lowest straw yield (3.324 t ha$^{-1}$) was recorded in BARI Gom-28 ($V_1$). Similar findings were also reported by Sultana *et al*. (2012) that Prodip gave highest straw yield (7.30 t ha$^{-1}$) and Shatapdi produced the lowest (6.99 t ha$^{-1}$) straw yield. Sultana (2009) showed that straw yield varied significantly among the wheat varieties.

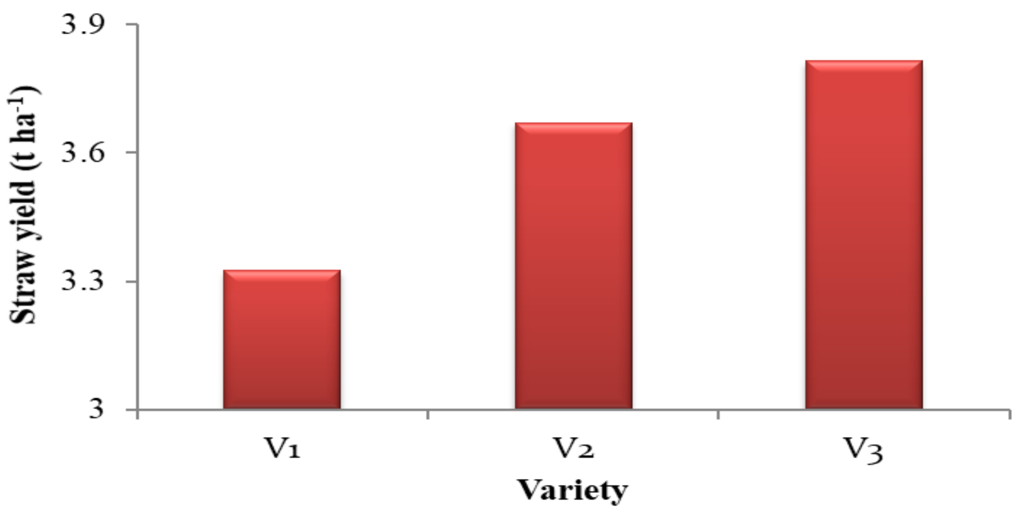



**Figure 28. Effect of variety on the straw yield of wheat (LSD $_{(0.05)}$ =0.20)**

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

### 4.7.2.2 Effect of weed control treatments

Significant variation was also observed due to different weed control treatments (Fig. 29). Highest straw yield (3.917 t ha$^{-1}$) was recorded from Panida 33EC ($W_2$) treated plots which was statistically similar with two hand weeding ($W_1$) and Panida 33EC + Afinity 50.75WP ($W_4$). However, the lowest (3.272 t ha$^{-1}$) was recorded from no weeding ($W_0$) treatment which was statistically similar with Afinity 50.75WP ($W_3$) and Panida 33EC + Afinity 50.75WP ($W_4$) treatment. This result was in agreement with the findings of Kaur *et al*. (2018) Ritu Singh (2014), Salam *et al.* (2010), and Sujoy *et al*. (2006) who revealed that weeding had significant variation on straw yield of wheat.

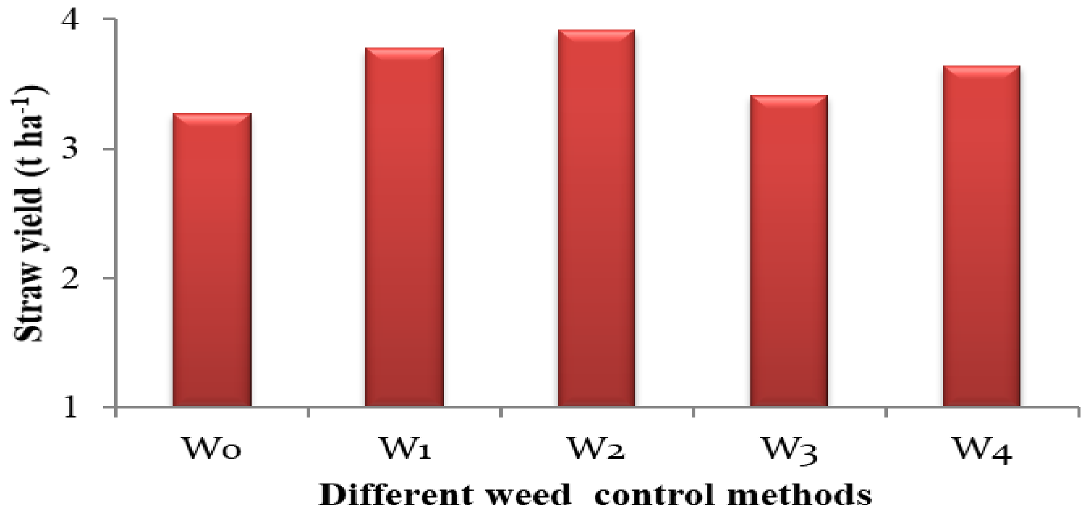



**Figure 29. Effect of different weed managements on the straw yield of wheat (LSD $_{(0.05)}$ =0.41)**

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

#### 4.7.2.3 Combined effect of variety and weed control treatments

The straw yield varied significantly due to different varietal and weed control treatment combinations (Table 10). The highest straw yield (4.093t ha$^{-1}$) was obtained from the combination BARI Gom-30 and Panida 33EC ($V_3W_2$) which was at par with almost all other combination except $V_1W_0$, $V_1W_3$ and $V_2W_0$. The lowest (3.27 t ha$^{-1}$) was found from the combination BARI Gom-28 with no weeding ($V_1W_0$) which was at par with $V_1W_1$, $V_1W_3$, $V_1W_4$, $V_2W_0$, $V_2W_3$ and $V_3W_0$. Similar results were also observed by Sultana *et al*. (2012) in cases of prodip and two hand weeding.

### 4.7.3 Biological yield

#### 4.7.3.1 Effect of variety

The biological yield affected significantly due to variety shown in Figure 30 and Appendix XI. It was observed that BARI Gom-30 ($V_3$) produced significantly highest biological yield (6.821t $ha^{-1}$). The second highest biological yield (6.383 t $ha^{-1}$) was measured from BARI Gom-29 ($V_2$) and the lowest biological yield (5.740 t $ha^{-1}$) was recorded from BARI Gom-28 ($V_1$).

