PERFORMANCE OF HERBICIDE ON WEED SUPPRESSION TOWARDS GROWTH AND YIELD OF WHEAT

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CERTIFICATE

This is to certify that the thesis entitled, **"PERFORMANCE OF HERBICIDE ON WEED SUPPRESSION TOWARDS GROWTH AND YIELD OF WHEAT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY,** embodies the results of a piece of bonafide research work carried out by **MD. ANOWAR HOSSAIN,** Registration No. **27629/00693** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dated: 30.12.08

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Dedicated

To

MY BELOVED PARENTS

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PERFORMANCE OF HERBICIDE ON WEED SUPPRESSION TOWARDS GROWTH AND YIELD OF WHEAT

ABSTRACT

An experiment on the performance of herbicide (Ronstar, Sencor and Lintur) on weed suppression towards growth and yield of wheat was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November, 2007 to March, 2008. The experiment was laid out in a randomized complete block design having twelve combination treatments viz. (i) Ronstar 25EC @ 1.0 l/ha, (ii) Ronstar 25 EC @ 1.5 l/ha, (iii) Ronstar 25EC @ 2.0 l/ha, (iv) Ronstar 25EC @ 2.5 l/ha, (v) Lintur 70WG @ 0.20 kg /ha, (vi) Lintur 70WG @ 0.25 kg /ha, (vii) Lintur 70WG @ 0.30 kg /ha, (viii) Lintur 70WG @ 0.35 kg /ha, (ix) Sencor 70WG @ 0.30 kg/ha, (x) Sencor 70WG @ 0.40 kg /ha, (xi) Sencor 70WG @ 0.50 kg /ha, and (xii) Sencor 70WG @ 0.60 kg /ha, along with control (weedy) with three replications. Result showed that higher dry weight/plant, 1000 seed weight, total grain yield, harvest index and benefit cost ratio (42.58g, 45.84g, 3.51 t/ha, 46.69% and 1.50 respectively) were obtained with Sencor 70WG @ 0.50 Kg/ha treated crop. The highest plant height, number of tillers/plant, number of spikes/plant, spike length at harvest was also observed with the same treatment. In addition to those parameters, the lowest weed dry matter (19.38 kg/ha,) by Sencor 70WG @ 0.60 kg/ha, Sencor 70WG @ 0.50 kg/ha, showed the highest net return (23500.00 Tk/ha). So, Sencor 70WG @ 0.50-0.60 kg/ha, could be considered as the recommended rate for controlling weeds in wheat field.

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LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
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
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
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
SRDI	Soil Resources and Development Institute
TDM/ TDW	Total Dry Matter/ Total Dry Weight
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
t ha^{-1}	Ton per hectare
^{0}C	Degree Centigrade
%	Percentage
EC	Emulsifiable concentrate
WG	Wettable granule
SC	Soluble concentrate
AI/a.i	Active ingredient
WCE	weed control efficiency
PE	pre-emergence
POE	Post-emergence

Chapter 1
Introduction

CAHPTER 1

INTRODUCTION

Wheat (*Triticum aestivum*) is a one of the leading cereals in the world. 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). Wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2004). Rice is the staple food of Bangladesh but its total production is not sufficient to feed her growing population. Bangladesh is an over populated country. Increasing agricultural production per unit area of land is becoming most important step to cope with the present population growth in Bangladesh. Wheat can be a good supplement of rice and it can play a vital role to feed this vast population. From nutritional point of view, wheat is superior to rice for its higher protein content. In Bangladesh about 0.84 million ha of land is covered by wheat producing 0.976 million metric tons with an average yield of 2.16 t ha^{-1} (BBS, 2004), which is still below than that of many other countries. Among the factors responsible for this low grain yield of wheat, weed competition is the most important. About 27% of wheat production in the country is lost due to weed competition (Karim, 2003). However, weed can be controlled in various ways such as mechanical control, integrated weed management and herbicide application. Herbicide application is one of the most effective measures for weed control and it is more profitable than mechanical control of weed. Mechanical weed control produce less than the control with herbicide (Pardo, 2001).

The application rate of herbicide may influence the weed killing efficacy of herbicide. Excess rate of application is harmful for environment and also for human diet. It can primarily be more effective but gradually weed can be resistant to that herbicide more hazardous (Coleman *et al.*, 2003).

So, a study was undertaken to check the application rate of herbicides (Ronstar, Sencor and Lintur) for controlling weeds in wheat with the following objectives:

i) to evaluate the suppression efficacies of weeds in wheat field with herbicides

ii) to estimate the appropriate rate of herbicides for obtaining 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 performance of herbicide (Ronstar, Sencor and Lintur) on weed suppression towards growth and yield of wheat. It is an established fact that decreased weed infestation increases crop growth shows higher land equivalent ratio and above all gives higher yield and benefit cost ratio (Mengping and Zhangjinsong, 2005).

Nadeem *et al.* (2007) conducted a field experiment to assess the effect of different weed control practices and fertilizer levels on weeds and grain yield of wheat in Pakistan. The experiment comprised of four weed control practices of viz., weedy check, pre-emergence application of Pendimethalin, post-emergence application of Isoproturon + Carfentrazone ethyl and manual weed control (two hoeings) and three fertilizer levels viz., 0+0, 75+50 and 150+100 kg $N+P_2O_5$ ha^{-1}. Manual hoeing resulted in minimum weed density and dry weight in both the years. The maximum grain yield (5816 and 5071 kg ha^{-1}) was recorded in manual hoeing in 2002-03 and 2003-04 respectively mainly due to more number of fertile tillers, number of grains per spike and 100-grain weight. Weed density 40 days after sowing and weed dry weight increased significantly with each increased fertilizer level. The maximum grain yield was recorded with 150+100 kg $N+P_2O_5$ ha^{-1}. Manual weed control and application of 150+100 kg $N+P_2O_5$ ha^{-1} was found to be the best combination for obtaining higher grain yield of wheat.

Zand *et al.* (2007) conducted a field experiments in Iran, to study weed control and winter wheat response to post-emergence applications of Diflufenican plus MCPA at 0.5, 1, and 1.5 L/ha, Clopyralid plus 2,4-D, and Fluroxypyr both at 1.5, 2, and 2.5 L/ha, Tribenuron methyl, 2,4-D plus MCPA, Bromoxynil plus MCPA, and Dichloprop-p plus mecoprop-p plus MCPA. The post-emergence application of Diflufenican plus MCPA, Clopyralid plus 2,4-D, and Fluroxypyr provided better control of broadleaved weeds compared with other herbicides. The data showed that in most cases Fluroxypyr at 2.5 L/ha caused the most reduction in weed populations and biomass. The efficacy of Bromoxynil plus MCPA was generally better than Tribenuron methyl, 2,4-D plus MCPA, and Dichloprop-p plus mecoprop-p plus MCPA, although it varied among the locations and weed species. The application of Diflufenican plus MCPA, Clopyralid plus 2,4-D, and Fluroxypyr resulted in highest wheat yield among all treatments.

Oad *et al.* (2007) conducted a field experiment at Students Farm, Sindh Agriculture University, Tandojam, Pakistan. Weed densities tested were: weedy control (control), wheat+natural weeds (weedy for full season), wheat+mixed weeds (*Chenopodium album*, *Melilotus alba*, *Avena fatua*, *Phalaris minor*) (2:1), wheat+*Chenopodium album* (2:1), wheat+*Melilotus alba* (2:1), wheat+*Avena fatua* (2:1) and wheat+*Phalaris minor* (2:1). Among the tested weed densities, *Chenopodium album*, *Avena fatua*, *Phalaris minor* and *Melilotus alba* were the common and serious weeds in wheat crop. They reduced the tiller production, plant height, seed index, wheat biomass and grain yield. The highest wheat grain yield reduction was recorded by *Chenopodium album* (39.95% yield reduction), followed by *Avena fatua* (36.48%), *Phalaris minor* (35.33%), natural weeds for full season (34.96%), mixed weeds (32.14%) and *Melilotus alba* (24.01%). It was concluded that weeds caused economic yield losses to the wheat crop, which may range from 24.00 to 39.95%. These must be controlled during the full growing season of the crop for achieving satisfactory crop yields.

Hari *et al.* (2006) conducted an experiment during the winter seasons of 2001/02 and 2002/03 in India, to study the effect of weed control treatments in wheat sown by zero-tillage [no-tillage] method. Significantly higher grain yield was recorded with the use of Glyphosate + Sulfosulfuron and Glyphosate + Sulfosulfuron + Metsulfuron (each applied at different time) during both the years. Glyphosate and or Metsulfuron was also required to supplement Sulfosulfuron or Clodinafop for better weed management. The highest net returns over the control and benefit:cost ratio were observed with the application of Glyphosate + Sulfosulfuron, followed by Glyphosate + Sulfosulfuron + Metsulfuron. The lowest dry weight of weeds (55.6 to 62.2 and 31.2 to 55.7 g/m2 for the first and second year, respectively) was observed with Glyphosate + Clodinafop + Metsulfuron, glyphosate + Sulfosulfuron and Glyphosate + Sulfosulfuron + Metsulfuron treatment. The highest weed control efficiency was recorded with Glyphosate + Sulfosulfuron + Metsulfuron application (89.2%), followed by Glyphosate + Sulfosulfuron (86.9%). Metsulfuron was effective in controlling *Rumex spp.* and other broadleaf weeds.

Brzozowska *et al.* (2006) conducted a study in Poland during 2001-03 to evaluate various systems of weed control and N fertilizer application on winter wheat cv. Elena. The experiment was conducted on proper, medium and heavy brown soil. The herbicide treatments were: control; Granstar 75 WG (Tribenuron methyl); Granstar 75 WG + Starane 250 EC (Fluroxypyr); Granstar 75 WG + Chwastox Extra 300 SL (MCPA); Chwastox Extra 300 SL; Chwastox Extra 300 SL + Starane 250 EC; Aminopielik D 450 SL (2,4-D + Dicamba); and Mustang 306 SE (Florasulam + 2,4-D). N was applied at 120 kg/ha to the soil at 3 parts: 40 kg/ha after revival of vegetation; 27.6 kg/ha at the end of the reproduction stage; and 52.4 kg/ha at the end of the culm formation phase. Spraying and soil applications were also done, and urea was applied twice on the soil at 40 kg/ha after vegetation revival, 35.8 kg/ha at the end of the culm formation phase. Spraying was done twice at 27.6 kg N/ha at the end of the reproductive phase (2% urea solution), and 16.6 kg/ha at the end of the culm formation phase (12% urea). The following indices were estimated: cost effectiveness of treatment, cost coverage index, cost return percentage and estimated index of treatment cost effectiveness. The economic indices depended mainly on the herbicide and herbicide mixtures, and to a smaller degree, on the N application. The highest cost effectiveness was obtained from Granstar 75 WG+ Chwastox Extra 300 SL and Granstar 75 WG + Starane 250 EC. The lowest value was obtained with Chwastox + Starane and Chwastox applied alone.

