WEED KILLING EFFICACIES OF HERBICIDES AS AFFECTED BY APPLICATION TIMES IN WHEAT

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CERTIFICATE

This is to certify that the thesis entitled, **"WEED KILLING EFFICACIES OF HERBICIDES AS AFFECTED BY APPLICATION TIMES IN WHEAT (*Triticum aestivum L.*)"** 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** in **AGRONOMY,** embodies the result of a piece of bonafide research work carried out by **MD. ZAKARIA REZA,** Registration No. **03-01209** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma before.

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.

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Dedicated to
My
Beloved Parents

SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

Abbreviations	**Full words**
AEZ	Agro- Ecological Zone
AI/a.i	Active ingredient
Anon.	Anonymous
Atm.	Atmospheric
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
EC	Emulsifiable concentrate
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
hr	Hour(s)
K_2O	Potassium Oxide
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
mm	Millimeter

Abbreviations	Full words
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
P_2O_5	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
SC	Suspension concentrate
SRDI	Soil Resources and Development Institute
TDM/ TDW	Total Dry Matter/ Total Dry Weight
TSP	Triple Super Phosphate
var.	Variety
WG	Water dispersible granule
Wt.	Weight
t ha^{-1}	Ton per hectare
^0C	Degree Centigrade
%	Percentage

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WEED KILLING EFFICACIES OF HERBICIDES AS AFFECTED BY APPLICATION TIMES IN WHEAT

ABSTRACT

The biological efficacy of different herbicides (Sencor 7 WG@ 500g ha^{-1}, Lintur 70 WG @ 250g ha^{-1}, Ronstar @ 1liter ha^{-1}) applied at different stages of crop growth as compared to untreated areas was studied for controlling weeds in wheat in a field experiments at the research farm of Sher-e-Bangla Agricultural University during 2007-08. Herbicides were applied at 7 DAS, 14 DAS and 21 DAS. A weedy check (no herbicide) was also included for comparison. The analysis of the data revealed significant differences among the times of application for biological yield and grain yield. Similarly significant differences were recorded for herbicidal treatments in traits like 1000 grains weight (g), biological yield (t ha^{-1}) and grain yield (t ha^{-1}). The interaction of the times of application and herbicides was significant for grain yield. Maximum 1000 grains weight (47.48g) was observed in plots treated with Ronstar, while minimum (38.17g) in weedy check plots (no herbicide). Biological yield (7.0 t ha^{-1}) and grain yield (3.16 t ha^{-1}) were higher in plots treated with Ronstar while lower biological yield (4.5 t ha^{-1}) and grain yield (1.62 t ha^{-1}) were in weedy check plots. Ronstar proved to be the most economical and effective herbicides which gives maximum grain yield of (3.37 t ha^{-1}) and biological yield (7.3 t ha^{-1}), when applied at 21 DAS in wheat.

Chapter 1
Introduction

A. (93)

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum L.)* is one of the most important cereal crops all over the world in respect of human nutrition. Most of the people meet their carbohydrate requirement from wheat. About two third of the world population use wheat as staple food (Majumder, 1991). It ranks first both in acreage and production among the grain crops of the world (FAO, 2006). About one third of the world population lives on wheat grains for their subsistence (Hanson *et al.*, 2007). It is the second most important cereal crop next to rice in Bangladesh. About 399 thousand hectares of land was covered by wheat cultivation with the annual production of 737 thousand tons in Bangladesh (BBS, 2008). Despite the acreages, production and yield rate of wheat has been increasing dramatically during the last decade, but the average yield of wheat in Bangladesh is too low (1.85 t ha^{-1}) in compare to the other countries of the world (FAO, 2006).

However, many factors are responsible for low yield. Among these factors infestations of weeds is a serious issue and require immediate action. Yield can be reduced adversely by weed infestation. About 27% of wheat production in the country is lost due to weed competition (Karim, 2003).

The control of weeds is a basic requirement and major component of management in most production systems (Young *et al.*, 1994, Norriss, 1998 & Triple, 1976). It is an established fact that decreased weed infestation increased crop production, showed higher land equivalent ratio and above all gives higher yield and benefit cost ratio (Mengping and Zhangjinsong, 2005).

Generally, weeds are managed manually. Nowadays it has become difficult due to labour cost and unavailability of labour. The weed control has been practiced since the time immemorial by manual labour and/or animal drawn implements, but these practices are laborious, tiresome and expensive due to increasing cost of labour. The growing mechanization of farm operations and over increasing labor wages has stimulated interest in the use of chemical weed control. Chemical weed control is the easiest and most successful alternative method. Reports are available on the efficacy of different herbicides in wheat (Khan *et al.*, 2001; Qureshi *et al.*, 2002; Hassan *et al.* & 2003). Mechanical weed control produces less yields than the control with herbicide (Pardo, 2001).

Various types of herbicide can be used for weed control such as Ronstar, Sencor, Lintur, Iodosulfuron, Ally 20 DF, Metsulfuron methyl, Pendimethalin, Metribuzin, Chlorsulfuron, Isoproturon, and Rotavator etc. Herbicides efficiently reduced the weed density and dry weight, and improved the yield and yield attributes (Yadav *et al.*, 2001).

Timely application of a herbicide is important for both efficacy and crop tolerance considerations. A set of standardized codes should be used to describe the various stages of crop development. (Lancashire *et al.*, 1991). Several reports address the importance of weed control at proper time in wheat. Rossarola *et al.* (1993) reported that application of herbicides resulting in increasing grain yield at 2nd nodal stage.

In view of the above background, however, the present study was undertaken with the given application of different herbicide along with time of application for weed control in the wheat variety 'Shatabdi' (BARI gom21) with the following objectives:

1. to find out the proper time of herbicide application
2. to compare the efficacies of different herbicides for controlling weeds for higher grain yield of wheat

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of research in relation to weed control in wheat with different herbicides and time of application.

It is an established fact that decreased weed infestation increased crop production, showed higher land equivalent ratio and higher yield and benefit cost ratio (Mengping and Zhangjinsong, 2005).

A field trial was conducted at Shyampur and Rajshahi during winter season of 2004-2005 by Hossain *et al.* (2009) to make certain a suitable herbicide for weed control as well as increase the yield of wheat. Effect of twelve treatment combinations i.e., Lintur 70 WG at two, four and six leaves stage of three doses, 2-4,D Amine at four leaves stage, one hand weeding and control on wheat variety Shatabdi were studied. The major weeds observed were *Chenopodium album, Cyprus rotundus, Cynodon dactylon and Echinochloa crusgalli*. The population and dry weight of wheat were minimum in Lintur 70 WG @ 375 g ha^{-1} at two leave stage and maximum in control plot i.e. no weeding. Weed control efficiency (%) was maximum in Lintur 70 WG @375 g ha^{-1} at two leave stage which was at par with hand weeding. Yield and yield components significantly responded to different treatments. Lintur 70 WG @ 375 g ha^{-1} at two leave stage sprayed significant effects on weeds. The maximum grain yield (3.4 t ha^{-1}) was obtained by Lintur 70 WG @ 375 g ha^{-1} at two leave stage which was at par with hand weeding due to lower weed-crop competition resulted higher absorption of nutrients and sufficient interception of sunlight as well as air. The lowest grain yield (2.4 t ha^{-1}) was found in control plot (No weeding) due to weed-crop competition from first to last resulted sharing of nutrient, air and sunlight.

Significantly more wheat yield was recorded in weed free treatment. Wheat yield was gradually decreasing with the increasing of weed populations.

An experiment was conducted by Satao and Padole (1994) consisting treatments of weeding 20 to 25 DAS; pre-em. application of 1 kg ha^{-1}isoproturon; post-em. (20 to 25 DAS) application of 1 kg ha^{-1}isoproturon and 1 kg ha^{-1} 2,4-D; pre-em. and post-em. application of 1 + 1 kg ha^{-1} isoproturon + 2,4-D; pre-em. application of 1 kg ha^{-1} isoproturon + one weeding 20 to 25 DAS; and two hand-weeding 20 and 40 DAS. Two hand-weeding resulted in the greatest height (58.24 cm), number of functional leaves (17.05 at 40 DAS), leaf area (3.42 dmsuperscript 2), number of effective tillers (77.58 m^{-1} row) and total dry matter $plant^{-1}$ (9.86 g at harvest) as well as grain yield (2.74 t ha^{-1}) in the wheat crop. Overall, two hand-weeding resulted in the best weed control, followed by the isoproturon + one weeding treatment. Results indicated that isoproturon was more effective in controlling wheat crop weeds than 2,4-D.

Pandey *et al.* (2006) evaluated the efficacy of sulfosulfuron (20, 25 or 30 g ha^{-1} applied at 40 or 60 days after sowing), isoproturon (1000 g ha^{-1} at 40 DAS), 2,4-D (500 g ha^{-1}at 40 DAS), metribuzin (230, 245 or 260 g/ha at 40 DAS, or 260 g ha^{-1}at 60 DAS) and manual weeding (at 25, 50, 75 and 100 DAS; control) against weeds (mainly *Phalaris minor*, *P. plebeium* and *Melilotus indica*) infesting wheat (CV(%). VL 738) in Uttaranchal, India. All treatments except 20 g sulfosulfuron ha^{-1}applied at 60 DAS significantly reduced the weed density. The lowest weed densities were obtained with metribuzin at both rates and manual weeding. Higher rates of sulfosulfuron applied at 40 DAS completely controlled *M. indica* and showed excellent control of *P. minor*. The density of *P. plebeium* increased in plots treated with sulfosulfuron at 60 DAS. Sulfosulfuron was slightly toxic on wheat, especially when applied at 60 DAS. Manual weeding gave the tallest plants. The highest number of tillers was obtained with 30 g sulfosulfuron ha^{-1} applied at 40 DAS and 230 g metribuzin ha^{-1}. Ear length was lowest for 30 g sulfosulfuron/ha applied at 60 DAS. Metribuzin was generally superior to sulfosulfuron in terms of number of grains per ear. Sulfosulfuron applied at 60 (all rates) and 40 DAS (20 g ha^{-1}), 2,4-D and manual weeding registered the highest 1000-grain weight. Grain yields were highest with 20 and 25 g sulfosulfuron ha^{-1} applied at 40 DAS, 230 and 245 g metribuzin ha^{-1} applied at 40 DAS, and manual weed control. The highest net return was obtained with 20 g sulfosulfuron ha^{-1} applied at 40 DAS.

Dhiman and Rohitashav (2006) conducted a field experiment during the winter seasons of 2002-03, in Pantnagar, Uttar Pradesh, India, 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), isoproturon at 1 kg ha^{-1} at 30 DAS, clodinafop-propargyl [clodinafop] at 0.06 kg ha^{-1} at 30 DAS and weedy control) in wheat. Conventional tillage + isoproturon recorded the highest net return (Rs. 21 089 ha^{-1}), followed by strip till drill + isoproturon (Rs. 21 074 ha^{-1}), conventional tillage + hand weeding (Rs. 20 725 ha^{-1}), and zero tillage + isoproturon (Rs. 20 502 ha^{-1}). Strip till drill + isoproturon and zero tillage + isoproturon recorded the highest benefit: cost ratios of 2.09 and 2.05, respectively.

Marwat *et al.* (2005) conducted an experiment to assess the effect of various herbicides for weed control in wheat (CV(%). Kt-2000), at Barani Agriculture Research Station, Kohat, Pakistan during the rabi season of 2003-04. Treatments (kg ha^{-1}) comprised: clodinafop at 0.05, 2,4-D at 0.7, bromoxynil + MCPA at 0.49, isoproturon at 1.0, carfentrazone-ethyl [carfentrazone] at 0.02, terbutryn + triasulfuron at 0.16 and fenoxaprop-p-ethyl [fenoxaprop-P] at 0.93 kg a.i. ha^{-1} and a weedy control. The data were recorded on weed kill efficiency (%), fresh weed biomass (kg ha^{-1}), plant height (cm), spike length (cm), number of tillers m^{-2}, number of grains $spike^{-1}$, 1000-grain weight (g), biological yield (kg ha), grain yield (kg ha^{-1}) and harvest index (%). The data recorded on weed kill efficiency (%), fresh weed biomass (kg ha^{-1}), 1000-grain weight (g), biological yield (kg ha^{-1}), and grain yield (kg ha^{-1}) were significantly affected by different herbicidal treatments. Buctril [bromoxynil] M 40 EC exhibited the best performance, with maximum weed kill efficiency (47.2%) and minimum fresh weed biomass (400 kg ha^{-1}) compared to 1102 kg ha^{-1} fresh weed biomass in the weedy control. Similarly, the number of spikes (506 m^{-2}), number of grains $spike^{-1}$ (57.3), 1000-grain weight (46.6 g), biological yield (16 750 kg ha^{-1}) and grain yield (1970 kg ha^{-1}) were also highest in Buctril M 40 EC compared to the weedy control having the values of 400 m^{-2}, 50.2, 41.4 g, 10 850 kg and 1653 kg ha^{-1}, for the respective parameters.

Dheer *et al.* (2004) conducted a field experiment in Pantnagar, Uttar Pradesh, India, to study the performance of different herbicides (fluchloralin, isoproturon, metribuzin and pendimethalin) on Anagallis arvensis, Erigeron canadensis [Conyza canadensis] and Phalaris minor populations and grain yield of wheat CV (%). UP 2425. The treatment comprised: weedy (T_1); weed-free (T_2); hand weeding at 20 and 45 days after sowing (DAS; T_3); 0.5 kg fluchloralin (T_4); 1.0 kg fluchloralin (T_5); 1.0 kg isoproturon (PE; T_6); 1.0 kg isoproturon at 30 DAS (T_7); 100 g metribuzin (PE; T_8); 200 g metribuzin (PE; T_9); 0.75 kg pendimethalin (PE; T10); 1.50 kg pendimethalin (PE; T_{11}); and 0.5 kg 2,4-D ha^{-1} at 35 DAS (T_{12}). P. minor was significantly controlled by all herbicides except 2; 4-D. *A. arvensis* was not controlled in T_6 but was controlled in T_7. Weed populations were significantly reduced in T_4, T_5, T_7, T_9,

T_{10} and T_{11} treatments. Weed dry matter was higher in the weedy control (157 g m^{-2}) compared to all the herbicide treatments except in T_{12} and T_8. Higher plant height (67.10 cm) was recorded in T_2 followed by T_3 but was lower in T_4 and T_5. The highest grain yield (26.18q ha^{-1}) was recorded in T_2 and lowest in T_1 (21.72 q ha^{-1}).