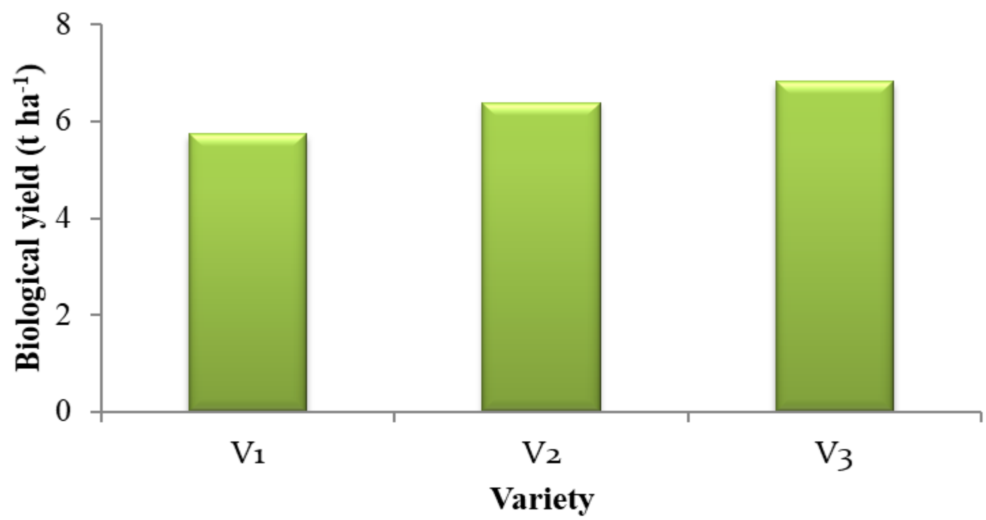



**Figure 30. Effect of variety on the biological yield of wheat (LSD $_{(0.05)}$ =0.38)**

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

### 4.7.3.2 Effect of weed control treatment

The biological yield varied significantly due to different weed control treatments shown in Figure 31 and Appendix XI. Weeds controlled by Panida 33EC ($W_4$) gave the highest biological yield (7.041 t $ha^{-1}$) which was statistically similar with two hand weeding ($W_1$). No weeding ($W_0$) treatment gave the lowest biological yield (5.647 t $ha^{-1}$) which was statistically similar with Afinity 50.75WP ($W_4$). Zahoor *et al.* (2012) and Sujoy *et al.* (2006) also concluded that weed control methods increased biological yield of wheat reducing the weed infestation.

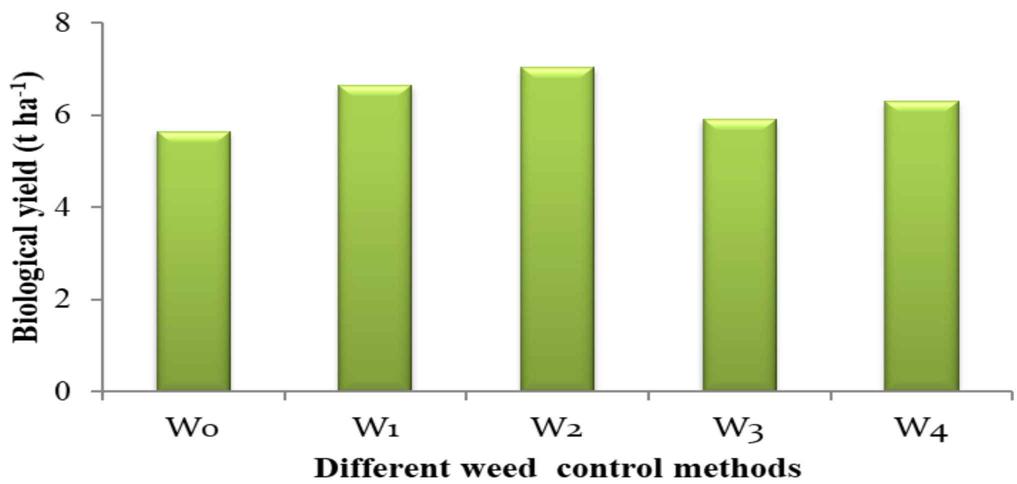



**Figure 31. Effect of different weed managements on the biological yield of wheat (LSD (0.05) =0.57)**

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

### 4.7.3.3 Combined effect of variety and weed control treatments

Biological yield was significantly affected by the combined of variety and weed control treatments (Table 10). The highest biological yield (7.617 t $ha^{-1}$) was obtained from the combination BARI Gom-30 and Panida 33EC ($V_3W_2$) which was at par with $V_2W_1$, $V_2W_2$, $V_3W_1$ and $V_3W_4$. The lowest biological yield (4.997 t $ha^{-1}$) was found from the combination BARI Gom-28 with no weeding ($V_3W_0$) which was at par with $V_1W_3$, $V_1W_4$ and $V_2W_0$. This result was similar to the findings of Salam *et al.* (2010) who stated that the highest grain yield (7.15 t $ha^{-1}$) and straw yield (7.37 t $ha^{-1}$) were found due to application of Machete 5G @ 25 kg $ha^{-1}$.

### 4.7.4 Harvest index

### 4.7.4.1 Effect of variety

Variety showed significant variation in harvest index (%) (Fig. 32 and Appendix XI). BARI Gom-30 ($V_3$) showed the highest harvest index (44.04%) whereas lowest harvest index (30.37%) in BARI Gom-28 ($V_1$) which was statistically similar with BARI Gom-29 ($V_2$).