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 at 30 DAS, Clodinafop-propargyl [Clodinafop] at 0.06 kg/ha at 30 DAS and weedy control) in wheat. Conventional tillage + Isoproturon recorded the highest net return (Rs. 21 089/ha), followed by strip till drill + Isoproturon (Rs. 21 074/ha), conventional tillage + hand weeding (Rs. 20 725/ha), and zero tillage + isoproturon (Rs. 20 502/ha). Strip till drill + Isoproturon and zero tillage + Isoproturon recorded the highest benefit:cost ratios of 2.09 and 2.05, respectively.

Kanojia and Nepalia (2006) conducted a field study during 1999-2000, in Udaipur, Rajasthan, India, to evaluate the relative uptake of nutrients by wheat and associated weeds under the influence of new herbicides. Minimum NPK uptake by weeds was recorded when weeds were controlled by 2,4-D at 400 g/ha + Isoproturon at 750 g/ha, followed by Sulfosulfuron at 25 and 30 g/ha. In contrast, maximum NPK uptake by wheat was recorded under the treatment with 2,4-D at 400 g/ha + Isoproturon at 750 g/ha, followed by Sulfosulfuron at 30 g/ha.

Ashok *et al*. (2006) conducted a study in Haryana, India to evaluate the efficacies of Tralkoxydim (Grasp 10% EC, at 250 and 300 g/ha), Isoproturon (Arelon 75% WP, at 750, 1000 and 1250 g/ha), Atrazine (Atrafap 50% WP, at 25, 50 and 100 g/ha), Oxyfluorfen (Goal 23.4% EC, at 50, 75, 100 and 125 g/ha) and Diclofop (Illoxan 28.5% EC, 700 and 880 g/ha), applied alone or in mixtures, against weeds infesting wheat. Oxyfluorfen at 50-125 g/ha alone

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caused 52-77% weed complex control, and 10-20% crop injury. Oxyfluorfen at 50-100 g/ha mixed with 750 and 1000 g/ha Isoproturon increased weed control efficiency (WCE) of isoproturon by 4-17% but did not increase yield due to crop toxicity. Tank mixture of Oxyfluorfen at 25 and 50 g/ha with Diclofop at 700 g/ha and Tralkoxydim at 250 g/ha increased WCE of these herbicides by 4-11 and 11-19%, respectively, but resulted in crop toxicity of 10-20%. WCE of Oxyfluorfen and Isoproturon as 1:1 tank mix or formulated similarly was less compared to that at a ratio of 1:5, and the difference was more pronounced at lower rates. Atrazine alone reduced weed dry weight only up to 4-21%, caused crop toxicity of 10-50%, and produced yield that was similar to that in the weedy control. Atrazine at 25 and 50% increased WCE of Isoproturon by 4-18% but due to crop toxicity of 20-50%, the yield level was not different from that of Isoproturon alone. Tank mixture of Atrazine at 25 and 50 g/ha with Tralkoxydim at 250 g/ha did not increase WCE, but was toxic to wheat (25-35% phytotoxicity). Isoproturon at 1000 and 1250 g/ha showed a WCE of 86%, and was the only treatment that increased grain yield to statistically similar levels to those of weed-free plots.

Gul *et al.* (2006) studied on the integration of zero tillage and herbicides for wheat production in a rice-based cropping system in Dera Ismail Khan, Pakistan. Zero and conventional tillage regimes were assigned to the main plots, while post-emergence herbicides (Buctril-M [Bromoxynil + MCPA] and Affinity [Carfentrazone-ethyl + Isoproturon]) and weedy control were maintained in the sub-plots. Herbicide treatments showed significant differences in weed density, while tillage regimes and their interaction with herbicides showed no significant effects. The tillage plots showed numerically fewer weed infestations than zero till plots. As far as the interaction was concerned, both herbicide treatments showed lower weed density compared to weedy control under either tillage regime. Fleabane (*Conyza stricta*) exceptionally grew in zero till plots. 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 under the zero tilled wheat covered with Buctril-M. The lowest marginal net benefit was attained in the Affinity+zero tillage. It is, thus, recommended that zero tillage may be adopted for lucrative income and sustainability of the production system with the use of Buctril-M. Adoption of such a resource conservation technology has been a timely intervention to reduce production costs, improve efficiency of natural resource management practices, benefit the environment, and exploit potential of the rice-based system.

Pandey *et al.* (2006) evaluated the efficacy of Sulfosulfuron (20, 25 or 30 g/ha applied at 40 or 60 days after sowing), Isoproturon (1000 g/ha at 40 DAS), 2,4-D (500 g/ha at 40 DAS), Metribuzin (230, 245 or 260 g/ha at 40 DAS, or 260 g/ha 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 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 applied at 40 DAS and 230 g metribuzin/ha. 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), 2,4-D and manual weeding registered the highest 1000-grain weight. 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.

Sujoy *et al.* (2006) conducted a field experiment in Nadia, West Bengal, India, to study different weed management practices in wheat (cv. UP 262). Results revealed that hand weeding at 21 and 35 days after sowing (DAS) was effective in controlling the weeds in the field. This treatment recorded the highest values for number of effective tillers m2, number of grains per earhead, grain and straw yield, and harvest index. The combination of Oxyfluorfen 23.5 EC at 0.125 kg/ha as pre-emergence (PE) and Sulfosulfuron 75 WDG at 0.025 kg/ha as post-emergence (POE) along with 0.2% surfactant at 21 DAS (T3) was the next best treatment with respect to growth, yield and yield attributing characters, straw yield, harvest index and weed index.

Kieloch, (2005) carried out a field experiments Wrocaw, Poland, with winter wheat to investigate the efficacy of herbicide Herbaflex 585 SC (Isoproturon 500 g/l+Beflubutamid 85 g/l). The herbicide (at 2 l/ha) was applied alone or in mixture with Starane [Fluroxypyr] 250EC (at 4 l/ha). Herbaflex 585 SC effectively (85-100%) controlled *Alopecurus myosuroides, Anthemis arvensis, Apera spica-venti, Galium aparine, Papaver rhoeas, Thlaspi arvense, Veronica spp.,* and *Viola arvensis.* Addition of Starane 250 EC markedly improved the efficacy of the herbicide against *G. aparine* and *Brassica napus.*

Jakubiak and Krawczyk (2005) carried out a field experiments in Poland to estimate the efficacy of herbicides Treflan 480 EC (Trifluralin, at 1.0 l/ha), Glean 75 WO (Chlorsulfuron, at 10 g/ha) and Expert 60 WG (Flufenacet, at 0.2 l/ha) used at reduced doses as tank mixtures for weed control in winter wheat. The treatments were applied when the winter wheat was at 11-12 of BBCH scale. All the herbicide combinations were very effective against *Descurainia sophia, Veronica ssp., Thlaspi arvense, Chenopodium album* and *Papaver rhoeas. Apera spica-venti* was well controlled after Treflan 480 EC+Glean 75 WG and Expert 60 WG+Glean 75 WG application. The effective weed control increased the grain yield of winter wheat in comparison with the control.

Upadhyay *et al.* (2005) conducted a field experiment in Madhya Pradesh, India from 1999-2000 to 2001-02 to evaluate the effect of Isoproturon and its mixture with 2,4-D on weed management, yield and economics of wheat. The treatments were: (1) weedy control; (2) hand weeding; (3) Pendimethalin at 1.0 kg/ha (pre-emergence); (4) Isoproturon at 1.0 kg/ha (pre-emergence); (5) Isoproturon at 1.0 kg/ha post-emergence; (6) post-emergence 2,4-D at 0.6 kg/ha; (7) tank mixture of Isoproturon + 2,4-D (pre-emergence) at 0.5 + 0.5 kg/ha; and (8) tank mixture of Isoproturon (pre-emergence) + 2,4-D post-emergence at 0.5 + 0.5 kg/ha. Treatment 8 showed the highest weed control efficacy, net returns and benefit cost ratio. Weed-free treatment and tank mixture of Isoproturon (pre-emergence) + 2,4-D post-emergence at 0.5 + 0.5 kg/ha showed the highest yields.

Ashok *et al.* (2005) evaluated the efficacy of Metribuzin (100 or 200 g/ha), Diclofop (700 or 880 g/ha), Metribuzin + Diclofop (50 or 100 + 700 g/ha), Metribuzin + Diclofop (150 + 700 g/ha), Metribuzin + Fenoxaprop (50 + 100, 100 + 100 or 150 + 100 g/ha), Fenoxaprop (100 or 120 g/ha), Metribuzin + urea (175 g/ha + 3%) and Sulfosulfuron + urea (25 g/ha + 3%) against weeds infesting wheat (cultivars Raj 3765 and WH 542 on the first and second seasons) in Hisar, Haryana, India. The herbicides were applied at 35 days after sowing. The dominant weeds in the area were *Avena ludoviciana* [*A. sterilis subsp. ludoviciana*], *Phalaris minor, Rumex retroflexus* and *Melilotus indica.* Metribuzin at 200 g/ha, Diclofop at 700 and 800 g/ha, Fenoxaprop at 100 and 120 g/ha, Metribuzin with Diclofop and Fenoxaprop were equally effective in the reduction of the density and dry weight of grassy weeds (*Avena ludoviciana* and *Phalaris minor)* by 77-93%. Tank mixture of 100 and 150 g metribuzin with 700 g Diclofop or 100 g Fenoxaprop reduced the dry weight of broadleaved weeds by 76-88% in 1997-98 and by 82-89% in 1998-99. Metribuzin alone or in combination with Diclofop and Fenoxaprop was effective against a complex of weeds, but resulted in a phytotoxicity level of 8-30%. All treatments significantly increased the grain yield of wheat over the weedy control. The presence of weeds reduced the yield by 44.9 and 24.5% in 1997-98 and 1998-99, respectively. Among the herbicides, Sulfosulfuron +

urea registered the highest grain yields (2425 kg/ha in 1997-98 and 4595 kg/ha in 1998-99).