A two-year study carried out by Bartolini *et al.* (2000) to investigate the sensitivity of winter wheat cultivars (Centauro, Serio, Eureka, Victo, Bilancia, Eridano, Mieti, Palio, Vaiolet, Enesco) to post-emergence treatments applying grass-killer herbicides such as tralkoxydim, clodinafop-propargil+cloquintocet-mexil, fenoxaprop-p-ethyl+mefenpyr-diethyl and fenoxaprop-p-ethyl+mefenpyr-diethyl+diclofop-methyl, mixed with fluroxypyr, fluroxypyr+clopyralid+MCPA, tribenuron-methyl, triasulfuron and amidosulfuron. The obtained results showed that all the tested herbicide mixtures were well tolerated by winter wheat cultivars. Phytotoxicity occurred occasionally, but no yield reductions were recorded.

Panwar *et al.* (2000) reported that Isoproturon applied alone @ 750 g ha^{-1}did not control wild oat, while diclofopmethyl applied alone @ 1000 g ha^{-1} was not effective against lambsquarter. Tank mixtures of herbicides were less effective than sequential treatments of broad-leaved herbicides with diclofopmethyl in reducing the population and dry weight of grassy and broad-leaved weeds. For lambsquarter control, tribenuron @ 7.5 or 2,4-D @ 250 g ha^{-1} used as tank mixture or follow up treatments proved more useful than fluoroxypyr applied @ 200 g ha^{-1}. Presence of weeds for the entire crop season reduced the grain yield of wheat by 49%.

Rapparini (2001) stated that the only new herbicides available are a new formulation of metribuzin that controls early infestations of broad-leaved species while containing common grasses, and a re-issue of clopyralid + 2,4-D + MCPA. Details are given of the activity and mode of use of the following graminicides: imazamethabenz, fenoxaprop-P, clodinafop-propargyl [clodinafop], tralkoxydim and diclofop alone or in a formulated mixture with fenoxaprop-P. For control of various dicotyledon infestations, the relative merits of a variety of herbicides, alone or formulated in combinations are considered. A table was provided showing the trade names and distributors of the herbicides discussed, with application rates and timings, the degree of toxicity and safety periods, costs, selectivity in soft and hard wheat, barley, oats and rye and the susceptibility/resistance of 31 dicotyledons and 4 common grasses.

Field studies were conducted by Rola and Goebiowska (1999) with Sekator 6.25 WG for broadleaved weed control in winter wheat. Concentrations of 150, 200, 300 g ha^{-1} were applied to winter wheat post-emergence at the tillering and shoot stage. A good level of control was observed for *Galium aparine*, *Viola arvensis*, *Stellaria media*, *Descurainia sophia* at 150-300 g ha^{-1} applied at the tillering stage, and 200-300 g ha^{-1} at the shoot stage.

Adamczewski *et al.* (1999) found that during the years 1995-98 propisochlor, which is the active ingredient of Proponit 720 EC, was tested in winter wheat and winter barley. Dicot- and monocotyledonous weed control was observed. Proponit 720 EC was applied after sowing and post-emergence at the 1-3 leaf stage and tillering stage. Control of *Avena spica-venti* was very good in both cereals and there was no difference in efficacy to Proponit 720 EC. The yield of winter wheat and winter barley was higher after the application of Proponit 720 EC at the 1-3 leaf stage.

Studies conducted by Kushwaha and Singh (2000) in wheat fields during the rabi season of 1994-95 at Uttar Pradesh, Inia, showed that two hand weeding at 30 and 60 days after sowing gave a similar crop yield to that obtained when keeping the crop free of weeds for the entire growing season (which was less economic). Chemical control methods were cheaper. Isoproturon gave a more effective level of control than 2, 4-D. Pre-emergence application of isoproturon at either reduced both grassy and non-grassy weeds and was superior to the post-emergence application of isoproturon either alone or in combination with 2,4-D.

Jiang *et al.* (1999) reported that, all herbicides studied controlled broad-leaved weeds such as *Descurainia sophia, Capsella bursa-pastoris* and *Erysimum cheiranthoides* by >90%. The use of of sulfonylurea herbicides year on year caused a shift in the weed community. At the start of the experiment dicotyledonous weeds, mainly *Descurainia sophia* were prevalent, but gradually the community was changed into a mixture of monocotyledonous and dicotyledonous weeds in which both *Bromus japonicus* and *Descurainia sophia* were dominant. The population of *Bromus japonicus* increased year after year and its density went up from 0.1-0.4 plants m^{-2} to 31.5-78.5 plants m^{-2}, while *Descurainia sophia* decreased from 78.3-176.4 plants m-2 to 33.3-53.2 plants m^{-2}.

Awan *et al.* (1999) found that two herbicides, Cheetah (Fenoxaprop-P-ethyl) and Starane2 (Fluroxypyr) were applied to the crop sown with and without artificially seeded infestations of black grass (*Alopecurus myosuroides*) and cleavers (*Galium aparine*), respectively. Protein content and SDS value both increased significantly with increase in herbicide application time.

The effect of the relative density of *B. diandrus* in a wheat crop on the efficacy of MON 37532 (Sulfosulfuron) sprayed at either the 2 or 6 leaf stage of the weed was studied in a pot experiment conducted by Agenbag and Crous (1999) in a temperature-controlled glasshouse. A density of 3 plants/pot (170 plants m^{-2}) was used for the wheat crop, while that of *B. diandrus* varied between 0 and 10 plants/pot (565 plants m^{-2}). At early applications (2-leaf stage), efficacy of MON 37532 improved with higher densities of *B. diandrus*. This was possibly due to stress conditions created by higher weed densities. This tendency was less evident when MON 37532 was applied at the 6-leaf stage. Reduced susceptibility in the older plants and less efficient wetting of weeds in pots with high weed densities were probably the reason for reduced percentage control when plants were sprayed at this stage.

Madafiglio *et al.* (1997) reported that all herbicides reduced the seed production of the two target species, some by up to 100%. Reductions in seed production of *R. raphanistrum* were less from all herbicide treatments when the stage of spraying was delayed beyond early flowering. At the rates evaluated, triasulfuron and chlorsulfuron gave the highest reductions of seed production. Yield was unaffected by most herbicides, with the exception of reductions from dicamba (44%) and 2,4-D (13%) when applied at GS 57 to 65. These experiments indicate that considerable potential exists for the management of weed populations by targeting seed production through the use of strategically-applied herbicides.

Durgan *et al.* (1997) conducted an experiment and found that the best control with an F8426 treatment was similar to control from MCPA tank mixed with thifensulfuron + tribenuron, bromoxynil, or dicamba. Weed control 30 and 45 days after treatment (DAT) was less for F8426-containing treatments than standard treatments, which was probably related to reduced crop competition after severe crop injury. Increasing the F8426 rate from 0.026 to 0.035 kg a.i. ha-1 did not greatly increase wheat injury, whereas adding 0.28 kg a.i. ha^{-1}2,4-D to either F8426 rate greatly increased crop injury. Wheat yield was reduced up to 63% by F8426 and 2,4-D combinations.

Studies conducted by Azad and Singh (1997) at the Regional Agriculture Research Farm, R.S. Pura, Jammu on clay loam soil with wheat CV(%). HD-2329 showed that post-emergence application of 100 kg N ha^{-1} and of isoproturon + 2,4-D at 0.75 + 0.5 kg ha^{-1}, respectively, 30-35 days after sowing gave highest grain yields (39.0-44.1 q ha^{-1}), control of weeds and lowest weed dry matter production (0.45-1.73 q ha^{-1} at 120 days after sowing). This treatment was equivalent to application of isoproturon + 100 kg N ha^{-1} in two or three split doses.

Panwar *et al.* (1995) reported that all herbicide treatments resulted in 93-95, 65-95, 73-90, 83-90 and 87-90% control of resp. weeds. The highest combined rate of the 2 herbicides resulted in the best overall control of the 5 weeds (90-95%) and of the total weed population at 60 d after sowing (2.62-3.36 plants/msuperscript 2, compared to 11.36-15.65 plants in the weedy control). Isoproturon + 2,4-D at 1.20 + 0.30 kg also gave good control of the 5 weeds (87-95%), and resulted in the lowest total weed population at 90 d after sowing (2.32-2.75 plants, compared to 9.51-9.62 plants). Herbicide treatments increased wheat yields from 3262 and 2817 kg/ha to 4276-4859 and 4034-4528 kg in 1990-91 and 1991-92, resp., and all combined treatments resulted in malformed ear heads (15-50 and 18-47% in resp. years).

Five herbicides were tested by Al-Zumair *et al.* (1994) for their efficacy against weeds and effects on wheat production at Ibb Farm Research Station, Ibb (Yemen). The herbicides were Basagran (bentazone), 2,4-DEB (2,4-D), Dicuran MA (chlorotoluron), Tribunil 80 (methabenzthiazuron) and Illoxan 28% (diclofop-methyl). The data revealed the superior effect of Dicuran and Basagran + 2,4-D in controlling weeds and consequently increasing yield of wheat. Tribunil also gave considerable effects in comparison with the hand weeded control.

Al-Zumair *et al.* (1994) found that a yield increase of 15-123% was obtained following herbicidal application in comparison with yield given by non-treated plots. The effectiveness of the herbicidal treatments was verified by a large scale demonstration plots during the following season. Selective herbicides such as Basagran, U-46, Dicuran and Tribunil showed successful weed control under the conditions of the Taiz area..

Deshmukh *et al.* (1995) evaluate the use of 1 kg/ha 2,4-D, 0.75 kg isoproturon, 0.75 + 0.125 kg isoproturon + 2,4-D, Isoguard Plus (isoproturon + 2,4-D at 0.75 + 0.187 and 0.5 + 0.125 kg) and hand-weeding at 35 and 25 days after sowing in wheat CV(%). AKW 1071. The dominant weeds were *Chenopodium album, Parthenium hysterophorus, Euphorbia hirta, Argemone mexicana* and *Anagallis arvensis*. Hand-weeding resulted in a weed control efficiency (WCE) of 79.82% and increased wheat grain yield from a weedy control value of 1.467 t ha^{-1} to 2.792 t. Herbicide treatment at 35 days after sowing resulted in WCE of 68.12-77.40% and grain yields of 2.184-2.721 t, the most effective treatment being Isoguard Plus at rates of 0.75 + 0.187 kg isoproturon + 2,4-D.

Alvarez *et al.* (1994) reported that a total of 324 samples were processed and showed a significant annual reduction in colony-forming units of soil fungi in herbicide-treated plots compared with untreated controls. Cellulolytic strains were affected only by metsulfuron-methyl and 2,4-D + picloram, and keratinophilic strains only by metsulfuron-methyl. Both mixtures containing dicamba also caused significant annual variations in the total mycote. The prolonged depressive effect has important implications for the restoration of imbalances in the crop-soil-mycote interactions.

An experiment was conducted by Balyan *et al.* (1993) comprising of Diclofop-methyl (0.50, 0.75 and 1.00 kg ha^{-1}), isoproturon (0.75 kg), diclofop + isoproturon (0.50 + 0.50, 0.75 + 0.25 and 0.25 + 0.75 kg), diclofop + 2,4-D (1.00 + 0.25 and 1.00 + 0.50 kg), diclofop + fluroxypyr (1.00 + 0.50 and 1.00 + 0.20 kg) or tralkoxydim (0.25 and 0.30 kg) were applied at 3 leaf stage and tillering stage to wheat CV(%). WH283, and compared to unweeded and weed-free controls in field trials at Hisar during 1990-92. Best control of Avena [sterilis subsp.] ludoviciana was obtained with 1.00 kg diclofop-methyl and 0.25 and 0.30 kg tralkoxydim when applied in 3 leaf stages, while best control of Chenopodium album (100%) was obtained with diclofop + 2,4-D when applied in 3 leaf stages. Wheat grain yields were highest (5799 kg/ha) in the weed-free control, while in herbicide-treated plots highest grain yields (5623 kg) were recorded with 0.75 kg diclofop + 0.25 kg isoproturon when herbicide applied in 3 leaf stages.

A field experiment was conducted by Kierzek and Adamczewski (2005) to evaluate the efficacy of 2,4 D + dicamba (Aminopielik D 450 SL) applied singly (at 1.5 or 3.0 litres ha^{-1}) or in combination (1.5 litre ha^{-1}) with adjuvants (RA 2003, Olbras Super 90 EC, Olbras 88 EC or Atpolan 80 EC at 1.0 litre ha^{-1}) against broadleaved weeds in winter and spring wheat. The treatments were applied in spring at the tillering stage of cereals. The mixture of 2,4 D + dicamba applied alone and with adjuvants was very effective against almost all weed species infesting wheat. The adjuvants enhanced the activity of 2,4 D + dicamba, especially against broadleaved weeds that were difficult to control, such as Viola arvensis, Papaver rhoeas, Galium aparine and Veronica hederifolia. 2,4 D + dicamba applied alone and with adjuvants was safe to winter wheat and spring wheat plants.

Hassan *et al.* (2003) studies on the integration of zero tillage and herbicides for wheat production in a rice-based cropping system were conducted during rabi 2002-03 in Dera Ismail Khan, Pakistan. Herbicide treatments showed significant differences in weed density, while tillage regimes and their interaction with herbicides showed no significant effects. The herbicide Buctril-M outyielded ($P<0.05$) Affinity and weedy control, but Affinity was statistically at par with the weedy control. The highest net benefit (Rs. 5965 ha-1) was achieved Buctril-M.

All treatments except 20 g sulfosulfuron/ha applied at 60 DAS significantly reduced the weed density. The lowest weed densities were obtained with metribuzin at both rates and manual weeding. Higher rates of sulfosulfuron applied at 40 DAS completely controlled M. indica and showed excellent control of P. minor. The density of P. plebeium increased in plots treated with sulfosulfuron at 60 DAS. Sulfosulfuron was slightly toxic on wheat, especially when applied at 60 DAS. Manual weeding gave the tallest plants. Grain yields were highest with 20 and 25 g sulfosulfuron/ha applied at 40 DAS, 230 and 245 g metribuzin/ha applied at 40 DAS, and manual weed control. The highest net return was obtained with 20 g sulfosulfuron/ha applied at 40 DAS.

The biological efficacy of herbicide Mustang (a.i. florasulam+2.4 D ester 6.25+452.5 g L^{-1}) applied at doses 0.6, 0.45, 0.3 and 0.15 l ha-1 as compared to untreated areas was evaluated by Auskalnis and Kadzys (2006) on the number and biomass of weeds in spring wheat. Herbicide was applied at the 3-leaf stage, at tilling, and at the beginning of stem elongation of cereals. The best efficacy on weed mass in all years of the experiments was achieved when the herbicide was applied at the 3-leaf stage and during the tilling stage of spring wheat. The weed biomass decreased by 82 to 92% in 2003 and 2004 and by 74-96% in 2005, from 0.3, 0.45 and 0.6 l ha-1 doses. When herbicides were applied using higher doses, 0.45-0.6 l ha^{-1}, during the spring wheat stem elongation stage (BBCH 31-32), the biomass of weeds decreased by 75-95%. When the lowest dose, 0.15 l $ha^{-1}$of the herbicide Mustang was applied at the beginning of the stem elongation stage of spring wheat, the efficacy on the total fresh mass of weeds was insufficient.