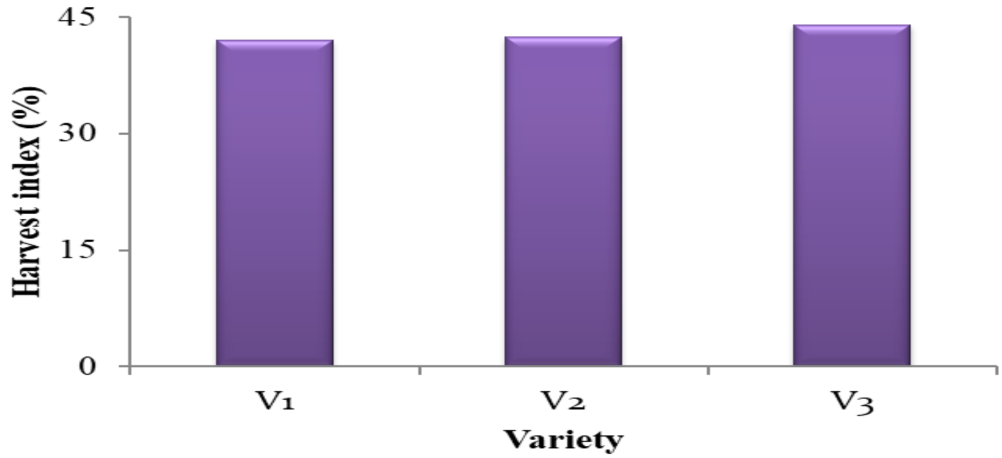



**Figure 32. Effect of variety on the harvest index of wheat (LSD (0.05) =1.43)**

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

### 4.7.4.2 Effect of weed control treatment

Non-significant variation was observed in harvest index (%) influenced by the effect of weeding (Figure 33 and Appendix XI).

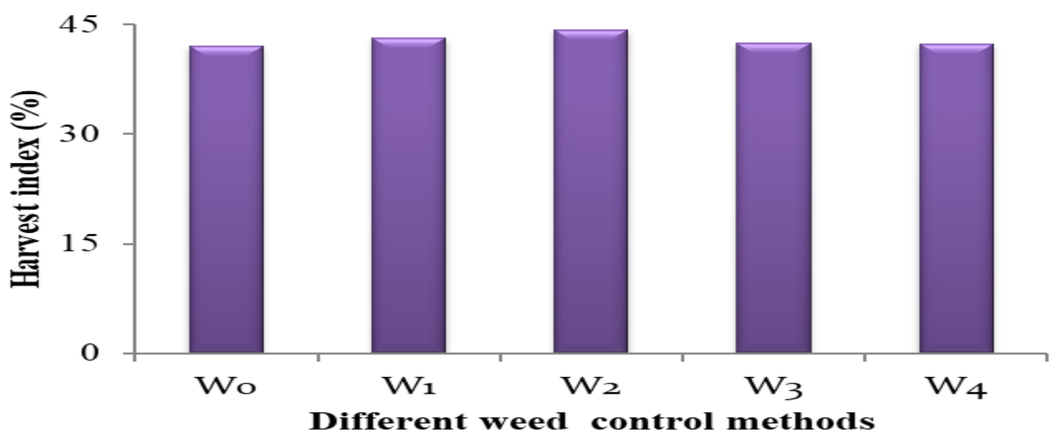



**Figure 33. Effect of different weed managements on the harvest index of wheat (LSD $_{(0.05)}$ =NS)**

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

Numerically highest harvest index (44.30 %) was found due to the effect of Panida 33EC ($W_4$). On contrast, no weeding ($W_0$) gave the lowest harvest index (42.07 %). Sultana

(2009) and Sujoy *et al*. (2006) found significant variation in harvest index of wheat due to weed control treatments.

#### 4.7.4.3 Combined effect of variety and weed control treatment

Combined effect of variety and weeding treatment showed non-significant variation in harvest index (%) (Table 10). Numerically highest harvest index (46.33%) was observed from the combined effect of BARI Gom-30 with panida 33EC ($V_3W_2$). The second highest harvest index (45.56%) was recorded from the combined effect of BARI Gom-30 with two hand weeding ($V_3W_1$) treatments. Hence, the lowest harvest index (41.51%) was obtained from the combined of BARI Gom-30 with combine treating of panida 33EC and Afinity 50.75WP ($V_1W_4$).

**Table 10. Combined effect of variety and different weed managements on the yield characters of wheat**

| Treatment combinations | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $V_1W_0$ | 2.09 g | 2.91 d | 5.00 e | 41.80 |
| $V_1W_1$ | 2.57 d-f | 3.51 a-d | 6.08 cd | 42.20 |
| $V_1W_2$ | 2.69 d-f | 3.64 a-c | 6.33 b-d | 42.51 |
| $V_1W_3$ | 2.27 fg | 3.08 cd | 5.36 de | 42.43 |
| $V_1W_4$ | 2.46 d-g | 3.47 a-d | 5.93 c-e | 41.51 |
| $V_2W_0$ | 2.43 e-g | 3.33 b-d | 5.76 c-e | 42.21 |
| $V_2W_1$ | 2.79 c-e | 3.87 ab | 6.66 a-c | 41.85 |
| $V_2W_2$ | 3.16 a-c | 4.01 ab | 7.17 ab | 44.05 |
| $V_2W_3$ | 2.54 d-g | 3.50 a-d | 6.05 cd | 42.26 |
| $V_2W_4$ | 2.64 d-f | 3.63 a-c | 6.27 b-d | 42.24 |
| $V_3W_0$ | 2.60 d-f | 3.58 a-d | 6.18 cd | 42.21 |
| $V_3W_1$ | 3.29 ab | 3.94 ab | 7.23 ab | 45.56 |
| $V_3W_2$ | 3.52 a | 4.09 a | 7.62 a | 46.33 |
| $V_3W_3$ | 2.70 c-f | 3.65 a-c | 6.35 bc | 42.70 |
| $V_3W_4$ | 2.92 b-d | 3.81 ab | 6.73 a-c | 43.41 |
| **LSD $_{(0.05)}$** | **0.46** | **0.71** | **0.98** | **NS** |
| **CV (%)** | **10.18** | **11.60** | **9.23** | **11.50** |

**$W_0$= 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**

## 4.8 Economic performance of different weed control treatments

The cost of production and return of unit plot of Wheat varieties (cv. BARI Gom-28, BARI Gom-29, and BARI Gom-30) converted into hectare and discussed below.

Economic performance of wheat varieties (cv. BARI Gom-28, BARI Gom-29, and BARI Gom-30) was varied for different weed control treatments in the present experiment. The cost of production was varied mainly for the weeding cost and grain yield. The weeding cost was varied mainly for laborers and material required under different weed control measures.