Walia *et al.* (2005) conducted a field experiments in Ludhiana, Punjab, India. The experimental field was sandy-loam in texture with 72.7% sand, 11.7% silt and 15.6% clay and was under rice-wheat sequence for many years. Wheat sown with zero tillage technique after the spray of Paraquat recorded significantly less dry matter of *Phalaris minor* compared to conventional tillage crop. Also, the dry matter of broadleaf weeds was significantly higher in zero tillage sown crop without Paraquat application than the other tillage treatments. Mesosulfuron + Iodosulfuron at 12 or 15 g ha^{-1} and Sulfosulfuron at 25 g ha^{-1} provided effective control of *P. minor* and broadleaf weeds, whereas Clodinafop at 60 g ha^{-1} and Fenoxaprop-p-ethyl at 100 g ha^{-1} controlled only *P. minor.* Significantly higher grain yield was recorded in zero tillage sown crops after spraying Paraquat than zero tillage without Paraquat spray as well as conventional tillage treatments and the former treatment gave 15.8% higher yield than the latter one. On an average of two years, highest grain yield (4266 kg ha^{-1}) was recorded in meso + iodo at 15 g ha^{-1} and it was followed by Sulfosulfuron, Fenoxaprop-p-ethyl followed by 2,4-D and Clodinafop followed by 2,4-D, respectively.

Shah and Habibullah (2005) conducted an experiments during 2003/04-2004/05 in Peshawar, Pakistan, to study the effect of different methods (hand weeding, narrow spacing, hand hoeing, chemical weed control with Buctril super + Puma super [Fenoxaprop-P + Fenchlorazole], and unweeded control) of weed control on wheat cv. Salem 2000. Data were recorded for plant height, number of tillers m^{-2}, 1000-grain weight, crop yield and number of weeds m^{-2}. There were non-significant differences among the various weed control methods during 2003/04, for all the parameters recorded. However, the highest numerical yield was obtained with planting wheat in narrow spacing. There were significant differences among weed control methods for number of weeds and tillers m^{-2} and grain yield during 2004/05. Chemical weed control out yielded the rest of the treatments except hand weeding. The highest grain yield of 3804 kg/ha was recorded with chemical weed control followed by hand hoeing (3696 kg/ha). The yield gain of 28.51% over the control was realized in the tank mixed Buctril super + Puma super. Narrow row spacing suppressed weeds.

Marwat *et al.* (2005) conducted an experiment in Pakistan, during the 2003/04 rabi season to evaluate the effect of different herbicides for controlling weeds in wheat cv. Fakhr-i-Sarhad. The treatments comprised Terbutryn + Triasulfuron at 0.16 kg, 2,4-D at 0.7 kg, Fenoxaprop-P-ethyl at 0.93 kg, Clodinafop at 0.05 kg, Bromoxynil + MCPA at 0.49 kg, Carfentrazon-ethyl at 0.02 kg and Isoproturon at 1.0 kg a.i./ha. Isoproturon revealed the best performance with maximum weed kill efficiency (48.26%) and minimum fresh weed biomass (433.3 kg/ha) compared to the weedy control (6% and 1102 kg/ha, respectively). Similarly, the spike length (8.34 cm), number of tillers (427 m^{-2}), number of grains spike-1 (38.0), thousand grains weight (39.85 g), biological yield (8475 kg/ha), grain yield (2530 kg/ha) and harvest index (31.3%) were the highest in Isoproturon treatments compared to the weedy control having (7.64 cm, 356 m^{-2}, 34.1, 37.12 g, 6858 kg/ha, 1913 kg/ha and 27%, 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^{-1}), 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.

Gul *et al.* (2005) conducted a field experiment NWFP Agricultural University, Peshawar, Pakistan, during the rabi season of 2003-04 to study the effect of different herbicides on weed density and some agronomic traits of wheat. Treatments consisted of seven herbicides and a control. The herbicidal treatments were post-emergence applications of Affinity (Carfentrazone ethyl ester), WH-01 (Clodinafop-propargyl [Clodinafop]), Pujing (Fenoxaprop-P-ethyl [Fenoxaprop-P]), Sencor (Metribuzin), Puma super (Fenoxaprop-P-ethyl) Pujing + Sencor (Fenoxaprop-P-ethyl + Metribuzin), Puma super+Sencor (Fenoxaprop-P-ethyl + Metribuzin) and a weedy control. Wheat cv. Ghaznavi-98 was planted on 13 November 2003. 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 major weeds infesting the experiment were *Avena fatua, Coronopus didymus, Euphorbia helioscopia, Fumaria indica, Convolvulus arvensis, Rumex dentatus, Chenopodium album, Poa annua, Medicago denticulata* and *Vicia sativa.* 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.

Jarwar and Arain (2005) carried out an experiment in Pakistan to observe the effect of post emergence chemical weed control on weed density and grain yield of wheat during rabi seasons of 2001-02 and 2002-03. The data revealed that Topik [Clodinafop] 15 WP at 250 g ha^{-1} showed maximum weed control efficacy of 97.74 and 97.86% during 2001-02 and 2002-03, respectively. The maximum wheat grain yield of 3285.71 and 3071.42 kg ha^{-1} was also obtained in Topik 15 WP at 250 g ha^{-1} during both years. Thus, based on the data, it is concluded that Topik 15 WP is better than the standard product Puma super-70 EW, and is hence recommended for controlling grassy weeds in wheat crop.

Tiwari *et al.* (2005) carried out an experiment in Kanpur, Uttar Pradesh, India, to evaluate the efficacy of new herbicides and their tank mixtures in controlling associated weed species in irrigated dwarf wheat *(T. aestivum)* cv. K9107. The treatments comprised a weedy control till maturity, hand weeding twice at 30 and 60 days after sowing, 2,4-D Na salt (500 g/ha), isoproturon (750 g/ha), A 9526 A (50 g/ha), Metsulfuron-methyl [Metsulfuron] (3 g/ha), Diclofop-methyl [Diclofop] (1000 g/ha), Metribuzin (200 g/ha), Tralkoxydim (350 g/ha), Isoproturon + 2,4-D Na salt (750 + 500 g/ha), Isoproturon + Metsulfuron-methyl (750 + 3 g/ha), Isoproturon + Metribuzin (750 + 200 g/ha), A 9526 A + Metsulfuron-methyl (50 + 3 g/ha), Diclofop-methyl + 2,4-D Na salt (1000 + 500 g/ha), and Diclofop-methyl + Isoproturon (500 + 500 g/ha). The major weeds in the control plots at 60 days after sowing were *Phalaris minor* (47.19%) among grassy weeds, and *Chenopodium album* (30.59%), *Anagallis arvensis* (13.06%), *Melilotus alba* (7.85%) and *Convolvulus arvensis* (1.30%) among broad-leaved weeds. Isoproturon (750 g/ha) + 2,4-D Na salt (500 g/ha) eliminated weed competition (WCE 88.16%) resulting in increased mean seed yield (4.58 ton/ha) closely followed by Isoproturon (750 g/ha) + Metsulfuron-methyl (3 g/ha). Metsulfuron-methyl (3 g/ha) proved to be good alternative of 2,4-D sodium salt (500 g/ha) with regard to broad-leaved weed control.

Metribuzin showed efficient control of grassy as well as broad-leaved weeds but depressed grain yield.

Smeia *et al.* (2005) conducted a field experiment in winter season on sandy loam soil in Allahabad, Uttar Pradesh, India, to study the effect of different levels of Sulfosulfuron (25, 27.5 and 30 g/ha), Fenoxaprop-p-ethyl [Fenoxaprop-P] (80, 100 and 120 g/ha), Isoproturon (750, 1000 and 1250 g/ha) and Isoproturon+2,4-D (1000+500 g/ha) with weed-free and weedy control in late-sown wheat. The predominant weeds in the field were *Chenopodium album, Anagallis arvensis, Parthenium hysterophorus, Vicia hirsuta* and *Phalaris minor.* Next to weed-free plots, lower weed population was recorded in the Isoproturon+2,4-D treatment followed by Isoproturon at 1000 g/ha. After 80 days, next to weed-free plots, maximum plant dry weight were observed in the plots treated with Sulfosulfuron at 30 g/ha. The highest growth and yield of wheat was obtained with Sulfosulfuron at 30 g/ha.

Tunio *et al.* (2004) conducted a field experiment in Pakistan to determine the effects of integrated weed management (IWM) practices on the yield of the crop. Eight weed management treatments viz., hand weeding full season (normal sowing), hand weeding full season (cross sowing), weedy full season (normal sowing), weedy full season (cross sowing), normal sowing + application of Puma super at 500 ml/acre, cross sowing + Puma super at 500 ml/acre, normal sowing + application of Agritox at 500 ml/acre, and cross sowing + application of Agritox at 500 ml/acre were tested. *Convolvulus arvensis, Cynodon dactylon, Chenopodium album, Anagallis arvensis, Avena fatua* and *Cyperus rotundus* were the major weeds infesting wheat. Broad leaved weeds were denser than the grass weeds, with *Anagallis arvensis* recording the highest population (43.3/m2). *Avena fatua* (24.18/m2) and *Cyperus rotundus* (3.68/m2) had the highest densities among the grass weeds and sedges. The weed management treatments had highly significant effect on plant height, number of tillers, grain weight, grain yield (kg/ha). Hand weeding during full season under normal sowing resulted in the highest (4166 kg/ha) grain yield. Cross sowing + application of Puma super at 500 ml/acre resulted in the highest grain yield (3958 kg/ha), whereas cross sowing + application of Agritox 500 ml/acre resulted in the lowest yield. Hand weeding during normal sowing was the best method of controlling weeds in wheat and resulted in the highest grain yield. The results are significant at 0.05%.

Lopez *et al.* (2004) conducted an experiment in Mexicali Valley, Mexico, during 2000-01, post-emergence (Paraquat and Glyphosate) and pre-emergence (Trifluralin) herbicides, each at 2 and 3 l/ha, were evaluated. The treatments were applied on wheat planted after sorghum under conservation tillage. All herbicides efficiently controlled the weeds; however, Trifluralin at 3 l/ha but was slightly phytotoxic to wheat, reducing grain test weight by as much as 20%. Trifluralin at 2 litres/ha was superior among the treatments, resulting in a yield of 8525 kg/ha, followed by Trifluralin and Glyphosate at 3 litres/ha, resulting in yields slightly more than 8 t/ha.