Four field trials were conducted by Bradley and Conley (2006) to evaluate the effect of imazamox rate and tank-mix combinations on winter annual broadleaf weed control and yield in imidazolinone-resistant (IR) wheat. Results from these trials indicate that timely fall applications of imazamox will provide good control of henbit and common chickweed in IR wheat, which are some of the most common winter annual broadleaf weeds encountered in many wheat production systems in the United States. No benefit in weed control was observed by increasing the imazamox rate from 35 to 44 or 53 g/ha or by the addition of a thifensulfuron plus tribenuron or 2,4-D tank-mix combination.

To assess the effect of various herbicides for weed control in wheat (CV(%). Kt-2000), an experiment was conducted by Marwat *et al.* (2005). The data recorded on weed kill efficiency (%), fresh weed biomass (kg ha^{-1}), 1000-grain weight (g), biological yield (kg ha^{-1}), and grain yield (kg ha^{-1}) were significantly affected by different herbicidal treatments. Buctril [bromoxynil] M 40 EC exhibited the best performance, with maximum weed kill efficiency (47.2%) and minimum fresh weed biomass (400 kg ha-1) compared to 1102 kg ha^{-1}fresh weed biomass in the weed control. Similarly, the number of spikes (506 m^{-2}), number of grains $spike^{-1}$ (57.3), 1000-grain weight (46.6 g), biological yield (16 750 kg ha^{-1}) and grain yield (1970 kg ha^{-1}) were also highest in Buctril M 40 EC.

A field experiment was conducted to study the effect of different herbicides on weed density and some agronomic traits of wheat. The data were recorded on weed density m^{-2}, plant height at maturity (cm), wheat spike length (cm), grains weight spike-1, 1000-grain weight (g), and grain yield (t ha^{-1}). For controlling weeds, Puma super+metribuzin proved to be the best, recording only 16.00 weeds m-1 compared to 98.75 in the control treatments. The maximum grain yield (1.51 t ha^{-1}) was recorded in Pujing+Sencor- followed by 1.343 t ha^{-1}in Puma super+Sencor-treated plots. The minimum grain yield (0.713 t ha^{-1}) was recorded in weedy control plots. The herbicide mixtures of Sencor with Pujing or Puma super are recommended for the effective management of weeds in wheat.

The experiment was carried out by Buriro *et al.* (2003) on post emergence weed control in wheat. It was noted that most of the weeds present in wheat were broad leaved weeds, whereas narrow leaved grasses and sedges were in small number. With the application of herbicides though the number of weeds of all species decreased but in most of the cases their intensity increased. All the growth, yield and yield parameters increased with the application of herbicides as compared to un-weeded plots. The additional yield (49.98%) was exhibited with the application of Topik 240 WP at 250 g ha^{-1} herbicide followed by Arelon 50 dispersion at 0.75 l ha^{-1}, which increased 43.74% grain yield. It is concluded that weeds reduce the economic yield by competing for nutrients, light and moisture. The cost and maintenance of cultivation are increased and soil fertility is degraded due to weed problem. Thus, it was prime important to control weeds and an increase in the yield up to 50% or more could be achieved.

To determine the efficacy of different herbicides for controlling weeds in wheat, an experiment was conducted by Khan *et al.* (2003) at Malkandher Research Farm, NWFP Agricultural University Peshawar, Pakistan. Treatments comprised 8 herbicides and a weedy control. The maximum grain yield (4.6 t ha^{-1}) was recorded upon treatment with Affinity 50 WDG, followed by plots treated with Buctril-M 40 EC and Logran Extra 64 WDG with grain yield of 4.2 and 4.0 t ha^{-1}, respectively. In every case herbicides are applied at 25 days after sowing. The minimum yield of 2.8 t ha^{-1} was recorded in the weedy control plots.

A field trial was conducted at regional wheat research Centre, Shyampur and Rajshahi during winter season of 2007-08 by Hossain *et al.* (2009); to select the suitable herbicide for weed control of wheat var. Prodip. Six treatment combinations i.e. Affinity @1.5 kg ha^{-1}, Hammer @ 104 ml ha^{-1}, 2-4, D Amine @ 1200 ml ha^{-1}, U 46 @1200 ml ha^{-1} at 25 day after sowing (DAS), one hand weeding at 24 DAS and control (no weeding) were considered for this study. Four major weeds namely *Chenopodium album, Cyperus rotundus, Cynodon dactylon and Vicia sativa* were observed in the experimental field. The weed population and dry weight of weeds were low with Affinity @ 1.5 kg ha^{-1} at 25 DAS and high with control plots. Among the treatments, Affinity @1.5 kg ha^{-1} at 25 DAS showed higher weed control efficiency (77.4%) which is at par with hand weeding (78.2%). Different treatments were significantly influenced grain yield and yield components of wheat. The maximum grain yield (4.28 t ha^{-1}) was obtained with Affinity @ 1.5 kg ha^{-1} at 25 DAS and hand weeding (4.35t ha^{-1}). This higher yield might be due to less weed-crop competition resulting higher absorption of nutrients and sufficient interception of sunlight as well as air circulation. The grain yield (3.93 t ha^{-1}) was found with control as anticipated. Wheat yield was found to be gradually decreased with the increase of weed populations.

An experiment was conducted by Khan *et al.* (2002) to study the efficacy of grass- and broadleaf-specific or broad-spectrum herbicides. Puma Super, Topik and their tank mixtures with the broadleaf killers resulted in an excellent control of grasses. Isoproturon was moderately effective in controlling grassy weeds, but was very weak in controlling wild oats. The broadleaf killers and their tank mixtures exhibited a remarkable control of broadleaf weeds. Isoproturon was also equally effective in controlling broadleaf weeds. The weed density was non-significant at 30 days after spray or at the time of wheat harvesting, indicating that the herbicides resulted in a successful season-long control of the target weeds. Mixing grass- and broadleaf-specific herbicides offered a synergistic control of the weeds, and is thus, recommended for effective weed management.

Olea *et al.* (2003) reported that occurrence of weed species (*Avena spp., Bromus spp., Parietaria debilis, Bowlesia incana, Hybanthus parviflorus*) and weed resistance to glyphosate herbicide in Tucuman, Argentina, are outlined. Use is discussed of a tank mixture of glyphosate and 2,4-D, as well as metsulfuron, dicamba and MCPA for pre-sowing and post-emergence weed control. Data are tabulated on characteristics and doses of 15 types of treatments, including single herbicides and mixtures of herbicides for post-emergence weed control.

Proponit 720 EC, was tested by Adamczewski *et al.* (1999) in winter wheat and winter barley. Dicot- and monocotyledonous weed control was observed. Proponit

720 EC was applied after sowing and post-emergence at the 1-3 leaf stage. Three concentrations 0.5, 0.75 and 1 l ha^{-1} were used. Control of *Avena spica-venti* was very good in both cereals and there was no difference in efficacy to Proponit 720 EC. The yield of winter wheat and winter barley was higher after the application of Proponit 720 EC.

The effect of different herbicides applied at different timings viz. 30, 45 and 60 days after sowing (DAS) of wheat crop was studied by Khan *et al.* (2003) for controlling weeds. Herbicidal treatments were Assert (Imazamethabenz-methyl) 0.30, isoproturon 1.12 kg alone and buctril-M (bromoxynil+MCPA) 0.72 kg+topik (clodinofop) 0.37 kg, logran (trisulfuron) 0.64 kg+topik (clodinofop) 0.37 kg, 2,4-D (2,4-D ester) 1.20 kg+topik (clodinofop) 0.37 kg and puma super (phenoxyprop-ethyle) 0.75 kg+2,4-D (2,4-D ester) 1.20 kg a.i. ha^{-1}. A weedy check was also included for comparison. The analysis of the data revealed significant differences among the times of application for biological yield and grain yield. Similarly significant differences were recorded for herbicidal treatments in traits like spikelets $spike^{-1}$, 1000 grains weight (g), biological yield (kg ha^{-1}) and grain yield (kg ha^{-1}). The interaction of the times of application and herbicides was significant for spikelets $spike^{-1}$ and for grain yield. Maximum number of spikelets $spike^{-1}$ and heavier 1000 grains weight was observed in plots treated with buctril-M+topik mixture, while minimum in weedy check plots. Biological and grain yield (kg ha^{-1}) were higher in plots treated with buctril-M+topik and logran extra+topik while lower biological and grain yield were in weedy check plots. Buctril-M+topik proved to be the most economical herbicides giving maximum return of Rs. 24631 ha^{-1}, if applied 45 DAS in wheat.

A field experiment was conducted by Angiras *et al.* (2008) at Palampur to standardize the dose and time of application of clodinafop propargyl as an alternative herbicide to control grassy weeds in wheat. Four doses of clodinafop-propargyl (45, 60, 75 and 90 g ha^{-1}) each at 20 and 35 DAS, isoproturon 1.0 kg ha^{-1}+ surfactant 0.1% at 20 and 35 DAS, hand weeding twice and weedy check were evaluated for weed control and grain yield of wheat. *Phalaris minor* and *Avena ludoviciana* were the most dominating grassy weeds. Clodinafop 75 g ha^{-1} at 20 and 35 DAS and 60 g ha^{-1} at 35 DAS, controlled *P. minor* effectively. Clodinafop 90 g ha^{-1} at 35 DAS gave significantly lower count of *A. ludoviciana*. Clodinafop was most effective against *Lolium temulentum* and *Poa annua* at all the doses except 45 g ha^{-1} applied at 35 DAS. In general build up of broadleaved weeds (*Vicia, Anagallis, Ranunculus* and *Coronopus*) was observed when the grassy weeds were adequately controlled with the herbicidal treatments. The application of clodinafop in general was better at 35 DAS than at 20 DAS in influencing weed control, yield and returns. Clodinafop at 75 and 90 g ha^{-1} (35 DAS) was as effective as hand weeding twice in reducing the total dry matter of weeds. Clodinafop 75 g ha^{-1} applied at 35 DAS resulted in significantly higher wheat grain yield and net return. However, MBCR (marginal benefit cost ratio) was highest for isoproturon + surfactant (20 DAS). Uncontrolled weeds reduced wheat grain yield by 49.7 per cent.

A field experiment was conducted by Verma *et al.* (2007) during the winter seasons of 2003–04 and 2004–05 to evaluate the effect of time of herbicides application on weeds in wheat under zero-tillage system. Herbicides applied after 25 days after sowing were more effective than 15 days after sowing. Sulfosulfuron (25g ha^{-1}) applied after first irrigation was most effective against the grassy and broadleaf weeds and had minimum N, P and K uptake by weeds. Isoproturoon+2, 4-D sodium salt (750+500 g ha^{-1}) was at par with metribuzin (210 g ha^{-1}), but both were significantly superior to check in reducing weed growth and nutrients uptake by weeds. Sulfosulfuron had maximum number of ear heads, grains/ear head, 1000-grain weight, grain yield and nutrients uptake by crop.

Auskalnis and Kadzys (2006) evaluated the biological efficacy of herbicide Mustang. It applied at doses 0.6, 0.45, 0.3 and 0.15 l ha^{-1}as compared to untreated areas was evaluated on the number and biomass of weeds in spring wheat in field trials at the Lithuanian Institute of Agriculture. Herbicide was applied at the 3- leaf stage, at tilling and at the beginning of stem elongation of wheat. They reported that the best efficacy on weed mass in all years of the experiments was achieved when herbicide was applied at the 3-leaf stage and during the tilling stage of spring wheat.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka-1207 to study the weed killing efficacies of herbicides as affected by application times in wheat during the period of late November, 2007 to March, 2008. Detailed of the experimental materials and methods followed in the study are presented in this chapter.

3.1. Climate and soil type of the experimental site

3.1.1. Geographical location

The location of the experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 9 meter above the sea level. The site is around the central part of Bangladesh and situated at of Dhaka city, capital of Bangladesh.

3.1.2. Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3. Climate

The climate of the experimental site was sub-tropical characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season including the month of April to September and hardly rainfall, low temperature and short day period during the Rabi season including the month of October to March. Plenty of sunshine and moderately low temperature prevailed during rabi season, which were suitable for growing of winter vegetables like cauliflower, cabbage, radish etc. in Bangladesh. The detailed record of monthly total rainfall, temperature and humidity during the period of experiment were collected from the adjacent Meteorological Department of Bangladesh (Climate division), Agargaon, Dhaka-1207 and has been presented in Appendix II.

3.1.4. Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.00-6.63 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physico-chemical properties of the soil were presented in Appendix III.

3.2 Experimental Materials

3.2.1 Planting materials

The wheat variety "Shatabdi" released by wheat research center, BARI (2004) was used as experimental planting materials. The recommended optimum growing period of the wheat variety was mid-November to mid-March. This variety had bold and white grains and was described to be adaptable to late planting.

3.2.2 Herbicide

Three different herbicides were used for the study. The name of herbicide and origin of them are presented in Table-1.

Table 1. List of the herbicide used in the experiment

Serial No.	Herbicide	Common Name	Marketed By
01.	Sencor 7 WG@ 500g ha^{-1}	Metribuzin	Bayer Crops Science
02.	Lintur 70 WG @ 250g ha^{-1}	Dicamba	Bayer Crops Science
03.	Ronstar @ 1lit ha^{-1}	Oxadiazon	Bayer Crops Science

3.3 Details of the experiment

3.3.1 Land preparation

The land was first ploughed on 14 November, 2007 by disc plough. The land then was harrowed again on 16 and 18 November to bring the soil in a good tilth condition. The final land preparation was done by disc harrow on 23 November, 2007. The land was prepared thoroughly and leveled by a ladder. Weeds and stubbles were removed from the field. The experiment was laid out on 25 November, 2007 according to the design adopted.

3.3.2 Fertilizer dose

The recommended fertilizer dose of wheat which were applied as follows:

Compost	=	8000 Kg ha^{-1}
Urea	=	180 Kg ha^{-1}
TSP	=	140 Kg ha^{-1}
MOP	=	40 Kg ha^{-1}
Gypsum	=	110 Kg ha^{-1}

The land was uniformly fertilized with TSP, MOP, Gypsum and well rotten Cowdung at the time of final land preparation. Two third of urea was applied during the final land preparation. The rest one third of urea was top dressed at first irrigation (20 DAS).