In case of no weeding measure, there was no involvement of cost for weed control. In the treatment two hand weeding ($W_1$), 15 laborers were required for weeding $ha^{-1}$. In case of herbicidal treatments, panida 33EC ($W_2$) only a laborer was used for herbicide spraying. The weeding cost was Tk. 850.00 the treatment of panida 33EC ($W_2$) Including herbicide cost. The highest cost of production was (Tk. 58385.6 $ha^{-1}$) for the treatment $W_1$ (two hand weeding) and the lowest cost of production was (Tk. 53135.6 $ha^{-1}$) for the treatment no weeding ($W_0$) treatment (Appendix XII).

### 4.8.1 Gross return

Gross return was influenced by different weed control treatments (Table 11). The highest gross return (Tk. 75761.52 $ha^{-1}$) was obtained from the treatment Panida 33EC ($W_2$) and the lowest gross return (Tk. 57906.62 $ha^{-1}$) was obtained from no weeding treatment ($W_0$). The second highest gross return (Tk. 70128.48 $ha^{-1}$) was obtained from two hand weeding ($W_1$).

### 4.8.2 Net return

Net return varied in different weed control treatments (Table 11). The highest net return (Tk. 21775.92 $ha^{-1}$) was obtained from the treatment Panida 33EC ($W_2$). The second highest net return (Tk. 16142.88$ha^{-1}$) was obtained from the treatment ($W_1$). Lowest net return (Tk. 4771.02 $ha^{-1}$) was achieved from the unweeded treatment ($W_0$) (Appendix XV).

**Table 11. Cost of production, return and Benefit cost ratio (BCR) of wheat under different treatments**

| Treatments | Cost of production (Tk./ha) | | | Gross return (Tk/ha) | | | Net income (tk./ha) | BCR |
|---|---|---|---|---|---|---|---|---|
| | Fixed cost of production | Weeding cost | Total cost | From grain | From straw | Total | | |
| **$W_0$** | 53135.6 | 0 | 53135.6 | 53979.12 | 3924 | 57906.62 | 4771.02 | 1.09 |
| **$W_1$** | 53135.6 | 5250 | 58385.6 | 65594.88 | 4533.6 | 70128.48 | 16142.88 | 1.20 |
| **$W_2$** | 53135.6 | 850 | 53985.6 | 71061.12 | 4700.4 | 75761.52 | 21775.92 | 1.41 |
| **$W_3$** | 53135.6 | 750 | 53885.6 | 57167.76 | 4092 | 61259.76 | 7374.16 | 1.14 |
| **$W_4$** | 53135.6 | 1250 | 54385.6 | 60903.02 | 4357.2 | 65260.22 | 10874.62 | 1.20 |

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

### 4.8.3 Benefit Cost ratio

Benefit cost ratio varied in different weed control treatments (Fig. 34). It was evident that the herbicidal plots gave the higher BCR than the other treatments. Among all the treatments, Panida 33EC ($W_2$) gave the highest BCR (1.41). The second highest BCR (1.20) was given by the treatment two hand weeding($W_1$). The unweeded treatment ($W_0$) showed the lowest BCR (1.09). This might be because of less production due to higher weeds competition. Two hand weeding treatment ($W_2$) also performed well with BCR (1.20) but labor involvement was a crucial issue. It can be concluded from economic point of view that herbicidal control might serve as most beneficial means of weed control with synergistic and compatible with the crops and relevant weed species. Zahoor *et al*. (2012), Hossain (2008), Dhiman and Rohitashav (2006) also found highest benefit cost ratio using chemical herbicides. This result supported the findings of Bharat *et al*. (2012) who concluded that the highest B:C ratio was observed with isoproturon + 2,4-D.

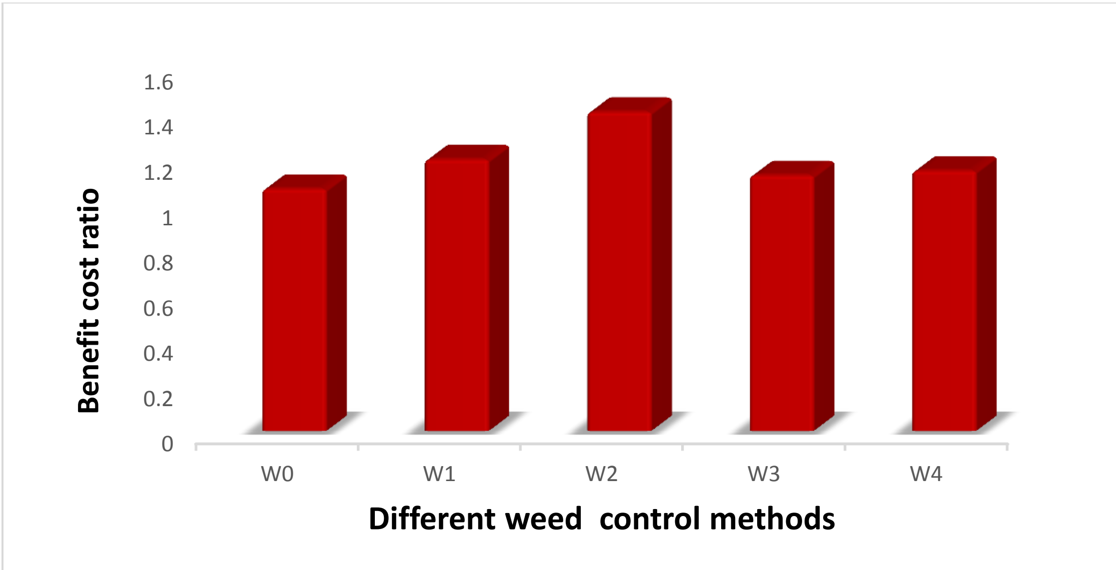



**Figure 34. Effect of weed control methods on benefit cost ratio (%) of Wheat.**

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

# Chapter V

# Summary and conclusion

## Chapter V

## SUMMARY AND CONCLUSION

The present piece of work was done at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November to April, 2017-2018 to find out the influence of different weed control methods on the growth and yield of wheat varieties cv. BARI Gom-28, BARI Gom-29 and BARI Gom-30.