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 (T1); weed-free (T2); hand weeding at 20 and 45 days after sowing (DAS; T3); 0.5 kg Fluchloralin (T4); 1.0 kg Fluchloralin (T5); 1.0 kg Isoproturon (PE; T6); 1.0 kg Isoproturon at 30 DAS (T7); 100 g Metribuzin (PE; T8); 200 g Metribuzin (PE; T9); 0.75 kg Pendimethalin (PE; T10); 1.50 kg Pendimethalin (PE; T11); and 0.5 kg 2,4-D/ha at 35 DAS (T12). *P. minor* was significantly controlled by all herbicides except 2,4-D. *A. arvensis* was not controlled in T6 but was controlled in T7. Weed populations were significantly reduced in T4, T5, T7, T9, T10 and T11 treatments. Weed dry matter was higher in the weedy control ($157 g/m^2$) compared to all the herbicide treatments except in T12 and T8. Higher plant height (67.10 cm) was recorded in T2 followed by T3 but was lower in T4 and T5. The highest grain yield (26.18q/ha) was recorded in T2 and lowest in T1 (21.72 q/ha).

Ciobanu (2003) presented the research results obtained at the Agricultural Research and Development Station Oradea, Romania, in a study on controlling weeds in wheat with herbicides. The weed population structure was qualitatively and quantitatively very variable as a function of pedoclimatic conditions of that area. The infestation was predominantly annual monocotyledons (e.g. *Apera spica-venti*) under albic luvisoil conditions and perennial dicotyledons (88%) under brown-luvic soil conditions. The control of *Apera spica-venti* achieved using pre-emergence herbicides such as Cougar (Diflufenican + Isoproturon) (1.25-1.50 l/ha) and Treflan [Trifluralin] (1.0-1.2 l/ha) is 87-88% and 78-85%, respectively, when there was optimal rainfall after application. With Dicuran Forte (Chlorotoluron + Triasulfuron) about 95-98% control is achieved. The high efficacy of *A. spica-venti* control was obtained by the application of tank-mixed herbicides such as Puma S (Fenoxaprop-ethyl), Monitor (Sulfosulfuron), Assert (Imazamethabenz) and Grasp (Tralkoxydim + Atplus) with anti dicotyledonous herbicides such as Glean (Chlorsulfuron), Granstar (Tribenuron-methyl), Icedin Super (2,4-D + Dicamba), Oltisan M (2,4-D + Dicamba) and Lontrel 300 [Clopyralid]. In the case of infestations of dicotyledons alone, the mixed herbicides (Oltisan M, Oltidin Super (2,4-D + Dicamba), Icedin Super, Mustang (2,4-D + Florasulam), Lancet (2,4-D + Fluroxypyr)) and the sulfonylurea herbicides (Glean, Granstar, Dacsulfuron (Chlorsulfuron), Lintur (Triasulfuron + Dicamba), Rival 75 PU (Chlorsulfuron), Sekator (Amidosulfuron + Iodosulfuron-methyl), Rival Super Star (tribenuron-methyl)) achieved more than 90% control and very significant yield gains.

Abu-Irmaileh (2002) conducted three-year field trials in Maru, Jubiaha, and Mshagger, Jordan, to formulate a weed management strategy, utilizing various inputs available for the small farmer to reduce weed impact on barley (cv. Acsad G2-172) and wheat (cv. Horani 27) yield. Date of planting, fertilizer rates, spacing, and chemical weed control were the main factors tested. Closer spacing, early planting, and increasing the fertilizer rates increased crop yields and reduced weed populations. Yield returns to cost ratio for these treatments were better than herbicide applications, especially if two herbicides were to be used for the control of broad leaf weeds and grasses.

Nisha *et al.* (2001) conducted a field experiment in Baraut, Uttar Pradesh, India to study the effects of Pendimethalin (0.5 and 1.0 kg a.i./ha), Isoproturon (0.5 and 0.75 kg a.i./ha), Metsulfuron-methyl [Metsulfuron] (0.004 and 0.008 kg a.i./ha), Isoproturon+Pendimethalin (0.5kga.i./haeach), and Isoproturon+Metsulfuron-methyl (0.5+0.004 kg a.i./ha) on wheat cv. HD 2329 and associated weeds (mainly *Phalaris minor, Melilotus indica, Fumaria parviflora, Chenopodium album, Anagallis arvensis, Cirsium arvense,* and *Rumex dentatus*). Wheat was sown on 29 November 1996 and 25 November 1997. All herbicides significantly reduced weed population and this dry weight. Pendimethalin (1.0 kg a.i./ha) was most effective in controlling *Chenopodium album*. Isoproturon (0.75 kg a.i./ha) showed the highest control efficiency against *P. minor*. Metsulfuron-methyl (0.008 kg a.i./ha) was most effective against *M. indica, F. parviflon, Cirsium arvense*, and *R. dentatus. A. arvensis* was most efficiently controlled by Metsulfuron-methyl (0.008 kg a.i./ha) and Isoproturon (0.5 kg a.i./ha)+Metsulfuron-methyl (0.004 kg a.i./ha). Unchecked weeds reduced yield by almost 37.8% in 1996-97 and 37.5% in 1997-98. The highest seed yield (mainly due to lower weed density) was obtained with 0.75 kg Isoproturon a.i./ha and all herbicide combinations. The lowest competition due to weeds (6.01 in 1996-97 and 5.76% in 1997-98) was observed in plots with 0.75 kg Isoproturon a.i./ha.

Singh *et al.* (2001) conducted a field experiment to evaluate the efficacy of Metribuzin in controlling weeds associated with wheat and its effect on the yield of wheat cv. UP 2338. Treatments consisted of different doses of Metribuzin (as pre-emergence or post-emergence treatment), Pendimethalin at 1 kg/ha (as pre-emergence treatment), Isoproturon at 1kg/ha (as post-emergence treatment) and weedy and weed-free control. The major weeds in the experimental field were *Phalaris minor, Chenopodium album* and *Melilotus indica*. The minor weeds were *Anagallis arvensis, Coronopus didymus, Fumaria parviflora, Lathyrus aphaca, Vicia sativa* and *Cyperus rotundus*. All the treatments reduced the density and dry weight of weeds except for the pre-emergence application of 210 g Metribuzin/ha. Weed density was lowest with post-emergence application of 385 or 450 g Metribuzin/ha, which was at par with 350 g Metribuzin/ha. Post-emergence application of 140 g Metribuzin/ha completely controlled *Chenopodium album* and *M. indica*. Symptoms of phytotoxicity were observed with post-emergence application of Metribuzin. Reduction in the number of wheat spikes at harvest was recorded in plants sprayed with 315 g Metribuzin/ha. All the treatments increased the grain yield of wheat except for pre-emergence application of 210 g Metribuzin/ha. Wheat plants in the weed free control recorded the highest grain yield followed by plants sprayed with 315 g Metribuzin/ha.

Rajvir and Pahuja (2001) observed that the application of Chlorsulfuron at 30 g ha^{-1}, Metsulfuron methyl at 8 g ha^{-1}, Metribuzin at 200, 400 g ha^{-1} alone and the tank mixture of Metribuzin (100 and 200 g) along with Chlorsulfuron (15 g) and Metsulfuron methyl (2g) were effective in controlling complex weed flora. Metsulfuron methyl at 4 g ha^{-1} and Chlorsulfuron at 15 g ha^{-1} were effective only against broad leaf weeds. While Isoproturon at 1000 g ha^{-1} was effective against *P. minor*. The efficacy of tank mixture of Metsulfuron methyl at 2 g ha^{-1} and Isoproturon at 500 g ha^{-1} was very poor against both types of weeds. The highest grain yield of wheat (4400 and 5000 kg ha^{-1}) was obtained in repeated weeded plot during both the years. Grain yields obtained with the application of Chlorsulfuron at 30 g ha^{-1}, Metsulfuron methyl at 8 g ha^{-1} alone and combined application of Chlorsulfuron at 15 g ha^{-1} and Metribuzin at 100 and 200 g ha^{-1} were statistically similar to weed-free during both the seasons. Metribuzin either alone at 200 and 400 g ha^{-1} or in combinations with Metsulfuron methyl showed phytotoxic effect on wheat crop.

Balyan (2001) conducted a field experiment during the winter seasons of 1997-98 and 1998-99. The results revealed that Sulfosulfuron 25 g+0.1% surfactant, Isoproturon 1000 g and tank mixture of Isoproturon+Metsulfuron methyl 750+4 g ha^{-1} provided satisfactory control of *Avena ludoviciana, Phalaris minor, Chenopodium album, Melilotus indica, Anagallis arvensis* and *Lathyrus aphaca*. Above herbicides gave 52-88% control of broad leaf weeds and 55-85% control of grassy weeds. Mon 48549 though provided excellent control of both type of weeds, but proved highly phytotoxic to wheat. Tank mix application of Isoproturon and Metsulfuron methyl (75+4 g ha^{-1}) gave crop yield more or less similar to weed-free during both the years.

Stefan *et al.* (2001) studied on the activity of a range of sulfonylurea herbicides used for weed control in winter wheat in the Research Institute for Plant Protection Bucharest in Romania. The efficacy and the selectivity of the following herbicides were investigated: Glean 75 DF (Clorsulfuron [Chlorsulfuron] 75%), Granstar 75 DF (Tribenuron methyl 75%), Grodyl 75 WG (Amidosulfuron 75%), Harmony 75 DF (Thifensulfuron methyl [Thifensulfuron] 75%) and Logran 75 WG (Triasulfuron 75%). Those were selective systemic herbicides, absorbed mainly by the roots and by the foliage and translocated throughout the plant. Plant growth is inhibited. The weed spectrum included broadleaved weeds and some annual grasses. All treatments proved to be safe to the crop. The potential yield loss from weed competition was recouped from herbicide applications.

Zengin (2001) sprayed 2,4-D amine and 2,4-D isooctylester repeatedly in the spring of 5 consecutive years on spring wheat (*Triticum aestivum* L. cv. Kirik) in Erzurum, Turkey. Herbicide efficacy against all broadleaved weeds and against the most common weed species was determined by comparing the number of weeds in untreated and treated plots. The most abundant weed species were *Polygonum aviculare, Amaranthus retroflexus* and *Chenopodium album* in spring wheat. The effect of 2,4-D amine decreased after 3 or 4 years in *A. retroflexus, C. album, Convolvulus arvensis, Acroptilon repens,* *Lactuca serriola, P. aviculare, Cirsium arvense* and other broadleaved weeds. Effects against *Sinapis arvensis* and *Sisymbrium altissimum* remained unchanged. The reduction in the effectiveness of isooctylester on *A. retroflexus, C. album, C. arvensis, C. arvense, A. repens, L. serriola, P. aviculare* and other broadleaved weeds was statistically significant, but the rate of decrease was not statistically significant for *S. arvensis* and *S. altissimum*. The resistance of *A. retroflexus* against isooctylester increased in the 4th year. The results indicated that herbicide affected some weeds the effects were reduced especially from the 4th year. It was concluded that herbicides should be changed periodically.