3.3.3 Treatments

Twelve treatments combinations included in the study were as follows:

1. $H_0\ T_1$
2. $H_0\ T_2$
3. $H_0\ T_3$
4. $H_1\ T_1$
5. $H_1\ T_2$
6. $H_1\ T_3$
7. $H_2\ T_1$
8. $H_2\ T_2$
9. $H_2\ T_3$
10. $H_3\ T_1$
11. $H_3\ T_2$
12. $H_3\ T_3$

Here:

$H_0\ T_1$- No Herbicide but water spray at 7 days after Sowing (DAS)

$H_0\ T_2$- No Herbicide but water spray at 14 days after Sowing (DAS)

$H_0\ T_3$- No Herbicide but water spray at 21 days after Sowing (DAS)

$H_1\ T_1$- Sencor 7 WG@ 500gha^{-1} applied at 7 days after Sowing (DAS)

$H_1\ T_2$- Sencor 7 WG@ 500g ha^{-1} applied at 14 days after Sowing (DAS)

$H_1\ T_3$- Sencor 7 WG@ 500g ha^{-1} applied at 21 days after Sowing (DAS)

$H_2\ T_1$- Lintur 70 WG @ 250g ha^{-1} applied at 7 days after Sowing (DAS)

$H_2\ T_2$- Lintur 70 WG @ 250g ha^{-1} applied at 14 days after Sowing (DAS)

$H_2\ T_3$- Lintur 70 WG @ 250g ha^{-1} applied at 21 days after Sowing (DAS)

$H_3\ T_1$- Ronstar @ 1liter ha^{-1} applied at 7 days after Sowing (DAS)

$H_3\ T_2$- Ronstar @ 1litre ha^{-1} applied at 14 days after Sowing (DAS)

H_3T_3- Ronstar @ 1liter ha^{-1} applied at 21 days after Sowing (DAS)

3.4 Crop management

3.4.1 Seed sowing date

Seeds were sown on 25 November 2007 by hand on lines, which were maintained 20 cm apart from each other.

3.4.2 Intercultural operations

3.4.2.1 Thinning

The plants were thinned to 4-5 cm distances at 15 days after sowing to maintain a uniform plant stand.

3.4.2.2 Weeding

The crop was infested with some weeds during the early stages of crop establishment. Weeding was done at 55 DAS to evaluate the efficiency of controlling weeds of treatments designed for the experimentation.

3.4.2.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done at 20 DAS and other was given at 55 DAS.

3.4.2.4 Drainage

There was a rainfall during the experimental period. Drainage channels were properly prepared to easy and quick drained out of excess water.

3.4.2.5 Plant protection measures

The crops were infested by insects and diseases. These were effectively and timely controlled by applying recommended insecticides and fungicides.

3.4.3 Harvesting and post harvest operation

Maturity of crop was determined when 80-90% of the grain became golden yellowish in color. The harvesting was done on 16th March, 2008. Five pre-selected plants per plot were isolated out of which different yield attributing data were collected and was separately harvested and bundled properly, tagged and then brought to the threshing floor. Matured plants from 1m^2 areas from every plot were also harvested at random and bundled properly, tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to maintain an approximate moisture level of 12% of seeds. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were determined and converted to ton ha^{-1}.

3.4.4 Recording of data

The following data were recorded from the experiment:

i. Plant height (cm)
ii. Dry weight plant^{-1} (g)
iii. No. of leaves plant^{-1}
iv. No. of effective tillers plant^{-1}
v. No. of un effective tillers plant^{-1}
vi. Plant population m^{-2}
vii. Average spike length(cm)
viii. Weight of spike plant^{-1}
ix. Fertile grains plant^{-1}
x. Unfertile grains plant^{-1}
xi. Weight of grain plant^{-1}
xii. Weight of straw plant^{-1} (g)
xiii. Weight of 1000 seed (g)
xiv. Grain yield (t ha^{-1})
xv. Straw yield (t ha^{-1})
xvi. Biological yield (t ha^{-1})
xvii. Harvest Index (%)
xviii. Dry weight of weed m^{-2}

3.4.5 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study was given below:

A. Wheat

a. Plant height (cm)

The height of ten plants were measured from the ground level to tip of the plants and then averaged. It was taken at 63, 70, and 77 days after sowing (DAS) and at harvest separately.

b. Dry weight plant^{-1} (g)

Five plants at different days after sowing (55 DAS, 63 DAS, 70 DAS, 77 DAS) and at harvest were collected and dried at 70° C for 24 hours. The dried samples were then those weighed and averaged.

c. No. of leaves plant^{-1}

Five plants at 70 and 77 days after sowing (DAS) were collected then the height were collected and averaged.

d. No. of effective tillers m^{-2}

Effective tiller of 1 m^2 from each plot were counted randomly at harvest.

e. No. of un effective tillers m

Un-effective tiller of 1 m^2 from each plot were counted

Plant population m^{-2}

Plant of 1 m^2 from each plot was counted randomly randomly at harvest.

f. Average spike length(cm)

Spike length were counted from ten plants and then averaged. This was taken at different days after sowing (DAS) separately.

g. Weight of spike plant^{-1}

h. At the time of harvest, from 10 plants weight of spike plant^{-1} was measured by the following formula

$$\text{Spike weight plant}^{-1}\ (\text{g}) = \frac{\text{Spike weight (g)}}{\text{Number of plants}}$$

i. Fertile grains plant^{-1}

Ten plants at harvest were collected and fertile grains were counted.

j. Unfertile grains plant^{-1}

Ten plants at harvest were collected and unfertile grains were counted.

k. Weight of grain plant^{-1}(g)

At the time of harvest, from 10 plants weight of grain plant^{-1} was measured by the following formula

$$\text{Grain weight plant}^{-1}\ (\text{g}) = \frac{\text{Grain weight (g)}}{\text{Number of plants}}$$

l. Weight of straw plant^{-1} (g)

At the time of harvest, from 10 plants weight of straw plant^{-1} was measured by the following formula

$$\text{Straw weight plant}^{-1}\ (\text{g}) = \frac{\text{Straw weight (g)}}{\text{Number of plants}}$$

m. Weight of 1000 seed (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

Grain yield (t ha^{-1})

Wheat was harvested randomly from 1 m^2 area of land in each plot. Then the seeds were threshed, cleaned and sun dried for seven days. The dried seeds were then weighed and averaged. The seed yield was recorded at 12% moisture level and converted to (t ha^{-1}).

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

Wheat was harvested randomly from 1 m^2 area of land in each plot. Then the total straw and grain was weighed. The biological yield was recorded and converted to ton/hectare.

o. Harvest Index (%)

Harvest Index was taken plot wise as per experimental treatments by the following formula

$$HI = \frac{\text{Grain yield (t ha}^{-1}\text{)}}{\text{Straw yield (t ha}^{-1}\text{) + grain yield (t ha}^{-1}\text{)}} \times 100$$

p. Dry weight of weed m^{-2}

Weeds of 1 m^2 area of land in each plot were collected at 55DAS and dried at 70° C for 24 hours. Then the dried samples were weighed.

3.4.5 Experimental design and data analysis

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. This experiment was divided into three blocks then the blocks were further sub-divided into 12 plots where different herbicides and their application times were randomly assigned. The unit plot size was 3m X 2m. Row to row distance was 20 cm and that of plot to plot was 1m. Data were analyzed by 'MSTAT'-C.

Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from present study for different crop characters, yields and other analyses have been presented and discussed in this chapter.

4.1 Plant height (cm)

4.1.1 Effect of herbicide

The effect of herbicide on the plant height of wheat was significant (Table 2).The maximum plant height at harvest was attained in the treatment H_3 (92.94 cm) and the minimum plant height of wheat plants was found in H_0 (80.45 cm) treatment.

Table 2: Herbicidal effects on plant height (cm) at different days after sowing (DAS)

Treatments	Plant height (cm)			
	63 DAS	70 DAS	77 DAS	At harvest
H_0	57.02	68.93	78.71	80.45
H_1	62.06	75.74	84.90	89.50
H_2	66.41	75.43	85.55	90.09
H_3	65.90	77.20	89.02	92.94
LSD (0.05)	1.19	2.80	2.72	1.37
CV (%)	1.06	2.46	1.77	9.14

H_0= No herbicide, H_1= Sencor 7 WG, H2= Lintur 70 WG, H_3= Ronstar

4.1.2 Effect of application time

Plant height of wheat influenced significantly by the application of different levels of planting time (Table 3). At harvest the highest plant height (91.79 cm) was obtained in treatment T_3. The lowest plant height (89.7 cm) was obtained in the T_2 treatment. 63 DAS, 70 DAS & 77 DAS also recorded similar type of results.

Table 3: Effects of time of application of herbicide on plant height (cm) at different days after sowing (DAS)

Treatments	Plant height(cm)			
	63 DAS	70 DAS	77 DAS	At harvest
T_1	63.55	76.24	84.33	90.11
T_2	64.65	75.74	86.12	89.71
T_3	65.84	76.41	89.02	91.79
LSD	1.07	2.68	2.60	1.14
CV (%)	1.06	2.46	5.77	3.97

T_1= Spray at 7 DAS, **T_2**=Spray at 14 DAS, **T_3**= Spray at 21 DAS

4.1.3 Interaction effect

Significant variation due to combinations of treatments on plant height was found in the experiment. At 63 DAS the highest plant height was recorded from the treatment H_2T_1 (69.67 cm) and it was statistically similar with the results of the treatments H_3T_3 (69.27 cm). At 70 DAS, the highest plant height was obtained from the treatment H_1T_1 (79.93 cm) and it was similar with treatments H_3T_3 (78.18 cm) and H_2T_2 (76.18 cm). Moreover the highest plant height was obtained from the treatment H_3T_3 (92.87 cm) at 77 DAS. However the highest plant height was recorded from the treatment H_3T_3 (93.63 cm) and there was no difference between the results of H_3T_1 (93.40 cm) and on the said parameter at the harvest of the crop. In all cases plots treated with no herbicide (H_0 T_1, H_0 T_2 & H_0 T_3) resulted with the lowest plant height of wheat as compared to the herbicide treated plots (Table 4). Similar result was obtained by Oad *et al.* (2007) and Marwat *et al.* (2005).

Table 4: Interaction effects of herbicides and time of application on plant height (cm) at different days after sowing

Treatments	Plant height (cm)			
	63 DAS	70 DAS	77 DAS	At harvest
$H_0 T_1$	57.87	71.27	79.37	80.21
$H_0 T_2$	53.73	66.13	79.10	82.11
$H_0 T_3$	59.47	69.40	77.67	79.03
$H_1 T_1$	62.44	79.93	83.40	89.54
$H_1 T_2$	61.07	75.61	84.50	88.35
$H_1 T_3$	62.67	76.07	86.81	90.61
H_2T_1	69.67	75.17	81.73	87.39
$H_2 T_2$	63.00	76.18	87.53	91..76
$H_2 T_3$	66.57	74.94	87.40	91.13
$H_3 T_1$	61.84	73.61	87.87	93.40
$H_3 T_2$	66.60	75.44	86.33	91.80
$H_3 T_3$	69.27	78.18	92.87	93.63
LSD (0.05)	1.13	1.74	2.16	2.10
CV (%)	1.06	2.46	1.77	2.49

$H_0 T_1$- Water spray at 7 DAS
$H_0 T_2$- Water spray at 14 DAS
$H_0 T_3$- Water spray at 21 DAS
$H_1 T_1$- Sencor applied at 7 DAS
$H_1 T_2$- Sencor applied at 14 DAS
$H_1 T_3$- Sencor applied at 21 DAS
$H_2 T_1$- Lintur applied at 7 DAS
$H_2 T_2$- Lintur applied at 14 DAS
$H_2 T_3$- Lintur applied at 21 DAS
$H_3 T_1$- Ronstar applied at 7 DAS
$H_3 T_2$- Ronstar applied at 14 DAS
$H_3 T_3$- Ronstar applied at 21 DAS

4.2 Dry weight plant^{-1}

4.2.1 Effect of herbicide

The effect of herbicide on the dry weight plant^{-1} of wheat was significant. The maximum dry weight plant^{-1}at harvest (4.19) was attained in the treatment H_3 and the minimum dry weight plant^{-1}of wheat plants (3.33) were found in H_0 treatment. At 63 DAS, 70 DAS & 77 DAS also recorded similar type of results. (Table 5)

Table 5: Herbicidal effects on dry weight plants^{-1} in different days after sowing (das) of wheat

Treatments	Dry Weight plants^{-1}				
	55 DAS	63 DAS	70 DAS	77 DAS	At harvest
H_0	1.21	1.89	2.72	2.85	3.33
H_1	1.43	2.09	2.96	3.3	3.87
H_2	1.80	2.04	2.92	3.36	3.98
H_3	1.51	2.05	3.06	3.62	4.19
LSD (0.05)	0.19	0.11	0.15	0.77	0.21
CV (%)	8.44	0.51	0.98	6.1	3.42

H_0= No herbicide, H_1= Sencor 7 WG, H2= Lintur 70 WG, H_3= Ronstar

4.2.2 Effect of application time

Dry weight plant^{-1}of wheat influenced significantly by the application of herbicides at different days. At harvest the highest dry weight plant^{-1} (4.35g) was obtained in treatment T_3. The lowest dry weight plant^{-1} (3.84g) was obtained in the T_1 treatment. At 63 DAS, 70 DAS & 77 DAS also recorded similar type of results (Table 6).

Table 6: Effects of time of application of herbicide on dry weight plants^{-1} & fresh weight plants^{-1} (g) in different days after sowing (DAS) of wheat

Treatments	Dry weight plants^{-1}				
	55 DAS	63 DAS	70 DAS	77 DAS	At harvest
T_1	1.65	2.04	2.93	3.39	3.84
T_2	1.42	2.03	2.94	3.32	4.16
T_3	1.78	2.10	3.08	3.46	4.35
LSD (0.05)	0.17	1.04	0.13	1.65	0.23
CV (%)	8.44	6.51	3.98	6.1	7.88

T_1= Spray at 7(DAS), **T_2**=Spray at 14 (DAS), **T_3**= Spray at 21(DAS)

4.2.3 Interaction effect

Wheat showed remarkable variations on dry weight per plant at different days after sowing (DAS) under different treatments. At 55 DAS the highest dry weight (2.11g) per dry plant was recorded from the treatment H_2 T_3 (Table 8) and it was statistically similar to all other treatments except H_0 T_2. The lowest dry weight was found with treatment H_0 T_2 (1.06 g). At 63 DAS the maximum value was recorded from the treatment H_1 T_1 (2.19 g) and that of the lowest was found from the treatment H_0 T_2 (1.86 g) though there was no significant variations among the treatments. At 70 DAS the maximum dry weight plant^{-1} (3.32 g) was recorded from the H_2 T_3 treated plot and the result was similar to all other treatments. The lowest dry weight was found in case of treatment H_0 T_2 (2.60 g). However, the significantly superior result was shown by H_3 T_3 treated stands as recorded at 77 DAS and at harvest. There were no significant differences found between H_3T_3 (4.37) and H_3T_2 (4.18) treatments on the said parameter. From the beginning to the harvest of the data recording interval of the experiment, the plots treated with no herbicide showed poorest performance in accumulating dry matter plant^{-1} (Table 7). The similar result was obtained from Smeia *et al.* (2005).