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. Varieties (3) were placed along the main plot and treatments (5) were placed along the sub plot. The weeding treatments were no weeding ($W_0$), two hand weeding at 20 DAS and 40 DAS ($W_1$), Panida 33EC (Pendimethalin) was applied @ 2000 g ha$^{-1}$ at 5 DAS for 3-5 days as pre-emergence herbicide. Afinity 50.75 WP (Isoprotouron)was applied @ 1500 g ha$^{-1}$ at 25 DAS when weeds were 2-3 leaf stage as post-emergence herbicide, and Panida 33EC (Pendimethalin) + Afinity 50.75WP (Isoprotouron): It was applied @ 2000 g ha$^{-1}$ at 5 DAS for 3-5 days as pre-emergence herbicide and Afinity 50.75WP (Isoprotouron) was applied @ 1500 g ha$^{-1}$ at 25 DAS when weeds were 2-3 leaf stage as post-emergence herbicide.

Seeds were collected from the Wheat Research Centre, Bangladesh Agricultural university Research Institute (BARI), Joydebpur, Gazipur. Germination test of collected seed was done in the laboratory before sowing and germination was found to be 95%.

The land of the experimental field was first opened on November 5, 2017 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing and cross-ploughed was done to obtain good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg ha$^{-1}$ to protect young plants from the attack of insects. Lay out of the experiment was done on November 13, 2017 with inter plot spacing of 0.50 m and inter block spacing of 1 m. Sowing was done on the next day

The data on weed parameters were collected from 20 DAS to 80 DAS. Weed parameters such as total weed population (no. $m^{-2}$); weed biomass (g $m^{-2}$) and weed control efficiency (%) were examined. The data on growth parameters *viz*. plant height, above ground dry matter weight $m^{-2}$, crop growth rate and relative growth rate were recorded during the period from 20 to 60 DAS. At harvest, characters like plant height, no of spikelet spike$^{-1}$, total grains spike$^{-1}$, length of spike, 1000 grain weight, grain yield, straw yield, biological yield and harvest index were recorded. To determine the economic feasibility of different weed control methods on wheat, total cost of production, gross return and net return were calculated to determine the benefit cost ratio (BCR).

Nine weed species infested the experimental plots belonging to eleven families. The most important weeds of the experimental plots were *Cynodond actylon, Cyperus rotundus, Echinochloa colonum, Eleusine indica, Chenopodium album, Alternanthera philoxeroides, Brassica kaber, Ieliotropium indicum, Vicia sativa* etc.

Weed density, relative weed density, weed biomass and weed control efficiency were significantly influenced by the weed control treatments. The highest weed density and weed biomass were observed in the no weeding treatment throughout the growing period. The lowest weed biomass were found in the from Panida 33EC +Afinity 50.75WP ($W_4$) treatment was at par with two hand weeding.

Highest Weed control efficiency (45.46 % and 70.36% at 20 and 40 DAS respectively) was highest by Panida 33EC + Afinity 50.75 WP ($W_4$) treatment whereas, the lowest weed control efficiency (0.00%) was observed under no weeding treatment ($W_0$). In this experiment, Sedge and grass weeds dominated the crop field throughout the growing period. The highest number of weed population was found in no weeding treatment throughout the growing period and Panida 33EC + Afinity50.75WP ($W_4$) was performed lowering the weed number.

Different weed control treatments had significant effect on crop growth parameters *viz*. plant height, plant dry weight, crop growth rate (CGR) and relative growth rate (RGR) at different DAS. The highest plant height was observed in BARI Gom-30 with Panida 33EC ($V_3W_2$) 24.88, 55.92, 80.27, 86.13 and 90.07cm at 20, 40, 60 DAS and at harvest respectively. The combination of BARI Gom-30 and Panida 33EC ($V_3W_2$) reveled the highest leaf area index (2.15 and 2.64) in case of 40 and 60 DAS respectively.

Above ground dry weight $m^{-2}$ (g) was highest in BARI Gom-30 with Panida 33EC ($V_3W_2$) 0.55 5.93, 10.43 and 13.47 g per plant at 20, 40, 60 and 80 DAS respectively. Crop growth rate (CGR) and relative growth rate (RGR) was highest in BARI Gom-30 and combined of $V_3W_2$ and $V_3W_2$ in most cases.

Weed control treatments had significant effect on the yield and yield contributing characters *viz*. spike length (15.77 cm), spikelets $spike^{-1}$(14.68), no of grain $spike^{-1}$ grain yield (43.02), straw yield (3.917 t $ha^{-1}$), 1000 grain weight (51.51 g), harvest index (44.30 %) and biological yield (7.041 t $ha^{-1}$) was highest in BARI Gom-30 and Panida 33EC ($V_3W_2$) treatment.

From the economic point of view, it was observed that the benefit cost ratio was the highest (1.41) from Panida 33EC ($W_2$) treatment which was followed by two hand weeding ($W_1$), Panida 33EC + Afinity 50.75WP ($W_4$), Afinity 50.75WP ($W_3$) and no weeding ($W_0$) (1.20, 1.15, 1.13 and 1.07, respectively).

Based on the results of the present experiment, the following conclusion can be drawn:

1) BARI Gom-30 was proved superior over other varieties in respect of growth and yield.
2) Panida 33 EC as pre-emergence herbicide was found to be the effective means of controlling weeds from economic point of view.
3) BARI Gom-30 treated with Panida 33EC at pre-emergence showed the best performance in form term of grain yield, straw yield and harvest index.