Panwar *et al.* (2000) conducted experiments during 1993-94 and 1994-95 in a field which was dominated by natural infestation of wild oat. 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%.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was carried out at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November, 2007 to May 2008. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

The research work relating to the suppression of weed as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur) in wheat was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the Rabi season of 2007-2008. The following map shows the specific area of experimental site Appendix I.

3.2 Location of the study

3.2.1 Geographical location

The experimental area was situated at 23°77' N latitude and 90°33' E longitude at an altitude of 8.6 meter above the sea level.

3.2.2 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. Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.2.3 Characteristics of soil

The soil of the experimental site belonged 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 p^H ranged from 6.00—6.63 and had organic matter 0.84%. 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 physicochemical properties of the soil are presented in Appendix III.

3.4 Crop/planting material

Certified seeds of wheat (*Triticum aestivum*) were collected from the Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. BARI GAM–23 (Bijoy) was used as planting material.

3.4.1 Description of variety: BARI GAM–23 (Bijoy)

This is a high yielding variety of wheat developed by Wheat Research Center, BARI. It was approved by the National Seed Board (NSB) as variety in 2005 due to its superior agronomic performance and better yielding ability.

The recommended optimum growing period of the wheat variety was mid-November to mid-March. This is a semi-dwarf variety with good tillering ability. The total life duration in the field is 103-112 days. The grains are white, bold and larger in size with 1000-grain weight of 47-52g. The variety is resistant to leaf rust and tolerant to Bipolaris leaf blight diseases. The variety also has some degree of tolerance to heat stress. Under normal environmental condition, the variety yields 4300-5000 kg/ha. The yield is 10-15% higher than Kanchan both in optimum planting and late planting. It can also be grown successfully throughout the country except in saline areas with salinity level more than 6 mmhos.

The grain is medium hard with protein content around 11-12%. This test weight of the variety is good having weak gluten in the grain. The variety is highly suitable for flat bread.

The plant is light green with few hairs in the upper culm node. Glaucosity is strong in the spike but medium to weak in flag leaf sheath and culm. Flag leaves are broad and recurved. The length of lower glume beak is very short with numerous beak spicules. Lower glume shoulder shape is square. The yield of this variety is 3.6-4.8 t/ha and was described to be adaptable to late planting.

3.5 Details of the Experiment

3.5.1 Treatments

The treatments included in the experiment were as follows:

Ho	=	Weedy Control
H_1	=	Ronstar 25EC @ 1.0Lt/ha
H_2	=	Ronstar 25 EC @ 1.5Lt/ha
H_3	=	Ronstar 25EC @ 2.0Lt/ha
H_4	=	Ronstar 25EC @ 2.5 Lt/ha
H_5	=	Lintur 70WG @ 0.20 Kg/ha
H_6	=	Lintur 70WG @ 0.25 Kg/ha
H_7	=	Lintur 70WG @ 0.30 Kg/ha
H_8	=	Lintur 70WG @ 0.35 Kg/ha
H_9	=	Sencor 70WG @ 0.30 Kg/ha
H_{10}	=	Sencor 70WG @ 0.40 Kg/ha
H_{11}	=	Sencor 70WG @ 0.50 Kg/ha
H_{12}	=	Sencor 70WG @0.60Kg/ha

3.6 Land preparation

The land was first ploughed on 10 November, 2007 by disc plough. The land then was harrowed again on 18 and 21 November to bring the soil in a good tilth condition. The final land preparation was done by disc harrow on 22 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 27 November, 2007 according to the design adopted.

3.7 Fertilizer application

The recommended fertilizer dose of wheat applied in the field for the experiment was as follows

Compost	=	8000 Kg/ha
N	=	220 Kg/ha
P_2O_5/ P	=	180 Kg/ha
K_2O	=	110 Kg/ha
S	=	110 Kg/ha
B	=	7 kg/ha

Two third ($^2/_3$) amount of N, whole amount of P_2O_5/P and K_2O were applied at the time of final land preparation. Rest amount of N ($^1/_3$) were applied as top dressing at the time of 1st irrigation.

3.8 Experimental design

The experiment was laid in a randomized complete block design with three replications. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 3.0 m × 2.0 m.

3.9 Sowing of seeds

Seeds were sown on 28th November, 2007 by hand. Seeds were sown in line. Seeds were then covered properly with soil. The line to line distance for wheat was 20 cm and plant to plant distance was 4-5 cm.

3.10 Intercultural operations

3.10.1 Thinning

After well establishment of seedling, thinning was done properly to reduce excess population and maintained the plant to plant (4~5 cm) by hand pulling.

3.10.2 Weeding

The crop was infested with some weeds during the early stages of crop establishment. Weeds were suppressed by the application of different herbicides at different rates according to the treatments. The herbicides used for weed control were Ronstar 25EC, Sencor 70 WG and Lintur 70WG. Herbicide application was done at 10 DAS as per treatment.

3.10.3 Mode of Action of Herbicides

Herbicide brings about various physiological and bio-chemical effects on the growth and development of the emerging seedlings as well as established plants, either after coming in contact with the plant surface or after reaching the site of action within the plant tissue; the net result is the death of the plant. The physiological and biological effects after followed by various types of visual injury symptoms. They are chlorosis, defoliation, stunting, necrosis, stand reduction, epinasty, morphological aberrations, growth stimulation, marginal leaf burn, desiccation, delayed emergence, germination failure etc. The rate of appearance of this effects varies with the characteristics actions of the herbicides and depends upon of tolerance or susceptibility of the plant species. The exact mechanism by which herbicide exerts their phytotoxicity effect of the susceptible plant species or varieties is yet unclear. However, several major mechanisms of action of herbicides have been outlined in brief below.

i) The key feature of Ronstar 25EC

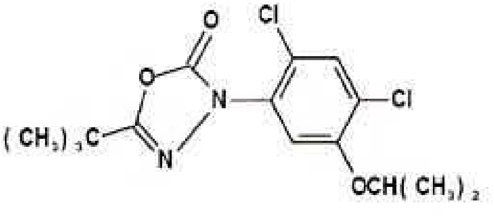
Name (common name, iso): Oxadiazon

Chemical name (IUPAC): 5-*tert*-butyl-3-(2,4-dichloro-5-isopropoxy-phenyl)-1,3,4 oxadiazol-2-(3*H*)-one

Chemical name (CAS): 1, 3, 4-oxadiazol-2(3H)-one,3-[2,4-dichloro-5-(1-methylethoxy) phenyl]-5-(1,1-dimethylethyl)

Empirical formula: $C_{15}H_{18}O_3N_2Cl_2$

Structural formula:



Structural formula of Ronstar

The Mode of action of Ronstar 25EC

Chlorophyll, the green pigment in leaves, is the molecule that absorbs sunlight and uses its energy to convert water and carbon dioxide into carbohydrates. Oxadiazon works by interfering with the pathway for chlorophyll production, and results in a breakdown of plant tissue on exposure to light. The specific biochemical reaction of oxadiazon in weeds is the inhibition of protoporphyrinogen oxidase (Protox), a critical enzyme in the chlorophyll biosynthetic pathway. When Protox is inhibited, protoporphyrinogen IX an intermediate in the porphyrin synthesis pathway, accumulates into the cytoplasm. In the presence of light, activated oxygen radicals are formed which causes lipid peroxidation (cell membrane disruption) and finally destruction of the plant.

ii) The key feature of Sencor 70WG

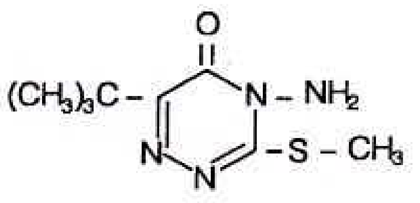
Name (common name, iso): Metribuzin

Chemical name (IUPAC): 4-amino-6-tert-butyl-4, 5-dihydro-=3-methylthio-1, 2, 4-triazin-5-one

Chemical name (CAS): 4- amino-6-(1, 1-dimethylethyl)-3-= (methylthio)-1, 2, 4-triazin-5(4H)-on

Empirical formula: $C_8H_{14}N_4OS$

Structural formula:



Structural formula of Sencor

The mode of action of Sencor 70 WG

Metribuzin is a selective herbicidal active ingredient which shows good effectiveness against grass and broad leaved weeds. Millet species such as *Setaria spp., Digitaria spp.* and *Echinochola spp.* are also controlled. The effectiveness against deep-rooted, perennial mono-and dicotyledonous weeds was found to be low. Under the the recommendation application conditions, Sencor is well tolerated by soyabeans, potatoes, vegetables (a.o. tomatoes and asparagus), cereals, alfalfa and sugarcane. Sencor is suitable for pre-emergence as well as also for post-emergence treatment, since it can be taken up via the roots and through the foliage. For a pre-emergence application there should be an adequate amount of moisture in the soil to achieve good control. Owing to its additional effect via foliar uptake, the active ingredient usually produces a more powerful effect as a post-emergence treatment so that for this application the rate of use can be reduced.

Humus content and texture of soil have a marked influence on the herbicidal activity and crop compatibility of Sencor. Use of a higher dosage rate is required on soils with a higher content of clay and humus. In this case a post-emergence application is of particular advantage.

The herbicidal activity of Sencor is also decisively influenced by the temperature level. To achieve the same herbicidal effect, lower dosage rates and needed in warm climatic zones then in temperate zones. Metrlbuzin is relatively quickly degraded in the soil so that there is not danger of phytotoxicity to succeeding crops if the product is used as recommended.

iii) The key feature of Lintur 70 WG

There are two active ingredients present in Lintur 70 WG i.e Dicamba and Triasulfuron

a) The key feature of Dicamba

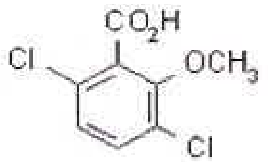
Name (common name, iso): Dicamba

Chemical name (IUPAC): Banvel® and Vanquish® products for forestry and non-crop sites.