Table 7: Interaction effects of herbicides and time of application of dry weight per plant (g) in different days after sowing (DAS) of wheat

Treatments	Dry weight plant^{-1}				
	55 DAS	63 DAS	70 DAS	77 DAS	At harvest
$H_0 T_1$	1.28	1.96	2.74	2.86	3.40
$H_0 T_2$	1.06	1.86	2.60	2.75	3.11
$H_0 T_3$	1.27	1.86	2.82	2.93	3.49
$H_1 T_1$	1.65	2.19	3.27	3.46	3.87
$H_1 T_2$	1.31	2.02	2.97	3.23	3.91
$H_1 T_3$	1.35	2.05	2.64	3.21	3.83
H_2T_1	1.95	2.02	2.68	3.15	3.92
$H_2 T_2$	1.36	2.02	2.78	3.45	4.08
$H_2 T_3$	2.11	2.07	3.32	3.49	3.94
$H_3 T_1$	1.36	1.93	2.84	3.57	4.02
$H_3 T_2$	1.29	2.04	3.07	3.61	4.18
$H_3 T_3$	1.88	2.18	3.29	3.67	4.37
LSD (0.05)	0.93	1.10	0.99	0.71	1.02
CV (%)	8.44	6.51	3.98	6.1	5.15

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.3 No. of leaves plant^{-1}

4.3.1 Effect of herbicide

The maximum number of leaves plant^{-1} at 70 DAS (5.82) was attained in the treatment H_3 and the minimum number of leaves plant^{-1}of wheat plants (4.49) was found in H_0 treatment. At 77 DAS the maximum no. of leaves plant^{-1} (4.98) was attained in the treatment H_3 and the minimum no. of leaves plant^{-1}of wheat plants (4.23) was found in H_0 treatment (Table 8).

Table 8: Herbicidal effects on no. of leaves plant^{-1}, plant population m^{-2}, no. of effective tillers m^{-2} & no of ineffective tillers m^{-2} at different days after sowing

Treatments	No. of leaves plants^{-1}		Plant population m^{-2}	No. of effective tillers m^{-2}	No. of ineffective tillers m^{-2}
	70 DAS	77 DAS	At harvest	At harvest	At harvest
H_0	4.49	4.23	1628	1530	98
H_1	5.36	4.80	1752	1701	51
H_2	5.57	4.79	2045	1981	64
H_3	5.82	4.98	1957	1938	45
LSD(0.05)	0.63	0.46	13.57	12.37	8.46
CV (%)	6.23	5.12	4.26	5.91	10.82

H_0= No herbicide, H_1= Sencor 7 WG, H2= Lintur 70 WG, H_3= Ronstar

4.3.2 Effect of application time

The maximum no. of leaves plant^{-1}at 70 DAS (5.90) was attained in the treatment T_3 and the minimum no. of leaves plant^{-1}of wheat plants (5.23) was found in T_1 treatment. At 77 DAS the maximum no. of leaves plant^{-1} (5.18) was attained in the treatment T_1 and the minimum no. of leaves plant^{-1}of wheat plants (4.69) was found in T_2 treatment. (Table 9)

Table 9: Effects of time of application of herbicide on no. of leaves plant^{-1}, plant population m^{-2}, no. of effective tiller m^{-2} & no. of ineffective tiller m^{-2} at different days after sowing

Treatments	No. of leaves plants^{-1}		Plant population m^{-2}	No. of effective tillers m^{-2}	No. of ineffective tillers m^{-2}
	70 DAS	77 DAS	At harvest	At harvest	At harvest
T_1	5.23	5.18	1844	1788	56
T_2	5.62	4.69	1904	1842	62
T_3	5.90	4.76	1970	1926	44
LSD (0.05)	0.51	0.34	23.45	15.19	8.34
CV (%)	6.23	5.12	4.26	6.71	14.82

T_1= Spray at 7(DAS), **T_2**=Spray at 14 (DAS), **T_3**= Spray at 21(DAS)

4.3.3 Interaction effect

Leaves plant^{-1} is an indicator of healthy plant. In this experiment, the crop showed variation on the no. of leaves plant^{-1} at different days after sowing (DAS) under different treatments. In the case of 70 DAS, the highest leaf per plant was recorded from the treatment H_3T_3 (6.19) (Figure 1). The lowest leaf per plant was found in H_0T_2 and the value is 4.13 (Figure 1). The rest treatment shows average results. At 77 DAS, the highest leaf per plant was obtained from the treatment H_1T_1 (5.33). The lowest leaf per plant was found in case of treatment H_0T_2 (4.23) and it was followed by treatment H_0T_1 (4.34). (Figure 1)

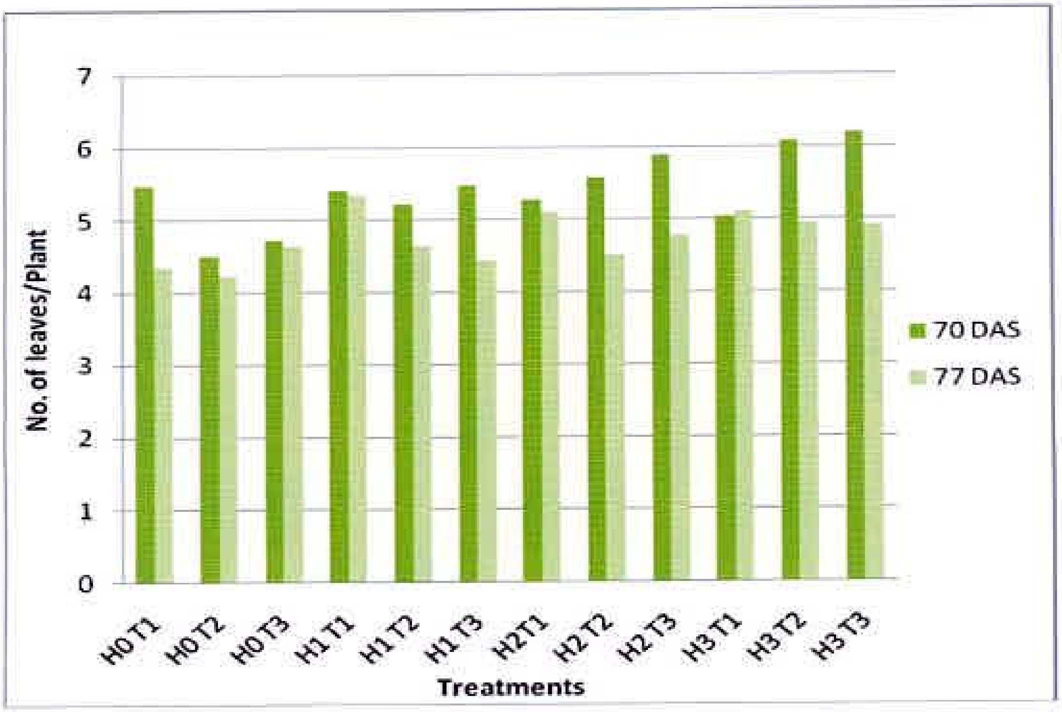

Figure 1: Interaction effects of herbicides and time of application on no. of leaves per plant in different DAS ($LSD_{0.05}$ = 0.56 & 0.40)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.4 Number of effective tillers m^{-2}

4.4.1 Effect of herbicide

The effect of herbicide on number of effective tillers m^{-2} of wheat was significant. The maximum number of effective tiller m^{-2} at harvest (1981) was attained in the treatment H_2 and the minimum (1530) was found in H_0 treatment (Table 8).

4.4.2 Effect of application time

Number of effective tillers m^{-2} of wheat influenced significantly by the application of different levels of planting time. At harvest the highest number of effective tillers m^{-2} (1926) was obtained in treatment T_3. The lowest number of effective tiller m^{-2} (1788) was obtained in the T_1 treatment (Table 9).

4.4.3 Interaction effect

The number of effective tillers is an important yield component of wheat. The highest number of effective tillers at harvest was found from the treatment H_3T_3 (2001), which at par to the treatment H_2T_3 (1992) (Table 10). The lowest no. of effective tiller was found from the treatment H_0T (1475).

From this result it can be concluded that in respect of no. of effective tiller m^{-2} H_3T_3 treatment appeared with less no. of effective tiller m^{-2}. The worst treatment was H_0 which attained with the highest no. of effective tillers m^{-2} area of land.

4.5 Number of ineffective tillers m^{-2}

4.5.1 Effect of herbicide

The effect of herbicide on number of ineffective tillers m^{-2} of wheat was significant. The maximum number of ineffective tillers m^{-2} at harvest (98) was attained in the treatment H_0 and the minimum (45) was found in H_3 treatment (Table 8).

4.5.2 Effect of application time

Number of ineffective tillers m^{-2} of wheat influenced significantly by the application of different levels of application time. At harvest the highest number of ineffective tillers m^{-2} (62) was obtained in treatment T_2. The lowest number of ineffective tillers m^{-2} (44) was obtained in the T_3 treatment (Table 9).

4.5.3 Interaction effect

The number of ineffective tillers is an important character in respect of grain yield of wheat. The highest number of ineffective tillers at harvesting period was found from the treatment H_0T_3 (103) that was at par to the treatment H_0T_2 (99). And the lowest no. of ineffective tillers was found from the treatment H_3T_3 (37) which was similar to the treatment H_3T_2 (40) (Table 10).

From this result it can be concluded that in respect of no. of ineffective tiller m^{-2} the best treatment was treatment H_3T_3 treatment was best in terms of lowest no. of ineffective tiller. The worst treatment was treatment H_0 which had highest no. of ineffective tiller.

4.6 Plant population m^{-2}

4.6.1 Effect of herbicide

The effect of herbicide on plant population m^{-2} of wheat was significant. The maximum plant population m^{-2} at harvest (2045) was attained in the treatment H_2 and the minimum plant population of wheat plants (1628) was found in H_0 treatment (Table 8).

4.6.2 Effect of application time

Plant population m^{-2} of wheat influenced significantly by the application of different levels of application time. At harvest the highest plant population m^{-2} (1970) was obtained in treatment T_3. The lowest plant population m^{-2} (1844) was obtained in the T_1 treatment (Table 9).

4.6.3 Interaction effect

Plant population is a good index of yield parameter. From the Table 10, it was found that the treatment H_2T_2 showed the highest plant population (2054) at harvest which was followed by the treatments H_2T_3 (2041) and H_3T_3 (2038). The lowest plant population was found from the treatment H_0T_2 (1574).).

Table 10: Interaction effects of herbicides and time of application of treatments on plant population m^{-2}, no. of effective tillers m^{-2} and no. of ineffective tillers m^{-2} in wheat

Treatment	Plant population m^{-2}	No of effective tillers m^{-2}	No of ineffective tillers m^{-2}
$H_0 T_1$	1630	1536	94
$H_0 T_2$	1574	1475	99
$H_0 T_3$	1682	1579	103
$H_1 T_1$	1829	1781	48
$H_1 T_2$	1725	1669	56
$H_1 T_3$	1702	1653	49
H_2T_1	1929	1873	56
$H_2 T_2$	2054	1967	87
$H_2 T_3$	2041	1992	49
$H_3 T_1$	1901	1844	57
$H_3 T_2$	1934	1894	40
$H_3 T_3$	2038	2001	37
LSD(0.05)	33.51	5.40	13.44
CV (%)	4.26	14.8	17.4

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.7 Spike length

4.7.1 Effect of herbicide

The effect of herbicide on the spike length of wheat was significant. The maximum spike length at harvest (14.57 cm) was attained in the treatment H_3 that was similar to H_2 and the minimum spike length of wheat plants (12.46cm) was found in H_0 treatment. At 70 DAS & 77 DAS also recorded similar type of results. (Table 11)

Table 11: Herbicidal effects on spike length (cm), fertile grain plants^{-1} and unfertile grain plants^{-1} in different days after sowing of wheat

Treatment	Spike length (cm)			Fertile grain plants^{-1}	Unfertile grains plants^{-1}
	70 DAS	77 DAS	At harvest	At harvest	At harvest
H_0	9.75	12.15	12.46	35	22
H_1	10.60	12.72	14.18	40	17
H_2	10.92	13.65	14.35	42	16
H_3	11.42	13.60	14.57	45	14
LSD(0.05)	1.10	1.08	0.87	27.45	6.21
CV (%)	5.9	4.23	3.6	8.47	4.29

H_0= No herbicide, H_1= Sencor 7 WG, H2= Lintur 70 WG, H_3= Ronstar

4.7.2 Effect of application time

Spike length of wheat influenced significantly by the application of different levels of application time. At harvest the highest spike length (14.90cm) was obtained in treatment T_2. The lowest spike length (14.18 cm) was obtained in the T_1 treatment. At 70 DAS & 77 DAS also recorded similar type of results (Table 12).

Table 12: Effects of application time of herbicide on spike length (cm), fertile grain plants^{-1} & unfertile grain plants^{-1} in different days after sowing of wheat

Treatment	Spike length (Cm)			Fertile grain plants^{-1}	Unfertile grain plants^{-1}
	70 DAS	77 DAS	At harvest	At harvest	At harvest
T_1	10.61	12.82	14.18	40	17
T_2	11.39	13.42	14.90	43	16
T_3	11.06	13.32	14.36	44	14
LSD (0.05)	0.96	0.75	0.21	1.33	6.09
CV (%)	4.23	3.6	4.95	8.47	4.29

T_1= Spray at 7(DAS), **T_2**=Spray at 14 (DAS), **T_3**= Spray at 21(DAS)

4.7.3 Interaction effect

Spike length is an important parameter of yield in wheat. In this experiment, the crop showed notable variation on spike length. At 70 DAS the highest spike length was obtained from the treatment H_3T_2 (11.96 cm) (Table 13) and that was statistically similar with those of the treatments H_2T_2 (11.76 cm) and H_3T_3 (11.61 cm) (Table 13). The lowest spike length was found in the treatment H_0T_2 (9.61 cm). The rest treatment showed similar results. At 77 DAS, the highest spike length was recorded from the treatment H_2T_3 (13.93 cm). The lowest spike length was found in case of treatment H_0T_2 (11.79 cm). At harvest the highest spike length was found from the treatment H_3T_2 (15.07 cm) and it was similar with the treatment H_2T_2 (15.00 cm). The lowest spike length was found in the H_0T_2 (12.03 cm) which was similar about to treatment H_0T_1 (12.37 cm) (Table 13). The result obtained from the present study was similar with the findings of Marwat *et al.* (2005) and Gul *et al.* (2005).