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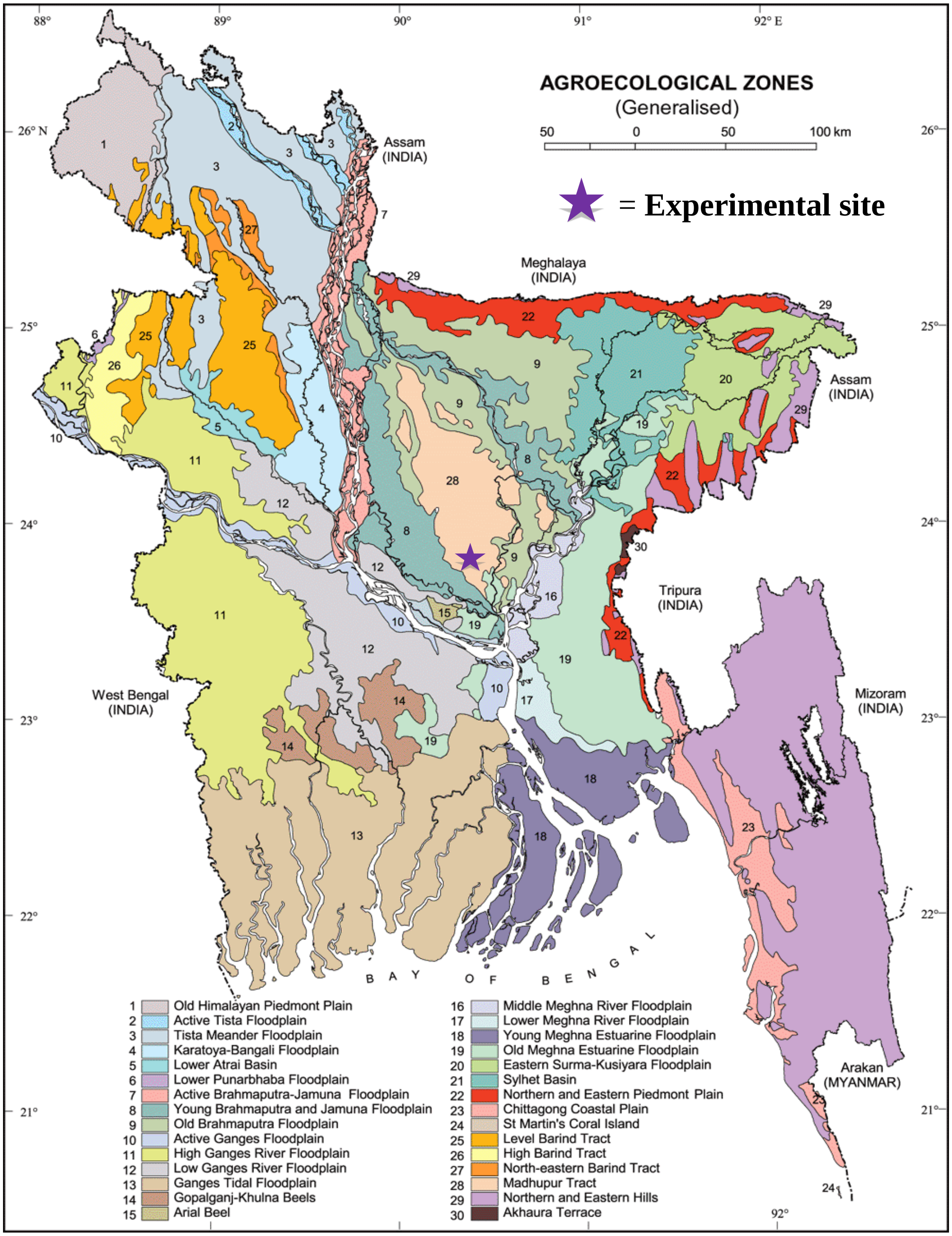
# Appendices

# APPENDICES

## Appendix I. Map showing the experimental site under study



**Appendix II. Characteristics of soil of the experimental field**

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Research Farm, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Deep Red Brown Terrace Soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

**B. The initial physio-chemical characteristics of soil of the experimental site (0 - 15 cm depth)**

| Physical characteristics | |
|---|---|
| **Constituents** | **Percent** |
| Sand | 27 |
| Silt | 45 |
| Clay | 28 |
| Textural class | Silty clay |
| **Chemical characteristics** | |
| **Soil characters** | **Value** |
| pH | 5.7 |
| Organic carbon (%) | 0.46 |
| Organic matter (%) | 0.77 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20.54 |
| Exchangeable K (me/100 g soil) | 0.10 |

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

**Appendix III. Monthly meteorological information during the period from November, 2017 to April, 2018**

| Year | Month | Air temperature ($^0C$) | | Relative humidity | Total rainfall |
|---|---|---|---|---|---|
| | | Maximum | Minimum | (%) | (mm) |
| 2017 | November | 28.10 | 11.83 | 58.18 | 47 |
| | December | 25.00 | 9.46 | 69.53 | 0 |
| 2018 | January | 25.20 | 12.80 | 69 | 00 |
| | February | 27.30 | 16.90 | 66 | 39 |
| | March | 31.70 | 19.20 | 57 | 23 |
| | April | 32.20 | 21.20 | 59 | 24 |

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

**Appendix IV. Means square values for the number of weeds on wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | |
|---|---|---|---|---|---|
| | | 20 DAS | 40D AS | 60 DAS | 80 DAS |
| Replication | 2 | 0.08 | 0.87 | 31.20 | 19.29 |
| Variety (V) | 2 | 66.26* | 257.06* | 134.60* | 40.29$^{ns}$ |
| Error (a) | 4 | 13.97 | 47.63 | 25.70 | 14.89 |
| Weeding (W) | 4 | 444.24* | 6604.39 * | 4933.70* | 2520.72* |
| VxW | 8 | 8.95* | 371.87* | 109.27* | 48.12* |
| Error (b) | 24 | 11.22 | 31.38 | 24.89 | 12.77 |

*Significant at 5% level

ns- Non-significant

**Appendix V. Means square values for weed control efficiency (%) and weed biomass ($g\ m^{-2}$) of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | |
|---|---|---|---|---|
| | | weed control efficiency (%) | | weed biomass ($g\ m^{-2}$) |
| | | 20 DAS | 40 DAS | At harvest |
| Replication | 2 | 16.40 | 28.20 | 353.23 |
| Variety (V) | 2 | 93.57* | 587.44* | 2164.52* |
| Error (a) | 4 | 10.21 | 53.81 | 81.23 |
| Weeding (W) | 4 | 2796.61* | 7544.93* | 6738.58* |
| VxW | 8 | 43.43* | 421.05* | 57.46* |
| Error (b) | 24 | 13.28 | 20.91 | 156.83 |