Chemical name (CAS): 3,6-dichloro-o-anisic acid or 3,6-dichloro-2-methoxy benzoic acid

Empirical formula: $C_8H_6Cl_2O_3$

Structural formula:



Structural formula of Dicamb

The mode of action of Dicamba:

Selective systemic herbicide absorbed by the leaves and roots, with ready translocation throughout the plant via both the symplastic and apoplastic systems. Acts as an auxin-like growth regulator.

Dicamba mimics naturally-occurring plant growth hormones called auxins. It kills plants by destroying tissue through uncontrolled cell division and growth. Dicamba affects cell wall integrity and nucleic acid metabolism. It increases cell wall permeability, leading to cell enlargement. At low concentrations, dicamba increases synthesis of DNA, RNA, and proteins, resulting in altered cell division and growth. At high concentrations, inhibition of cell division and growth occur.

Plant symptoms from Dicamba exposure include leaf cupping and stem curling, swelling, and lengthening. These symptoms are followed by yellowing or bleaching of plant tissues, wilting, inhibited growth, and death.

Dicamba uptake occurs by both the roots, stems, and foliage. The chemical translocates to all plants tissues but accumulates in growing tissues. Plants tolerant to Dicamba typically translocate the chemical slowly relative to susceptible plants.

b) The key feature of Triasulfuron

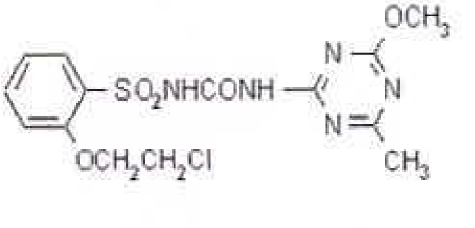
Common name: Triasulfuron (BSI, draft E-ISO, (*m*) draft F-ISO)

IUPAC name: 1-[2-(2-chloroethoxy) phenylsulfonyl]-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl) urea

Chemical abstracts name: 2-(2-chloroethoxy)-*N*-[[(4-methoxy-6-methyl-1, 3, 5-triazin-2-yl) amino] carbonyl] benzenesulfonamide

Empirical formula: $C_{14}H_{16}ClN_5O_5S$

Structural formula:



Structural formula of Triasulfuron

The mode of action of Triasulfuron

Selective herbicide, absorbed by the leaves and roots, and rapidly translocated to meristems. Uses Control of broad-leaved weeds pre- and post-emergence in wheat, barley and triticale.

3.10.4 Application of irrigation water

Irrigation water was added to each plot according to the need of the crop. All the plots were irrigated twice-one at 17 and the other at 50 days of growth of the crop.

3.10.5 Plant protection measures

Special care was taken to protect the crows and other birds from damages to the germinating seeds, young seedlings and the ripening grains of the spikes.

3.10.6 Harvesting

The crop was harvested at maturity on 2nd March 2008. The harvested crop of each individual plot was bundled separately. Grain and straw yields were recorded plot wise and the yields were expressed in t/ha.

3.11 Recording of data

The following data were recorded from the experiment

a) Plant height
b) Number of tillers/plant
c) Number of spikelets/spike
d) Dry matter weight/plant
e) Grain weight/spike
f) Weight of 1000 seeds
g) Grain yield
h) Straw yield
i) Harvest Index
j) Dry weight of weed

3.12 Procedure of recording data

The detail outline of data recording has been given below

a. Plant height

The height of five plants were measured from the ground level to tip of the plants and then averaged. It was taken at different days after sowing (DAS) separately.

b. Number of tillers/plant

At different days after sowing (DAS) it was taken from five plants separately and then averaged.

c. Number of spikelets/spike

Total number of spikelets were counted from five plants and then averaged.

d. Dry weight/plant

Five plants at different days after sowing (52, 59 and 67 DAS) were collected and oven dried at 70° C for 24 hours. The dried samples were then weighed and collected the dry wt. /plant (g).

e. Grain weight/spike

Thirty spikes were choosen at random and measured the parameter by the following formula

$$\text{Grain weight/spike (g)} = \frac{\text{Grain weight (g)}}{\text{Number of spike}}$$

f. Weight of 1000 seeds

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

g. Grain yield (t/ ha)

Wheat was harvested randomly from pre-selected 1 m^2 area of land of 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.

h. Straw weight

Straw obtained from each individual plot was dried, weighed carefully and the yield was expressed in t/ha.

i. Harvest Index (HI)

Harvest Index was measured as per experimental treatments by the following formula

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

j. Dry weight of weed

Weeding was done from 1 m^2 land at 20 and 45 DAS and the collected weed was oven dried at 70° C for 24 hours. The dried samples were then weighed and averaged and that was converted to t/ha.

3.13 Productivity performance

3.13.1 Net income

Net income was calculated by the following formula

Net income = Gross return – Total cost of production

3.13.2 Benefit to cost ratio (BCR)

Benefit to cost ratio (BCR) was calculated by the following formula

$$\text{Benefit to cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

3.14 Statistical analysis

The data collected on different parameters were statistically analyzed using the MSTAT-C computer package program developed by Russel (1986). Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

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

4.1 Growth parameters of wheat

4.1.1 Plant height

Plant height was significantly affected by different herbicide application at different rates (Table 1 and Appendix IV). Plant height differed with rates and types of herbicides. It was observed that the highest plant heights (39.33, 65.48, 89.23 and 91.39 cm) were shown by H_{11} at 30, 60, 90 and at harvest respectively. Among the herbicides, Sencor 70WG played best in performing higher plant height over Ronstar 25EC and Lintur 70WG in all the stages of recording data (30DAS, 60DAS, 90DAS and at harvest) in our experimentation. However, increasing the rate of individual herbicide reflected the trend of increasing plant height when compared with that of control treatment.

Table 1. Performance on plant height as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Ho	28.77 f	48.84 g	77.65 g	78.12 h
H_1	30.95 ef	51.88 f	81.84 f	83.20 g
H_2	32.02 d-f	54.83 e	82.26 ef	84.84 e-g
H_3	33.11 c-e	55.76 de	84.19 c-f	84.07 fg
H_4	34.25 b-e	57.38 c-e	86.59 a-c	85.27 d-f
H_5	33.39 c-e	55.46 de	83.36 d-f	84.56 e-g
H_6	34.12 b-e	58.45 cd	84.95 c-e	85.82 c-f
H_7	34.91 b-d	60.23 bc	85.79 b-d	86.13 c-e
H_8	36.66 a-c	62.87 ab	86.20 a-d	87.01 b-d
H_9	34.21 b-e	60.21 bc	85.94 b-d	86.83 cd
H_{10}	35.88 a-c	63.02 ab	86.40 a-d	87.35 bc
H_{11}	39.39 a	65.48 a	89.23 a	91.39 a
H_{12}	37.52 ab	63.96 a	88.73 ab	88.75 b
$LSD_{(0.05)}$	**3.310**	**2.823**	**2.752**	**1.728**
CV (%)	5.73	6.87	7.92	5.20

Here,

Ho = Weedy Control

H_1 = Ronstar 25EC @ 1.0Lt/ha

H_2 = Ronstar 25 EC @ 1.5Lt/ha

H_3 = Ronstar 25EC @ 2.0Lt/ha

H_4 = Ronstar 25EC @ 2.5 Lt/ha

H_5 = Lintur 70WG @ 0.20 Kg/ha

H_6 = Lintur 70WG @ 0.25Kg/ha

H_7 = Lintur 70WG @ 0.30 Kg/ha

H_8 = Lintur 70WG @ 0.35 Kg/ha

H_9 = Sencor 70WG @ 0.30 Kg/ha

H_{10} = Sencor 70WG @ 0.40 Kg/ha

H_{11} = Sencor 70WG @ 0.50 Kg/ha

H_{12} = Sencor 70WG @0.60Kg/ha

4.1.2 Number of tiller/plant

Number of tillers/plant was significantly affected by different herbicides at different rates (Table 2 and Appendix V). Number of tillers/plant increased with the effectiveness of herbicide. It was observed that the highest number of tillers/plant (2.52, 5.89, 6.01 and 6.10) was shown by H_{11} at 30, 60, 90 DAS and at harvest respectively which was not significantly different from Sen4 at harvest. Irrespective of data recording days (30 DAS, 60 DAS,40 DAS) and even upto harvest there found no significant differences on tillers/plant in Ronstar treated plots.

In case of Lintur, there was found no differences in tillers/plant upto 90DAS, but at harvest, the highest dose (H_8) of this herbicide showed highest tiller numbers as compared to the control plot. However, Sencor played best among the herbicides in performing the said parameter, although there were identical results among the plots treated with different doses of the herbicide in wheat.

Table 2. Effect of herbicidal rates on tillers/plant in wheat

Treatment	Number of tiller/plant			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Ho	1.70 e	3.96h	4.19f	4.21f
H_1	1.80 de	4.40 fg	4.49 ef	4.55 ef
H_2	1.81 de	4.32 g	4.58 d-f	4.64 d-f
H_3	1.84 de	4.49 e-g	4.59 d-f	4.67 d-f
H_4	1.87 c-e	4.60 e	4.79 de	4.88 de
H_5	2.01 c	4.39 fg	4.76 de	4.83 de
H_6	1.94 cd	4.58 ef	4.82 de	4.91 de
H_7	1.90 cd	4.67 e	4.96 c-e	5.02 c-e
H_8	1.85 c-e	4.87 d	5.12 cd	5.20 b-d
H_9	2.30 b	5.23 c	5.40 bc	5.53 a-c
H_{10}	2.33 b	5.55 b	5.68 ab	5.73 ab
H_{11}	2.52 a	5.89 a	6.01 a	6.10 a
H_{12}	2.34 b	5.68 b	5.890 ab	5.93 a
LSD $_{(0.05)}$	**0.1507**	**0.1767**	**0.5111**	**0.5382**
CV (%)	4.52	6.19	5.81	7.97

Here,

Ho = Weedy Control

H_1 = Ronstar 25EC @ 1.0Lt/ha

H_2 = Ronstar 25 EC @ 1.5Lt/ha

H_3 = Ronstar 25EC @ 2.0Lt/ha

H_4 = Ronstar 25EC @ 2.5 Lt/ha

H_5 = Lintur 70WG @ 0.20 Kg/ha

H_6 = Lintur 70WG @ 0.25Kg/ha

H_7 = Lintur 70WG @ 0.30 Kg/ha

H_8 = Lintur 70WG @ 0.35 Kg/ha

H_9 = Sencor 70WG @ 0.30 Kg/ha

H_{10} = Sencor 70WG @ 0.40 Kg/ha

H_{11} = Sencor 70WG @ 0.50 Kg/ha

H_{12} = Sencor 70WG @0.60Kg/ha

4.1.3 Spike length

Spike length/plant was significantly affected by different herbicide application at different rates (Table 3 and Appendix VI). Spike length increased with the effectiveness of herbicide. It was observed that the highest spike lengths (7.25, 12.12 and 12.47 cm) were shown by the H_{11} at 60, 90 DAS and at harvest respectively. Higher doses of Sencor 70 WG (H_{10}, H_{11} and H_{12}) had no differences in performing longer spike length significantly at 60 DAS and at harvest of wheat. A distinct difference in producing higher spike length was found in H_{11}, H_{12} and at harvest. However, a gradual trend of increased length of spike was found in all the herbicides with increased rate of application in compare to the control plots of wheat.