Table 13: Interaction effects of herbicides and time of application of treatments on spike length in different days after sowing and at harvest

Treatments	Spike length (Cm)		
	70 DAS	77 DAS	At Harvest
H_0 T_1	9.81	12.27	12.37
H_0 T_2	9.61	11.79	12.03
H_0 T_3	9.83	12.40	12.97
H_1 T_1	10.54	12.77	14.27
H_1 T_2	10.45	12.37	14.63
H_1 T_3	10.80	13.03	13.65
H_2T_1	10.39	13.00	14.50
H_2 T_2	11.76	14.17	15.00
H_2 T_3	10.77	13.93	13.93
H_3 T_1	10.90	12.70	13.77
H_3 T_2	11.96	13.73	15.07
H_3 T_3	11.61	12.98	14.53
LSD (0.05)	1.17	1.10	1.66
CV (%)	1.56	2.46	2.49

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.8 Weight of spike plant^{-1}

4.8.1 Effect of herbicide

The effect of herbicide on the weight of spike plant^{-1}of wheat was significant. The maximum weight of spike plant^{-1}at harvest (2.99g) was attained in the treatment H_3 and the minimum weight of spike plant^{-1}of wheat plants (2.12) was found in H_0 treatment (Table 14).

Table 14: Herbicidal effects on weight of spike plants^{-1} ,weight of grains plants^{-1} , weight of straw plants^{-1} , biological yield ,grain yield , weight of 1000seeds & dry weight of weeds m^{-2} in different days after sowing of wheat

Treatments	Weight of spike plants^{-1} (g)	Weight of grains plants^{-1} (g)	Weight of straw plants^{-1} (g)	Biological yield t ha^{-1}	Grain yield t ha^{-1}	Weight of 1000 seeds (g)	Dry weight of weeds m^{-2} (g)
	At Harvest						55 DAS
H_0	2.12	1.71	1.50	4.5	1.62	38.17	12.66
H_1	2.84	2.09	1.78	6.3	2.65	42.69	5.09
H_2	2.91	2.11	1.85	6.7	3.01	43.33	3.94
H_3	2.99	2.23	1.90	7.0	3.16	47.48	2.52
LSD(0.05)	0.35	0.88	0.73	0.25	0.20	7.63	1.22
CV (%)	6.41	5.28	5.27	8.41	6.65	9.27	76.11

H_0= No herbicide, H_1= Sencor 7 WG, H2= Lintur 70 WG, H_3= Ronstar

4.8.2 Effect of application time

Weight of spike plant^{-1}of wheat not influenced significantly by the application of different levels of application time. At harvest the maximum weight of spike plant^{-1} (2.98g) was obtained in treatment T_2. The minimum weight of spike plant^{-1} (2.83g) was obtained in the T_1 treatment (Table 15).

Table 15: Effects of application time of herbicide on weight of spike plants^{-1}, weight of grains plants^{-1}, weight of straw plants^{-1}, biological yield, grain yield, weight of 1000 seeds & dry weight of weeds m^{-2} in different DAS of wheat

Treatments	Weight of spike plants^{-1} (g)	Weight of grains plants^{-1} (g)	Weight of straw plants^{-1} (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Weight of 1000 seeds (g)	Dry weight of weeds m^{-2}
	At Harvest						55 DAS
T_1	2.83	2.12	1.82	6.4	2.70	41.67	6.24
T_2	2.95	2.18	1.87	6.7	2.92	43.72	4.95
T_3	2.98	2.26	1.96	6.9	3.09	45.87	3.04
LSD(0.05)	1.23	0.76	0.61	0.19	0.14	1.51	0.61
CV (%)	6.41	5.28	5.27	8.41	6.65	9.27	76.11

T_1= Spray at 7(DAS), **T_2**=Spray at 14 (DAS), **T_3**= Spray at 21(DAS)

4.8.3 Interaction effect

The weight of spike plant^{-1} is an important determinant of grain yield of wheat. According to the (Figure 2), it can be shown that, the highest weight of spike plant^{-1}at harvest was found from the treatment H_3T_3 (3.09 g) which was similar to the treatment H_3T_2 (2.96 g), H_3T_1, and H_1T_3 (2.91 g). The lowest weight of spike plant^{-1} was found from the treatment H_0T_2 (2.03 g) which was followed by the treatment H_0T_1 (2.41 g) (Figure 2).

From this result it can be concluded that, the best treatment was H_3T_3 in respect of spike weight plant^{-1}

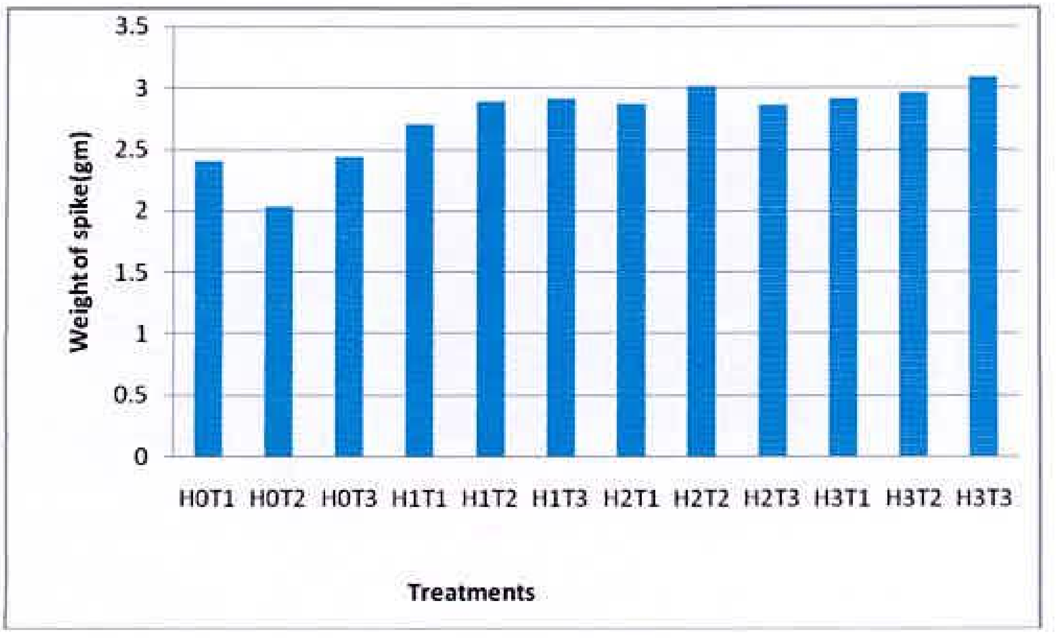

Figure 2: Interaction effects of herbicides and time of application on weight per spike at harvest of wheat ($LSD_{0.05}$=0.47)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.9 Fertile grains plant^{-1}

4.9.1 Effect of herbicide

The effect of herbicide on the fertile grains plant^{-1} of wheat was significant. The maximum weight of fertile grains plant^{-1} at harvest (45) was attained in the treatment H_3 and the minimum fertile grains plant^{-1} of wheat (35) was found in H_0 treatment (Table 14).

4.9.2 Effect of application time

Fertile grains plant^{-1} of wheat influenced significantly by the application of different levels of application time. At harvest the maximum fertile grains plant^{-1} (44) was obtained in treatment T_3. The minimum fertile grains plant^{-1} (40) was obtained in the T_1 treatment (Table 15).

4.9.3 Interaction effect

The fertile grain per m^{-2} plant is an important component of grain in yield of wheat. The highest numbers of fertile grains per plant at harvest was found from the treatment H_3T_2 (45.3) and it was followed by the treatment H_3T_3 (44.9) and H_2T_3 (42.6) (Figure 4.). Similarly the lowest fertile grains per plant were found from the treatment H_0T_1 (35.27) which were followed by the treatment H_0T_3 (37.04) (Figure 3). From this result it can be concluded that in respect of fertile grains per plant, the best combination of treatments was H_3T_2, which resulted with highest fertile grain. The worst treatment was no herbicide treated plots which had lowest no. of fertile grain m^{-2} (figure 3).

4.10 Unfertile grain plant^{-1}

4.10.1 Effect of herbicide

The effect of herbicide on the unfertile grains plant^{-1} of wheat was significant. The maximum unfertile grains plant^{-1} at harvest (22) was attained in the treatment H_0 and the minimum unfertile grains plant^{-1} of wheat plants (14) was found in H_3 treatment (Table 14).

4.10.2 Effect of application time

Unfertile grains plant^{-1} of wheat influenced significantly by the application of different levels of application time. At harvest the maximum unfertile grains plant^{-1}

(17) was obtained in treatment T_1. The minimum unfertile grains plant^{-1} (14) was obtained in the T_3 treatment (Table 15).

4.10.3 Interaction effect

The unfertile grains plant^{-1} is one of the important yield contributing characters of wheat. The highest unfertile grains plant^{-1} was found from the treatment H_0T_1 (22.15) it was followed by the treatment H_0T_3 (21.67) at harvest. (Figure 4) .And the lowest unfertile grain plant $^{-1}$ was found from the treatment H_3T_3 (12.65) which was followed by the treatment H_2T_3 (14.28). From this result it can be concluded that in respect of unfertile grain plant^{-1} the best treatment was H_3T_3 which had lowest unfertile grain. The worst treatment was H_0, (No Herbicide) which had highest no. of unfertile grains.

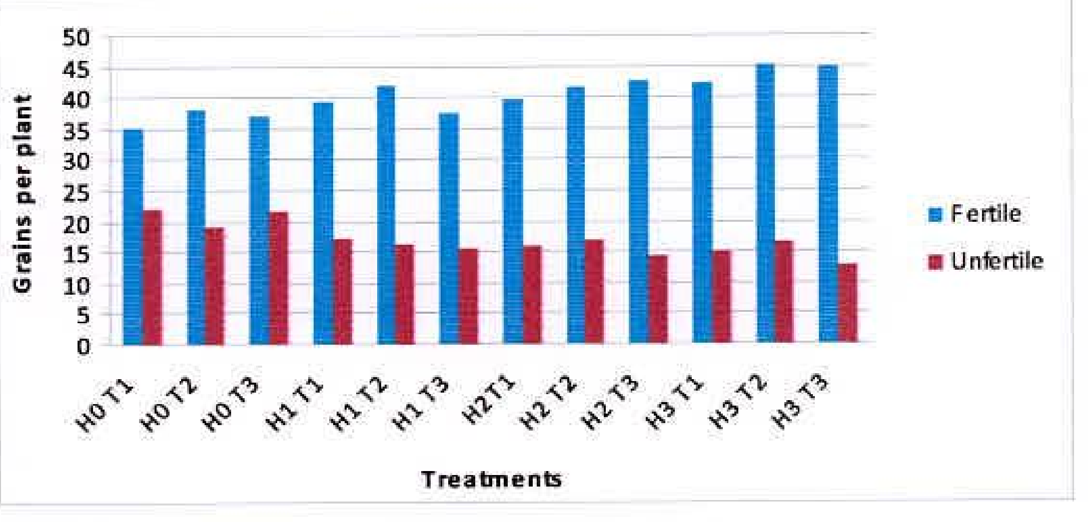

Figure 3: No. of fertile and unfertile grains per plant at harvest of wheat ($LSD_{0.05}$= 2.47 &1.29)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.11 Weight of grain plant^{-1}

4.11.1 Effect of herbicide

The effect of herbicide on the weight of grains plant^{-1} of wheat was significant. The maximum weight of grains plant^{-1} at harvest (2.23g) was attained in the treatment H_3 and the minimum weight of grains plant^{-1} of wheat plants (1.77g) was found in H_0 treatment. (Table 14).

4.11.2 Effect of application time

Weight of grains plant^{-1} of wheat influenced significantly by the application of different levels of application time. At harvest the highest weight of grains plant^{-1} (2.26g) was obtained in treatment T_3. The lowest weight of grains plant^{-1} (2.12) was obtained in the T_1 treatment (Table 15).

4.11.3 Interaction effect

The weight of grains per plant is an important character contributing yield of wheat. The highest value of this parameters at harvest was found from the treatment H_3T_3 (2.34g), which was statistically similar to the treatment H_3T_2 (2.21g) and H_2T_2 (2.19g). Moreover, the lowest weight of grains per plant was found from the treatment H_0T_2 (1.57 g) which was followed by the treatment H_0T (1.85 g) (Figure 5).

From this result it can be concluded that, in respect of weight of grain/ plant the best treatment was H_3T_3 which resulted with highest weight of grain. Contrary to that, the worst treatment was no herbicide treated plot which had lowest weight of grain.

4.12 Weight of straw plant^{-1}

4.12.1 Effect of herbicide

The effect of herbicide on the weight of straw plant^{-1} of wheat was significant. The maximum weight of straw plant^{-1} at harvest (1.90g) was attained in the treatment H_3 and the minimum weight of straw plant^{-1} of wheat plants (1.52g) was found in H_0 treatment (Table 14).

4.12.2 Effect of application time

Weight of straw plant^{-1} of wheat influenced significantly by the application of different levels of application time. At harvest the highest weight of straw plant^{-1} (1.96g) was obtained in treatment T_3. The lowest weight of straw plant^{-1} (1.82) was obtained in the T_1 treatment (Table 15).

4.12.3 Interaction effect

The weight of straw per plant is also a key point contributing yield of wheat. H_3T_3 (2.03g) resulted with highest straw weight plant^{-1} at harvest and that was similar to H_3T_2 (1.97g) and H_2T_2 (1.89) (Figure 4). The lowest weight of straw per plant was found from the treatment H_0T_2 (1.44) which was followed by the treatment H_0T_1 (1.55).