*Significant at 5% level

ns- Non-significant

**Appendix VI. Means square values for plant height of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | | |
|---|---|---|---|---|---|---|
| | | 20 DAS | 40DAS | 60 DAS | 80 DAS | At harvest |
| Replication | 2 | 19.29 | 20.60 | 86.03 | 37.02 | 9.34 |
| Variety (V) | 2 | 4.33* | 43.31* | 822.36* | $79.75^{ns}$ | $148.71^{ns}$ |
| Error (a) | 4 | 0.87 | 1.713 | 40.28 | 26.61 | 124.08 |
| Weeding (W) | 4 | $1.35^{ns}$ | 80.79* | 168.06* | $27.46^{ns}$ | $59.32^{ns}$ |
| VxW | 8 | 5.47* | 5.22* | 29.42* | $6.57^{ns}$ | 2.88* |
| Error (b) | 24 | 3.84 | 22.54 | 56.36 | 72.88 | 53.59 |

*Significant at 5% level

ns- Non-significant

**Appendix VII. Means square values for leaf area index of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | |
|---|---|---|---|---|
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 1.74 | 445.62 | 1226.47 |
| Variety (V) | 2 | 87.45* | 5774.87* | 5896.62* |
| Error (a) | 4 | 14.15 | 235.60 | 273.49 |
| Weeding (W) | 4 | 28.74* | 1921.71* | 2276.09* |
| VxW | 8 | 2.26* | 35.83* | 138.13* |
| Error (b) | 24 | 8.37 | 342.85 | 533.92 |

*Significant at 5% level

ns- Non-significant

**Appendix VIII. Means square values for above ground dry matter production of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | |
|---|---|---|---|---|---|
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.013 | 0.294 | 0.556 | 0.355 |
| Variety (V) | 2 | $0.009^{ns}$ | 5.457* | 7.030* | 9.728* |
| Error (a) | 4 | 0.003 | 0.289 | 0.729 | 0.995 |
| Weeding (W) | 4 | 0.003* | 1.151* | 3.612* | 6.473* |
| VxW | 8 | 0.004* | 0.157* | 0.084* | 0.124* |
| Error (b) | 24 | 0.002 | 0.370 | 1.019 | 1.811 |

*Significant at 5% level

ns- Non-significant

**Appendix IX. Means square values for Crop growth rate (CGR) and Relative growth rate (RGR) of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | | | |
|---|---|---|---|---|---|---|---|
| | | Crop growth rate (CGR) | | | Relative growth rate (RGR) | | |
| | | 20-40 DAS | 40-60 DAS | 60-80 DAS | 20-40 DAS | 40-60 DAS | 60-80 DAS |
| Replication | 2 | 0.91 | 3.58 | 0.80 | 0.0001 | 0.0001 | 0.0001 |
| Variety (V) | 2 | 31.72* | 1.37$^{ns}$ | 3.15* | 0.0001$^{ns}$ | 0.0001$^{ns}$ | 0.0001$^{ns}$ |
| Error (a) | 4 | 1.74 | 0.60 | 0.36 | 0.0001 | 0.0001 | 0.0001 |
| Weeding(W) | 4 | 6.52* | 4.45* | 3.64* | 0.0001$^{ns}$ | 0.0001$^{ns}$ | 0.0001$^{ns}$ |
| VxW | 8 | 0.89* | 1.52* | 1.11* | 0.0001* | 0.0001$^{ns}$ | 0.0001$^{ns}$ |
| Error (b) | 24 | 1.99 | 1.12 | 0.65 | 0.0001 | 0.0001 | 0.0001 |

*Significant at 5% level

ns- Non-significant

**Appendix X. Means square values for the yield contributing characters of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | |
|---|---|---|---|---|---|
| | | **Spikelets spike$^{-1}$** | **Grains spike$^{-1}$** | **Length of spike (cm)** | **1000 grain weight (g)** |
| Replication | 2 | 5.33 | 12.53 | 6.459 | 4.15 |
| Variety (V) | 2 | 8.81* | 153.25* | 19.788* | 60.63$^{ns}$ |
| Error (a) | 4 | 1.75 | 3.982 | 1.968 | 28.58 |
| Weeding (W) | 4 | 2.90* | 83.88* | 3.244 $^{ns}$ | 38.56* |
| VxW | 8 | 0.04* | 2.29* | 0.091* | 0.87* |
| Error (b) | 24 | 2.035 | 23.40 | 2.510 | 23.26 |

*Significant at 5% level

ns- Non-significant

**Appendix XI. Means square values for the yield contributing characters of wheat at different days after transplanting**

| Source of variance | Degrees of Freedom | Means square values at different days after transplanting | | | |
|---|---|---|---|---|---|
| | | **Grain yield (t ha$^{-1}$)** | **Straw yield (t ha$^{-1}$)** | **Biological yield (t ha$^{-1}$)** | **Harvest index (%)** |
| Replication | 2 | 0.05 | 0.23 | 0.52 | 14.19 |
| Variety (V) | 2 | 1.31* | 0.95* | 4.43* | 15.84* |
| Error (a) | 4 | 0.01 | 0.04 | 0.14 | 1.97 |
| Weeding (W) | 4 | 0.81* | 0.62* | 2.81* | 7.16$^{ns}$ |
| VxW | 8 | 0.03* | 0.02* | 0.04* | 2.74$^{ns}$ |
| Error (b) | 24 | 0.08 | 0.17 | 0.34 | 24.34 |

*Significant at 5% level

ns- Non-significant

**Appendix XII. Operation wise break up of labor required per hectare (ha) of wheat cultivation**

| Sl.No. | Item of work | Tractor driven | Rate (Tk.) | | Labor (No.) | Rate (Tk.) | | Total (Tk.) |
|---|---|---|---|---|---|---|---|---|
| | | | Per Tractor/ day | Total (Tk.) | | Per labor | Total (Tk.) | |
| **01** | Seed treatment | | | | 1 | 350 | 350 | 350 |
| **02** | preparation of main field by ploughing and laddering | 2 | 350 | 700 | 10 | 350 | 3500 | 4200 |
| **03** | Carrying manure, fertilizer and spreading | | | | 2 | 350 | 700 | 700 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **04** | Trimming, spading of corners and removing stubbles | | | | 2 | 350 | 700 | 700 |
| **05** | Sowing seeds and other operations | | | | 6 | 350 | 2100 | 2100 |
| **06** | Thinning | | | | 2 | 350 | 700 | 700 |
| **07** | Irrigation (2 times) | | | | 2 | 350 | 700 | 700 |
| **08** | Fertilizer and pesticide applying | | | | 2 | 350 | 700 | 700 |
| **09** | Harvesting, binding and carrying etc. | | | | 5 | 350 | 1750 | 1750 |
| **10** | Threshing and winnowing | | | | 5 | 350 | 1750 | 1750 |
| **11** | Drying and heaping | | | | 2 | 350 | 700 | 700 |
| **12** | Storing | | | | 2 | 350 | 700 | 700 |
| | | | | | | | **Grand total=** | 15050 |