Table 3. Performance on spike length of wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatment	Spike length (cm)		
	60 DAS	90 DAS	At harvest
Ho	4.95 g	8.89 h	8.93 h
H_1	5.44 f	9.91 g	10.01 g
H_2	5.77 e	10.05 g	10.27 fg
H_3	6.07 d	10.28 f	10.43 f
H_4	6.33 c	10.72 e	11.17 de
H_5	6.27 cd	10.68 e	10.84 e
H_6	6.35 c	10.83 de	11.23 de
H_7	6.46 c	10.98 d	11.50 cd
H_8	6.49 c	11.20 c	11.73 c
H_9	6.94 b	11.37 c	11.80 bc
H_{10}	7.05 ab	11.62 b	12.18 ab
H_{11}	7.25 a	12.12 a	12.47 a
H_{12}	7.14 ab	11.69 b	12.30 a
LSD $_{(0.05)}$	**0.2199**	**0.1913**	**0.3798**
CV (%)	6.76	8.17	7.87

Here,

Ho = Weedy Control
H_1 = Ronstar 25EC @ 1.0Lt/ha
H_2 = Ronstar 25 EC @ 1.5Lt/ha
H_3 = Ronstar 25EC @ 2.0Lt/ha
H_4 = Ronstar 25EC @ 2.5 Lt/ha
H_5 = Lintur 70WG @ 0.20 Kg/ha
H_6 = Lintur 70WG @ 0.25Kg/ha
H_7 = Lintur 70WG @ 0.30 Kg/ha
H_8 = Lintur 70WG @ 0.35 Kg/ha
H_9 = Sencor 70WG @ 0.30 Kg/ha
H_{10} = Sencor 70WG @ 0.40 Kg/ha
H_{11} = Sencor 70WG @ 0.50 Kg/ha
H_{12} = Sencor 70WG @0.60Kg/ha

4.1.4 Number of spikelets/spike

Numbers of spikelets/spike were significantly affected by different herbicide application at different rates (Table 4 and Appendix VII). Number of spikelets/spike increased with types of herbicides then doses of application. There was no significant effect on the said parameter at 60 DAS but at 90 DAS and at harvest it varied significantly. The highest numbers of spikelets/spike (5.98 and 6.08 cm) were recorded in H_{11} at 90 DAS and at harvest, respectively.

In the case of individual effect of herbicide, Ronstar showed non-significant effects at harvest of the crop. Similarly Lintur and Sencor have differences on performing spikelets/spike at 90 DAS but appeared with identical result at final harvest. Although there were non-significant differences on spikelets/spike in the herbicide (Ronstar, Lintur and Sencor) treated wheat, there were also found differences in performing better results over control plots. Out of 3 herbicides, Sencor treated plots were recorded with highest spikelets/spike over the other, two herbicides in the experiment.

Table 4. Performance on number of spikelets/spike as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatment	Number of spike/plant		
	60 DAS	90 DAS	At harvest
Ho	2.23	3.94 g	3.99 d
H_1	2.34	4.47 f	4.54 c
H_2	2.42	4.55 ef	4.64 c
H_3	2.44	4.58 ef	4.66 c
H_4	2.53	4.76 ef	4.88 c
H_5	2.35	4.72 ef	4.80 c
H_6	2.52	4.81 d-f	4.91 c
H_7	2.61	4.96 d-f	5.00 bc
H_8	2.79	5.11 c-e	5.15 bc
H_9	3.15	5.39 b-d	5.51 ab
H_{10}	3.50	5.65 a-c	5.73 a
H_{11}	3.81	5.98 a	6.08 a
H_{12}	3.61	5.88 ab	5.92 a
LSD $_{(0.05)}$	**NS**	**0.5291**	**0.5493**
CV (%)	7.19	6.21	8.06

NS = Not significant

Here,

Ho = Weedy Control

H_1 = Ronstar 25EC @ 1.0Lt/ha

H_2 = Ronstar 25 EC @ 1.5Lt/ha

H_3 = Ronstar 25EC @ 2.0Lt/ha

H_4 = Ronstar 25EC @ 2.5 Lt/ha

H_5 = Lintur 70WG @ 0.20 Kg/ha

H_6 = Lintur 70WG @ 0.25Kg/ha

H_7 = Lintur 70WG @ 0.30 Kg/ha

H_8 = Lintur 70WG @ 0.35 Kg/ha

H_9 = Sencor 70WG @ 0.30 Kg/ha

H_{10} = Sencor 70WG @ 0.40 Kg/ha

H_{11} = Sencor 70WG @ 0.50 Kg/ha

H_{12} = Sencor 70WG @0.60Kg/ha

4.2 Yield and yield parameters of wheat

4.2.1 Dry matter weight/plant

Dry weight/plant was significantly affected by different herbicide application at different rates (Table 5 and Appendix VIII). Dry weight/plant increased with the effectiveness of herbicide. It was observed that the highest dry weight/plant (6.10, 18.06, 30.84 and 42.58 g) were shown in plots treated with H_{11} at 30, 60, 90 DAS and at harvest, respectively.

At 30 DAS, higher dose of Ronstar 25 EC (H_4) reflected with the highest dry matter yield of crop. In later stages of growth (60 DAS and 90 DAS) and at harvest there were no significant differences among the plots treated with the said herbicide or not. Among the levels of Lintur 75 WG significant variations of doses on dry matter weight were found between H_5 and H_8 but no differences on the same recorded due to doses (H_9 to H_{12}) of Sencor 70 WG.

Table 5. Dry matter yield (g/plant) of wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatment	Dry weight/plant (g)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Ho	3.18 h	9.11 f	18.15 d	25.30 f
H_1	3.52 g	10.78 f	20.96 d	28.98 f
H_2	3.69 g	12.15 ef	21.21 d	29.29 ef
H_3	4.08 f	12.30 ef	23.35 cd	32.20 d-f
H_4	4.37 e	13.38 de	23.77 cd	32.74 d-f
H_5	4.34 e	12.44 ef	23.49 cd	32.46 d-f
H_6	4.56 de	13.41 de	24.40 cd	33.64 c-e
H_7	4.70 d	14.69 cd	25.73 bc	35.45 cd
H_8	5.24 c	15.98 bc	27.51 a-c	37.98 bc
H_9	5.36 c	16.24 a-c	26.39 bc	36.48 cd
H_{10}	5.65 b	16.92 ab	27.10 a-c	37.98 bc
H_{11}	6.10 a	18.06 a	30.84 a	42.58 a
H_{12}	5.59 b	17.09 ab	29.67 ab	40.90 ab
LSD $_{(0.05)}$	**0.2171**	**1.7011**	**3.9298**	**4.1011**
CV (%)	7.41	6.37	6.79	6.48

Here,

Ho = Weedy Control

H_1 = Ronstar 25EC @ 1.0Lt/ha

H_2 = Ronstar 25 EC @ 1.5Lt/ha

H_3 = Ronstar 25EC @ 2.0Lt/ha

H_4 = Ronstar 25EC @ 2.5 Lt/ha

H_5 = Lintur 70WG @ 0.20 Kg/ha

H_6 = Lintur 70WG @ 0.25Kg/ha

H_7 = Lintur 70WG @ 0.30 Kg/ha

H_8 = Lintur 70WG @ 0.35 Kg/ha

H_9 = Sencor 70WG @ 0.30 Kg/ha

H_{10} = Sencor 70WG @ 0.40 Kg/ha

H_{11} = Sencor 70WG @ 0.50 Kg/ha

H_{12} = Sencor 70WG @0.60Kg/ha

4.2.2 Grain weight/spike (g)

Grain weight/spike was not affected significantly by different herbicides appllied at different rates (Table 6 and Appendix IX). Although there was no significant effect observed in the case of grain weight/spike but H_{11} showed the highest grain weight/spike (0.77 g).

4.2.3 Weight of 1000 seeds

Weight of 1000 seeds was significantly affected by different herbicide application at different rates (Table 6 and Appendix IX). It was observed that the highest weight of 1000 seeds (45.84 g) was shown in the treatment H_{11} which was significantly similar with that of H_{10} and H_{12}.

4.2.4 Grain yield (t/ha)

Total grain yield (t/ha) was significantly affected by different herbicide application at different rates (Table 6 and Appendix IX). It was observed that the highest yield (3.51 t/ha) was shown in the treatment H_{11}, which was significantly similar with the H_{12} (3.21 t/ha) and H_{10} (3.15 t/ha). On the other hand the lowest yield (2.24 t/ha) was observed in the treatment Ho. The Lintur 70 WG applied with a maximum rate (210 mg/6m^2) resulted in 3.11 t/ha yield but was identical with other levels of this herbicide. There were no significant differences observed in Ronstar 25 EC treated plots on this parameter. However, herbicide treated plots showed better yield over non-treated plots and that was similar to all the cases of herbicides choosen in the study.