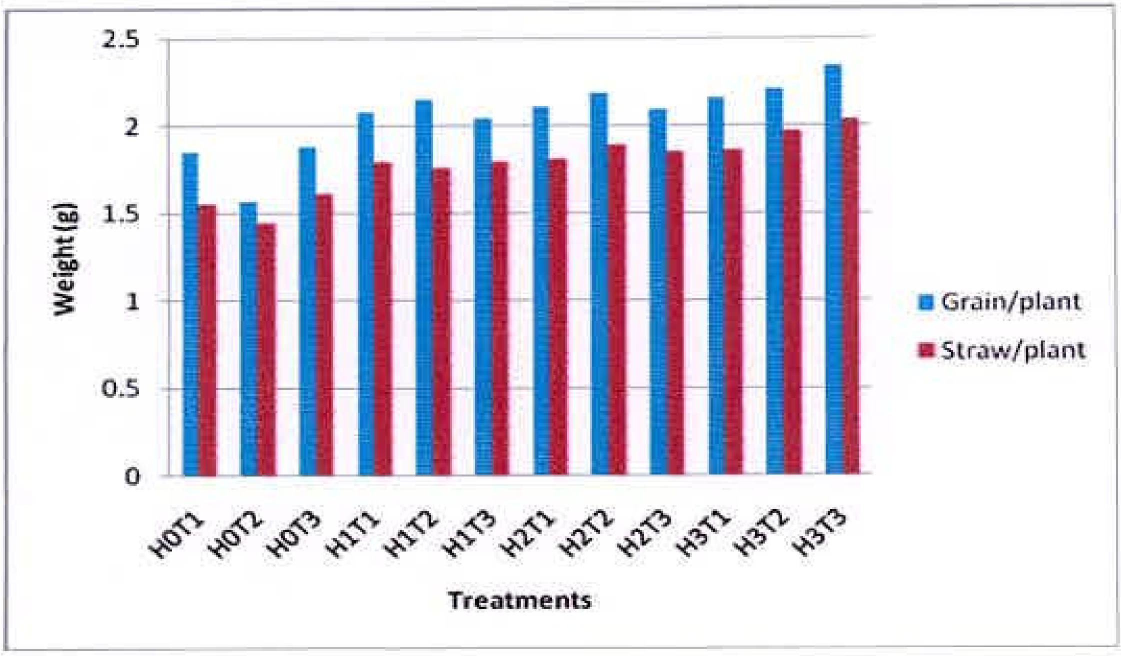

Figure 4: Straw and grain weight per plant at harvest of wheat ($LSD_{0.05}$ = 2.47 & 1.29)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.13 Weight of 1000 seeds (g)

4.13.1 Effect of herbicide

The effect of herbicide on the weight of 1000 seeds of wheat was significant. The maximum weight of 1000 seeds at harvest (47.48g) was attained in the treatment H_3 and the minimum weight of 1000 seeds of wheat plants (38.17g) was found in H_0 treatment (Table 14).

4.13.2 Effect of application time

Weight of 1000 seeds of wheat influenced significantly by the application of different levels of application time. At harvest the highest weight of 1000 seeds (45.87g) was obtained in treatment T_3. The lowest weight of 1000 seeds (41.67g) was obtained in the T_1 treatment (Table 15).

4.13.3 Interaction effect

Different herbicidal treatments significantly affected 1000 grains weight. The highest thousand seeds weight was recorded from the treatment H_3 T_1 (48.85 g) at harvest and it was similar with H_3 T_3 (47.17 g). The lowest thousand seeds weight was observed from the treatment H_0T_2 (37.52g) which was followed by the treatment H_0 T_3 (40.08 g) (Figure 5). Similar result also reported by Khan *et al.* (2003). Increasing 1000 grains weight with the use of herbicides are the similar results reported by Marinkovic *et al.* (1997)

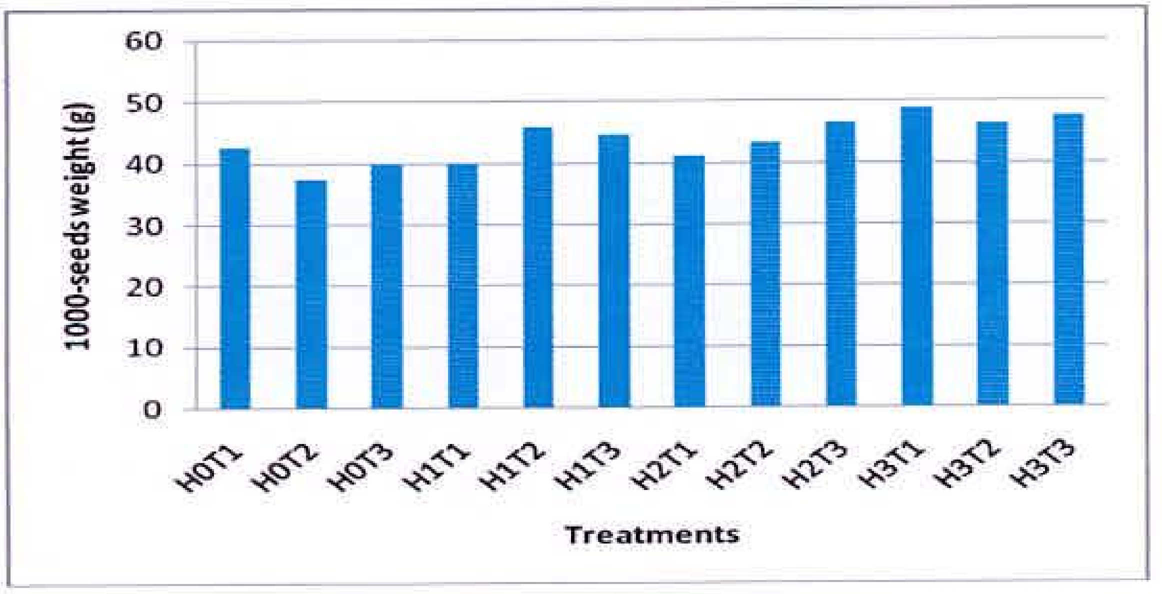

Figure 5: 1000 seeds weight (g) as affected by herbicidal treatment ($LSD_{0.05}$=2.43)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.14 Grain yield (t ha^{-1})

4.14.1 Effect of herbicide

The effect of herbicide on grain yield of wheat was significant. The maximum grain yield at harvest (3.16 t ha^{-1}) was attained in the treatment H_3 and the minimum grain yield (1.62 t ha^{-1}) was found in H_0 treatment (Table 14).

4.14.2 Effect of application time

Grain yield of wheat influenced significantly by the application of different levels of application time. At harvest the highest grain yield (3.09 t ha^{-1}) was obtained in treatment T_3. The lowest grain yield (2.70 t ha^{-1}) was obtained in the T_1 treatment (Table 15).

4.14.3 Interaction effect

Statistical analysis of the data indicated that, herbicidal treatment at different days after sowing had significant effect on the grain yield of wheat. The highest grain yield was recorded from H_3T_3 (3.37 t ha^{-1}).Which followed with non-significant variation among H_3T_2 (3.13 t ha^{-1}), H_2T_3 (3.07 t ha^{-1}) and H_2T_2 (3.01 t ha^{-1}) (Figure 7). The lowest yield performance was found at the plots treated with no herbicides. That is, H_0T_2 (1.81 t ha^{-1}) which was followed by the treatment H_0T_1 (1.89 t ha^{-1}) and H_0T_3 (1.91 t ha^{-1}) showed lowest yield (Figure 6).

However, the present study revealed that, grain yield increased with herbicidal treatments. Due to application of herbicide, the crop experienced lower level of competition for growth factors. As such, grain yield increased in relation to this effect. Similar results were reported by Verma and Sirvastava (1989). Significantly lowest yield were obtained from unwedded plot. Similar results were also reported by Holm *et al.* (2000) and Khan *et al.* ; (2003) Panwar *et al.* (2000) reported that presence of weeds for the entire crop season reduced the grain yield of wheat by 49%.

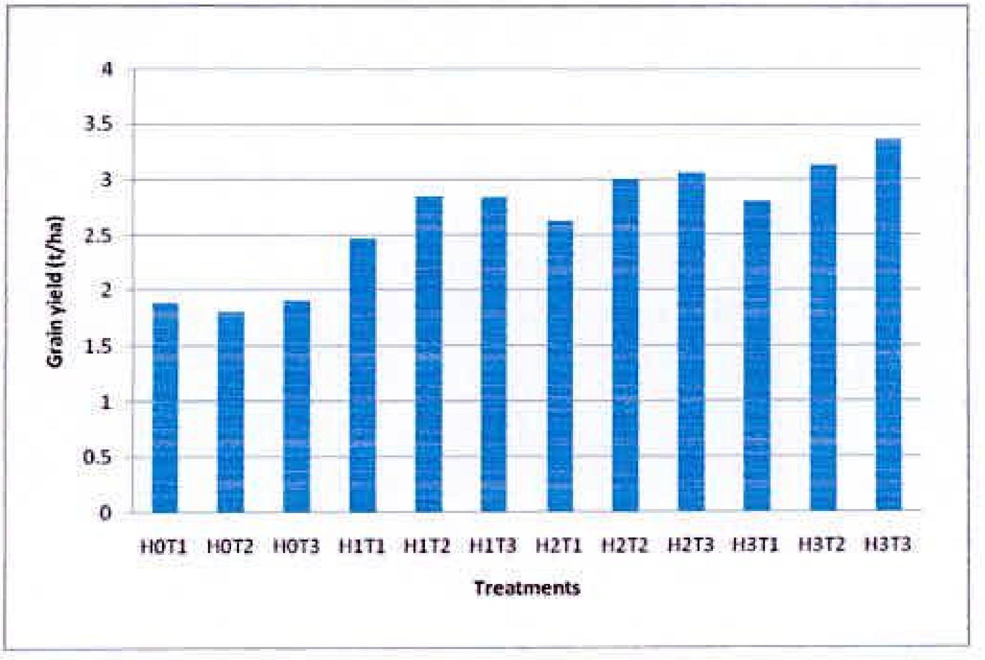

Figure 6: Interaction effects of herbicides and time of application on grain yield of wheat ($LSD_{0.05}$=0.92)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.15 Biological yield (t ha^{-1})

4.15.1 Effect of herbicide

The effect of herbicide on biological yield of wheat was significant. The maximum biological yield at harvest (7.0 t ha^{-1}) was attained in the treatment H_3 and the minimum biological yield of wheat plants (4.5 t ha^{-1}) was found in H_0 treatment (Table 14).

4.15.2 Effect of application time

Biological yield of wheat influenced significantly by the application of different levels of application time. At harvest the highest biological yield (6.9 t ha^{-1}) was obtained in treatment T_3. The lowest biological yield (6.4 t ha^{-1}) was obtained in the T_1 treatment (Table 15).

4.15.3 Interaction effect

The biological yield responded significantly with herbicidal treatments. The highest biological yield was found from the treatment H_3T_3 (7.3 t ha^{-1}). The second highest biological yield recorded from H_3T_2 (7.2 t ha^{-1}), which was not significantly different from H_3T_3 (7.3 t ha^{-1}). The lowest biological yield was found from the treatment H_0T_2 (4.8 t) which was followed by the treatment H_0T_1 (5.19 t) (Figure 7).

The study revealed that the presence of weed with their interference was severe in the plots with no herbicides. As such, the biological yield reduced to minimum in compare to the plots treated with herbicides. Similar findings also reported by Khan *et al.*(2003), Samar *et al.* (1993) and Sharma *et al* (1999). They reported that herbicides applied at 25 DAS reduced weed dry matter and increased grain and straw yield over control.

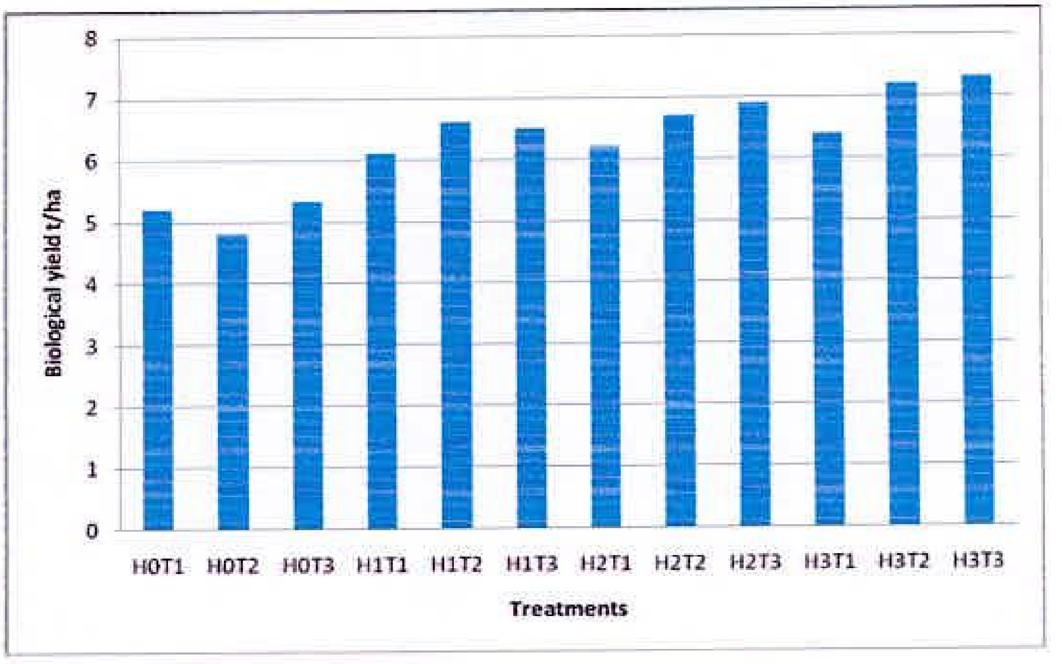

Figure 7: Effect of application times of herbicides on the biological yield (t ha^{-1}) of wheat ($LSD_{0.05}$=1.61)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.16 Harvest index (%)

Harvest index was significantly affected by different herbicide application at different application time (Figure 8). It was observed that the highest harvest index (46.16%) was shown in the treatment H_3T_3 which was statistically similar with H_2T_2 (44.92%) and H_2T_3 (44.49%) (Figure 8). On the other hand the lowest harvest index (35.80%) was observed in treatment H_0T_3which was statistically similar to H_0T_1 (36.38%). (Figure 8). The result obtained from the rest of the treatment showed intermediate result which was significantly different from all other treatments. Similar result was also found by Sujoy *et al.* (2006).