**Appendix XIII. Cost of production per hectare of wheat cultivation excluding weeding cost**

**Material cost:**

| Sl.No. | Items | Quantity | Rate | Cost (Tk.) |
|---|---|---|---|---|
| **01** | Cost of seed | 120kg/ha | 100tk/kg | 12000 |
| **02** | Cost of manures and fertilizers | | | |
| | a) Cowdung | 8ton/ha | 250tk/ton | 2000 |
| | b) Urea | 100kg | 15tk/kg | 1500 |
| | c)TSP | 120kg | 30 tk/kg | 3600 |
| | d) MOP | 80kg | 15 tk/kg | 1200 |
| | e) Gypsum | 110kg | 8 tk/kg | 880 |
| | f) Boron | 2 kg | 250tk/kg | 500 |
| **03** | Cost of irrigation water (2 times) | | | 1200 |
| **04** | Cost of pesticide | | | 500 |
| | | | Grand total= | 23380 |

Total input cost (Running capital) = (15050 +23380) Tk. = 38380 Tk.

**Overhead cost:**

| Sl No. | Items | Cost (Tk.) |
|---|---|---|
| **01** | Tax of land for 6 month | 150 |
| **02** | Interest of running capital @7% for 6 month | 2686.6 |
| **03** | Interest on fixed capital taking the value of land as Tk. 1 Lakh for 6 months or Leasing value of 1 ha for 6 month | 10000 |
| **04** | Miscellaneous (approximately 5% of the running capital) | 1919 |
| Total= | | 14755.6 |

Total cost of production (excluding weeding cost) = Running capital + Overhead cost = (38380 + 14755.6) Tk = 53135.6 Tk.

**Appendix XIV. Weeding cost of different weed control treatments for one hectare of land of wheat.**

| Treatments | No. of labor | Labor cost | Herbicide cost | Total Weeding cost |
|---|---|---|---|---|
| No weeding ($W_0$) | 0 | 0 | - | 0 |
| two hand weeding ($W_1$) | 15 | 5250 | - | 5250 |
| Panida 33EC ($W_2$) | 1 | 350 | 500 | 850 |
| Afinity 50.75WC ($W_3$) | 1 | 350 | 400 | 750 |
| Panida 33EC + Afinity 50.75WC | 1 | 350 | 1000 | 1250 |

**Appendix XV. Economic performance of different weed control treatments**

In case of all weeding method, same cost was 53135.6 Tk.

1 Mon= 37.32 Kg.

1 mon grain = 850 Tk. i.e.,1ton grain price = 850/37.32 x 1000= 22776Tk.

1 ton straw= 1200 Tk.

| **$W_0$ =No weeding** | |
|---|---|
| Input | Output |
| Labor Cost = 0<br>Total cost = 53135.6 Tk. | Grain yield = 2.37 t $ha^{-1}$<br>= 2.37 x 22776= 53979.12 Tk.<br>Straw yield = 3.27 t $ha^{-1}$<br>= 3.27 x 1200= 3924Tk.<br>Total Income: 57906.62 Tk. |
| BCR: 1.07 Tk. return per Tk. invested | |
| **$W_1$= two hand weeding** | |
| Input | Output |
| Labor Cost = 350 x 15 =5250Tk.<br>Total Cost = 53135.6 +5250 Tk.<br>=58385.6Tk. | Grain yield = 2.88 t $ha^{-1}$<br>= 2.88 x 22776= 65594.88 Tk.<br>Straw yield = 3.778 t $ha^{-1}$<br>= 3.778 x 1200= 4533.6 Tk.<br>Total Income: 70128.48 Tk. |

| | |
|---|---|
| BCR: 1.20 Tk. return per Tk. invested | |
| **$W_2$= Panida 33EC** | |
| Input | Output |
| Labor Cost = 350 x 1 =350 Tk.<br>Herbicide cost=500 Tk.<br>Total Cost = 53135.6 +350+500 Tk.<br>=53985.6 Tk. | Grain yield = 3.12 t $ha^{-1}$<br>= 3.12 x 22776= 71061.12 Tk.<br>Straw yield = 3.917 t $ha^{-1}$<br>= 3.917 x 1200= 4700.4 Tk.<br>Total Income: 75761.52 Tk. |
| BCR: 1.40 Tk. return per Tk. invested | |
| **$W_3$= Afinity 50.75WC** | |
| Input | Output |
| Labor Cost=350 x 1=350 Tk.<br>Herbicide cost=400 Tk.<br>Total Cost = 53135.6 +350+400 Tk.<br>=53885.6 Tk. | Grain yield = 2.51 t $ha^{-1}$<br>= 2.51 x 22776= 57167.76 Tk.<br>Straw yield = 3.41t $ha^{-1}$<br>= 3.41 x 1200= 4092 Tk.<br>Total Income: 61259.76 Tk. |
| BCR: 1.13 Tk. return per Tk. invested | |
| **$W_4$= Panida 33EC+Afinity 50.75WC** | |
| Input | Output |
| Labor Cost= 350 x 1=350 Tk.<br>Herbicide cost= 900 Tk.<br>Total Cost =53135.6 +350+9000 Tk.<br>=54385.6 Tk. | Grain yield = 2.674t $ha^{-1}$<br>= 2.674 x 22776= 60903.02 Tk.<br>Straw yield = 3.631t $ha^{-1}$<br>= 3.63 x 1000= 4357.2 Tk.<br>Total Income: 65260.22 Tk. |
| BCR: 1.15 Tk. return per Tk. invested | |

LIST OF PLATES


**Plate 1: Field view of unweeded (control) plot of wheat**


**Plate 2: Field view of two hand weeding treated plot**

**Plate 3: Field view of Panida 33EC treated wheat plot**



**Plate 4: Field view of Afinity 50.75WP treated plot**



**Plate 5: Field view of Panida 33EC + Afinity 50.75WP treated plot**