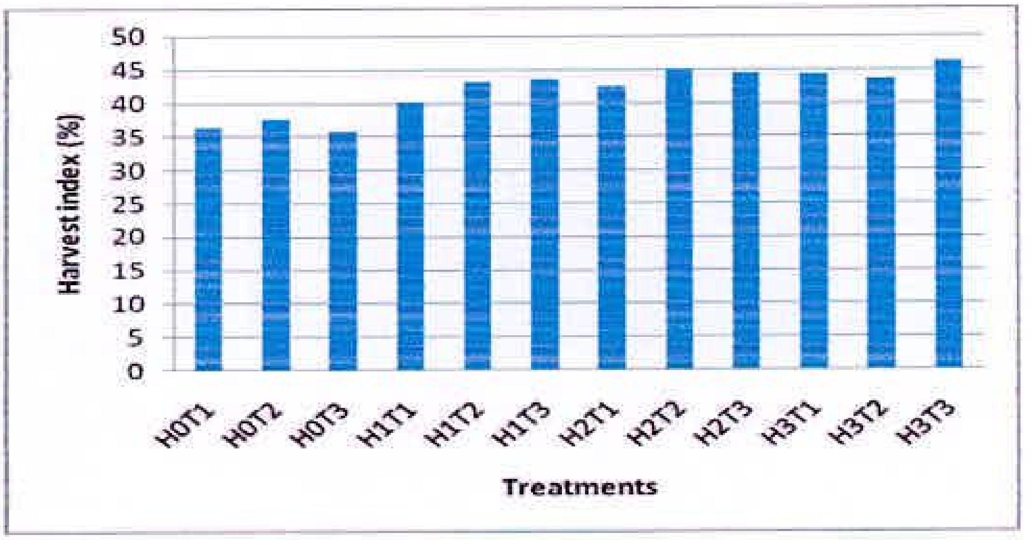

Figure 8: Effect on Harvest index (HI %) as reflected by the times of application of herbicides in wheat ($LSD_{0.05}$= 1.29)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

4.17 Dry weight of weeds m^{-2}

4.17.1 Effect of herbicide

The effect of herbicide on dry weight of weeds m^{-2} of wheat was significant. The maximum dry weight of weeds m^{-2} at harvest (12.66g) was attained in the treatment H_0 and the minimum dry weight of weeds m^{-2} of wheat plants (2.52g) was found in H_3 treatment (Table 145).

4.17.2 Effect of application time

Dry weight of weeds m^{-2} of wheat influenced significantly by the application of different levels of application time. At harvest the highest dry weight of weeds m^{-2} (6.24) was obtained in treatment T_1. The lowest dry weight of weeds m^{-2} (3.04) was obtained in the T_3 treatment (Table 15).

Chapter 5
Summary and Conclusion

4.17.3 Interaction effect

Dry weight of weeds is important for finding out the weed killing efficacies of different treatments. The highest dry weight of weed m^{-2} at 55 DAS was found from the treatment H_0T_1 (12.66 g) (Figure 9) that was followed by the treatment H_3T_0 (8.95 g) (Figure 10). The lowest dry weight was found from the treatment H_3T_3 (1.83 g) and it was followed by treatment H_1T_3 (2.32 g) (Figure 9). The result shows that the treatment H_0 (control) have the lowest efficiency in controlling the weeds and the treatment H_3T_3 have the highest efficiency in controlling weeds. Similar results were also observed by Sharma *et.al.* (1999). Auskalnis and Kadzys (2006) reported that the best efficacy on weed mass in all years of the experiments was achieved when herbicide was applied at the 3-leaf stage and during the tilling stage of spring wheat.

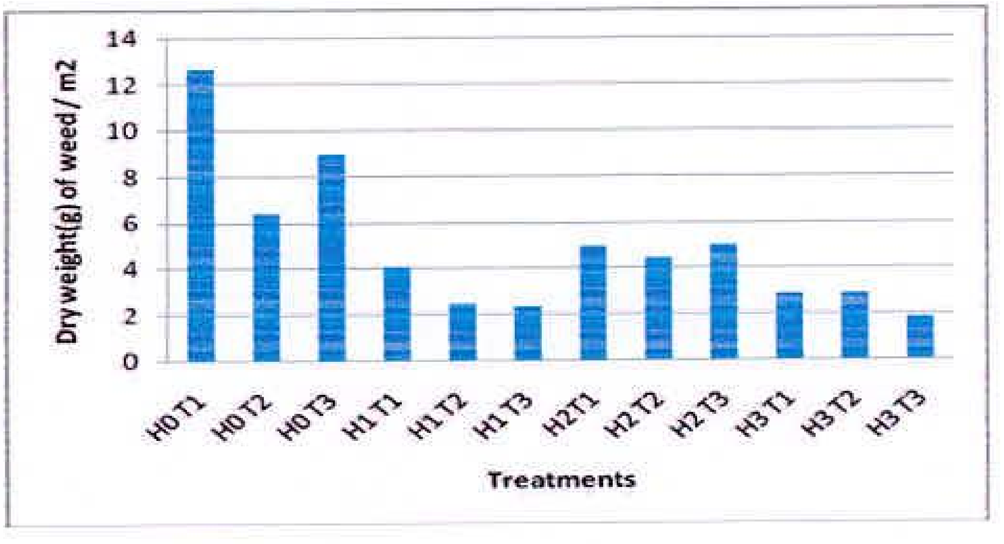

Figure 9: Dry weight of weed m^{-2} at 55 days after sowing (DAS) in wheat ($LSD_{0.05}$=1.15)

H_0 T_1- Water spray at 7 DAS
H_0 T_2- Water spray at 14 DAS
H_0 T_3- Water spray at 21 DAS
H_1 T_1- Sencor applied at 7 DAS
H_1 T_2- Sencor applied at 14 DAS
H_1 T_3- Sencor applied at 21 DAS
H_2 T_1- Lintur applied at 7 DAS
H_2 T_2- Lintur applied at 14 DAS
H_2 T_3- Lintur applied at 21 DAS
H_3 T_1- Ronstar applied at 7 DAS
H_3 T_2- Ronstar applied at 14 DAS
H_3 T_3- Ronstar applied at 21 DAS

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1. Summary

The experiment was conducted at the experimental site of Sher-e-Bangla Agricultural University (SAU) during the period from November, 2007 to March, 2008 to study the weed killing efficacies as affected by application time of herbicide on wheat. Three herbicides used in the study were Sencor 7 WG@ 500g ha^{-1}, Lintur 70 WG @ 250g ha^{-1}, Ronstar @ 1liter ha^{-1}. The experiment comprises twelve treatments viz.

(i) H_0 T_1- No herbicide but water spray at 7 DAS, (ii) H_0 T_2- No herbicide but water spray at 14 DAS (iii) H_0 T_3- No herbicide but water spray at 21 DAS (iv) H_1 T_1- Sencor 7 WG @ 500g ha^{-1}applied at 7 DAS, (v) H_1 T_2- Sencor 7 WG@ 500 g ha^{-1}applied at 14 DAS, (vi) H_1 T_3- Sencor 7 WG@ 500 g ha^{-1} applied at 21 DAS , (vii) H_2 T_1- Lintur 70 WG @ 250 g ha^{-1}applied at 7 DAS, (viii) H_2 T_2- Lintur 70 WG @ 250 g ha^{-1} applied at 14 DAS, (ix) H_2 T_3- Lintur 70 WG @ 250g ha^{-1}applied at 21 DAS, (x) H_3 T_1- Ronstar @ 1liter ha^{-1} applied at 7 DAS , (xi) H_3T_2- Ronstar @ 1liter ha^{-1} applied at 14 DAS and (xii) H_3 T_3- Ronstar @ 1liter ha^{-1} applied at 21 Days after Sowing DAS. The experiment was conducted in randomized complete block design (RCBD) with three replications and data were analyzed by MSTAT-c.

The results showed that some of the crop characters such as plant height, number of tillers plant^{-1}, and number of grains plant^{-1}, spike length, dry weight plant^{-1}, 1000 seed weight and yield were significantly affected due to application of different time of different herbicides. The other parameters such as harvest and dry weight of weed collected from the field were also significantly influenced by application of different rates of different herbicides. The treatment H_3T_3 showed highest plant height of 93.63

cm and dry weight per plant of 4.37g at harvest period. Fresh weight per plant scored the highest value of 10.46 g in H_3 T_3 while the lowest value of 8.16 g in H_1 T_1. The highest number of leaves per plant of 6.19 was recorded in H_3 T_3 at 70 days after sowing while the lowest number of 4.13 leaves per plant was found in no herbicide treated plot (H_0). The highest number of ineffective tillers per plant of 103 was observed in H_0 where the lowest value of 37 in H_3T_3. The highest value of 2001 of effective tillers per plant was recorded in H_3 T_3 whereas the lowest number of effective tillers was observed in the control level. The highest value of 2054 plant population per square meter was found in H_2 T_2 while the lowest value of 1574 was recorded in the control level. The remarkable value of average spike length of 15.07 cm was found in H_3 T_2 while the minimum value of 12.03 was recorded in control level. The highest weight of spike per plant of 3.09 g was observed in H_3 T_3 while the lowest value of 2.03 g was found in H_0. The value of fertilized grain per plant was observed the highest of 45.3 in H_3 T_2 and the lowest value of 35.27 was observed in no herbicide using level. The highest grain weight per plant of 2.34 g was recorded in H_3 T_3 and the lowest value of 1.57 g was observed in control treatment. The weight of 1000 seeds scored the highest value of 48.85 g in H_3 T_1 but the lowest value of 37.52 g was observed in control. The highest and remarkable grain yield of 3.37 t ha^{-1} in H_3T_3 and the lowest value of 1.81 tons were observed in no herbicide level of treatment.

5.2 Conclusions

From the above discussion it can be concluded that the weed killing efficiency had differed in different treatments and significant variation were found in herbicide treatments while comparing with control treatments. The treatment H_3T_3 performed very well among the treatments. It was the best among the treatments. The treatment H_3T_2, H_2T_3 & H_2T_2 also performed well in case of different parameter especially in the case of grain yield of wheat. These combinations of treatments might be considered for controlling weeds in wheat cultivation. The treatment H_1T_3 showed moderate performance in case of most of the parameter. The control treatment H_0 performed very poor in different parameters. The yield was very poor in case of that treatment.

Weed density was lowest with post-emergence application of different herbicides. All the treatments contributed to increase the grain yield of wheat except control treatments (no herbicide). Wheat sprayed with treatment H_3T_3 recorded the highest grain yield.

5.3 Recommendations

All the treatments reduced the density and dry weight of weeds except control treatments. So farmer should not go for wheat cultivation without herbicides application. Among the herbicidal treatments, the highest yield was obtained from the treatments H_3T_3. So, it can be recommended that the treatment H_3T_3 (Ronstar applied at 21 DAS) is the best treatment for controlling weeds in wheat field in Bangladesh condition. So, herbicides should be applied at a suitable time which will reduce the cost from the several applications as well as would be environment friendly.

Chapter 6

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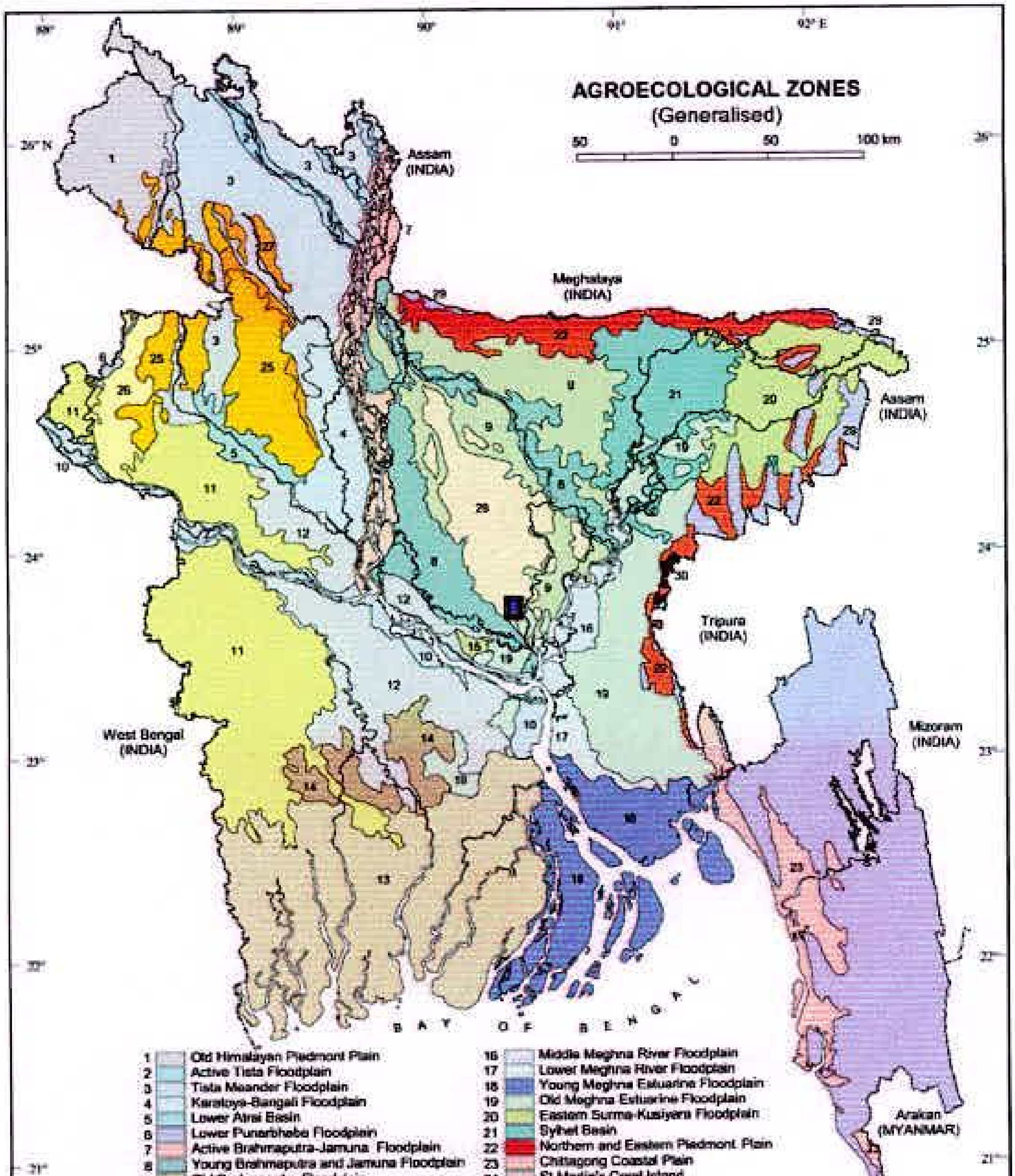
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

Appendix II: Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from November, 2007 to March, 2008

Month	Year	Monthly average air temperature (^0C)		Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum			
November	2007	31.8	16.8	67	111	1307.00
December	2007	28.2	11.3	63	0	1302.00
January	2008	29.0	10.5	61.5	23	1455.00
February	2008	30.6	10.8	54.5	56	1827.50
March	2008	34.6	16.5	61.5	45	1821.00

[Source: Bangladesh Metrological Department, Agargaon, Dhaka]

Appendix III. Physical characteristics and chemical composition of soil of the experimental plot

Soil Characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resources Development Institute, Farmgate, Dhaka