Table 6. Grain yield and yield parameters in wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatment	Grain weight/spike (g)	1000 seed weight (g)	Grain yield (t/ha)
Ho	0.49	35.74 e	2.24 d
H_1	0.59	36.97 e	2.72 c
H_2	0.61	39.81 d	2.77 c
H_3	0.63	41.27 cd	2.88 bc
H_4	0.67	41.83 cd	2.95 bc
H_5	0.65	42.09 b-d	2.88 bc
H_6	0.67	42.47 b-d	2.91 bc
H_7	0.68	42.96 bc	3.00 bc
H_8	0.70	43.96 a-c	3.11 a-c
H_9	0.69	42.25 b-d	3.06 bc
H_{10}	0.74	43.62 a-c	3.15 a-c
H_{11}	0.77	45.84 a	3.51 a
H_{12}	0.75	44.82 ab	3.21 ab
LSD $_{(0.05)}$	NS	**2.499**	**0.3728**
CV (%)	7.19	7.08	6.48

NS= Not significant

Here,

Ho	=	Weedy Control	H_7	=	Lintur 70WG @ 0.30 Kg/ha
H_1	=	Ronstar 25EC @ 1.0Lt/ha	H_8	=	Lintur 70WG @ 0.35 Kg/ha
H_2	=	Ronstar 25 EC @ 1.5Lt/ha	H_9	=	Sencor 70WG @ 0.30 Kg/ha
H_3	=	Ronstar 25EC @ 2.0Lt/ha	H_{10}	=	Sencor 70WG @ 0.40 Kg/ha
H_4	=	Ronstar 25EC @ 2.5 Lt/ha	H_{11}	=	Sencor 70WG @ 0.50 Kg/ha
H_5	=	Lintur 70WG @ 0.20 Kg/ha	H_{12}	=	Sencor 70WG @0.60Kg/ha
H_6	=	Lintur 70WG @ 0.25Kg/ha			

4.2.5 Harvest Index (%)

Harvest index was significantly affected by different herbicide application at different rates (Figure 1 and Appendix IX). It was observed that the highest harvest index (46.69%) was shown in the treatment H_{11}, which was significantly similar with those of H_{10} (44.01%) and H_{12} (44.56%). On the other hand the lowest harvest indices were observed in control plots, which were significantly similar to each other (31.25%, 31.29% and 31.32%). There were found a gradual trend of increasing the HI (%) in herbicides with their successive increase in rates of application. As such, it could be concluded that the use of herbicide in controlling weeds would be a good technique for higher yield recovery in wheat. In this case, Sencor 70 WG could preferably be selected for cultivating with improved yield potential of wheat.

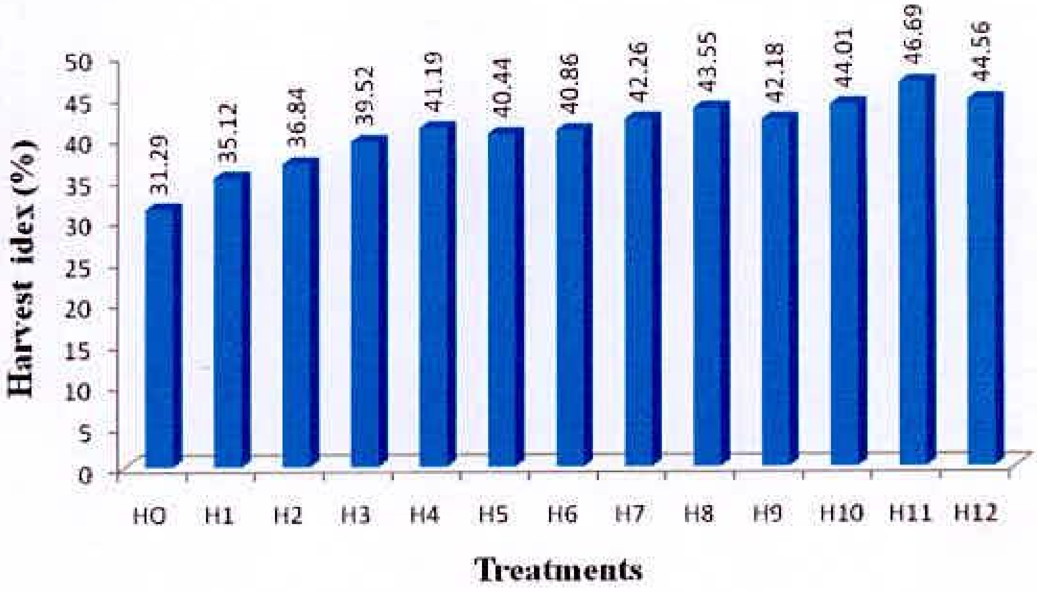


Fig. 1. Effect of herbicidal treatments on the harvest index (HI%) of wheat (LSD = 3.883)

Here,

Ho	=	Weedy Control	H_7	=	Lintur 70WG @ 0.30 Kg/ha
H_1	=	Ronstar 25EC @ 1.0Lt/ha	H_8	=	Lintur 70WG @ 0.35 Kg/ha
H_2	=	Ronstar 25 EC @ 1.5Lt/ha	H_9	=	Sencor 70WG @ 0.30 Kg/ha
H_3	=	Ronstar 25EC @ 2.0Lt/ha	H_{10}	=	Sencor 70WG @ 0.40 Kg/ha
H_4	=	Ronstar 25EC @ 2.5 Lt/ha	H_{11}	=	Sencor 70WG @ 0.50 Kg/ha
H_5	=	Lintur 70WG @ 0.20 Kg/ha	H_{12}	=	Sencor 70WG @0.60Kg/ha
H_6	=	Lintur 70WG @ 0.25Kg/ha			

4.3 Weed biomass in the crop field

4.3.1 Dry weight of weed (kg/ha)

Presence of weed in the crop field was significantly affected by different herbicide application at different rates (Table 7 and Appendix X). It was observed that the lowest dry weight of weed 12.27 and 7.11 kg/ha was shown in the treatment H_{12} at 20 DAS and 45 DAS respectively which was significantly different from all other treatments. On the other hand the highest dry weights of weeds were observed in control plots at 20 DAS, 45 DAS.

Increasing the doses of herbicides resulted in reduced weed dry weed (kg/ha) and that was found with similar trend in individual cases of herbicides. The weed killing efficacy was found best in Sencor 70 WG as supported by the lowest dry weed (7.11 kg/ha) in the experiment. The result obtained from the present experiment could partially be supported by the research works of Dhiman and Rohitashav (2006), Dheer *et al.* (2004) and Nisha *et al.* (2001).

Table 7. Dry matter yield of weed (kg/ha) as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Treatment	**Dry weight of weed (kg/ha)**	
	20 DAS	**45 DAS**
Ho	57.38 a	31.89 a
H_1	33.48 b	20.26 b
H_2	30.59 c	18.53 c
H_3	28.21 cd	17.92 c
H_4	25.77 d	15.39 d
H_5	26.51 d	16.22 d
H_6	23.32 e	13.81 e
H_7	21.21 e	11.25 f
H_8	20.92 e	10.19 fg
H_9	22.90 e	13.46 e
H_{10}	18.36 f	10.25 fg
H_{11}	16.58 f	9.230 g
H_{12}	12.27 g	7.110 h
LSD $_{(0.05)}$	**2.449**	**1.494**
CV (%)	5.60	5.89

Here,

Ho = Weedy Control

H_1 = Ronstar 25EC @ 1.0Lt/ha

H_2 = Ronstar 25 EC @ 1.5Lt/ha

H_3 = Ronstar 25EC @ 2.0Lt/ha

H_4 = Ronstar 25EC @ 2.5 Lt/ha

H_5 = Lintur 70WG @ 0.20 Kg/ha

H_6 = Lintur 70WG @ 0.25Kg/ha

H_7 = Lintur 70WG @ 0.30 Kg/ha

H_8 = Lintur 70WG @ 0.35 Kg/ha

H_9 = Sencor 70WG @ 0.30 Kg/ha

H_{10} = Sencor 70WG @ 0.40 Kg/ha

H_{11} = Sencor 70WG @ 0.50 Kg/ha

H_{12} = Sencor 70WG @0.60Kg/ha

4.4 Productivity performance

Productivity performance was evaluated by the total cost of production, gross return, net income and benefit cost ratio (Table 8). It were calculated in terms of the cost of different equipments such as cost of labour, seeds, fertilizer, tillage, irrigation, pesticides (according to the treatment) etc. including 12% of cost of land which was presented in appendix XI. It was observed that the highest net income (23500.00 Tk/ha) was achieved from H_{11}treatment and that of the lowest (766.00 Tk/ha) from Ho treatment. Treatment H_{10} (17000.00 Tk/ha) and H_{12} (16800.00 Tk/ha) were also promising in terms of net return but less than treatment H_{10}.

4.4.1 Benefit cost ratio (BCR)

Benefit cost ratio (BCR) was significantly affected by different herbicide application at different rates (Figure 2 and Appendix IX). It was observed that the highest benefit cost ratio (1.50) was achieved from H_{11}, which was significantly different from all other treatments. On the other hand the lowest benefit cost ratios were observed in control plots.

The over all performances on BCR leaded by Sencor 70 WG were scored higher than those of other herbicides and could be considered for cultivating wheat with highest benefit (Tk.) through controlling weeds by the dose as we found in the experiment.

Table 8. **Cost of cultivation and profitability of cropping as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur) in wheat**

Treatment	Total cost of production (Tk./ha)	Gross return (Tk./ha)	Net income (Tk./ha)
Ho	44100.00	44200.00	766.00
H_1	45100.00	54400.00	9300.00
H_2	45750.00	55400.00	9650.00
H_3	46400.00	57600.00	11200.00
H_4	47050.00	59000.00	11950.00
H_5	45200.00	57600.00	12400.00
H_6	45850.00	58200.00	12350.00
H_7	46500.00	60000.00	13500.00
H_8	47150.00	62200.00	15050.00
H_9	45300.00	61200.00	15900.00
H_{10}	46000.00	63000.00	17000.00
H_{11}	46700.00	70200.00	23500.00
H_{12}	47400.00	64200.00	16800.00
$LSD_{(0.05)}$	**10.58**	**15.26**	**13.69**
CV (%)	6.58	9.26	11.78

Here,

Ho = Weedy Control
H_1 = Ronstar 25EC @ 1.0Lt/ha
H_2 = Ronstar 25 EC @ 1.5Lt/ha
H_3 = Ronstar 25EC @ 2.0Lt/ha
H_4 = Ronstar 25EC @ 2.5 Lt/ha
H_5 = Lintur 70WG @ 0.20 Kg/ha
H_6 = Lintur 70WG @ 0.25Kg/ha
H_7 = Lintur 70WG @ 0.30 Kg/ha
H_8 = Lintur 70WG @ 0.35 Kg/ha
H_9 = Sencor 70WG @ 0.30 Kg/ha
H_{10} = Sencor 70WG @ 0.40 Kg/ha
H_{11} = Sencor 70WG @ 0.50 Kg/ha
H_{12} = Sencor 70WG @0.60Kg/ha

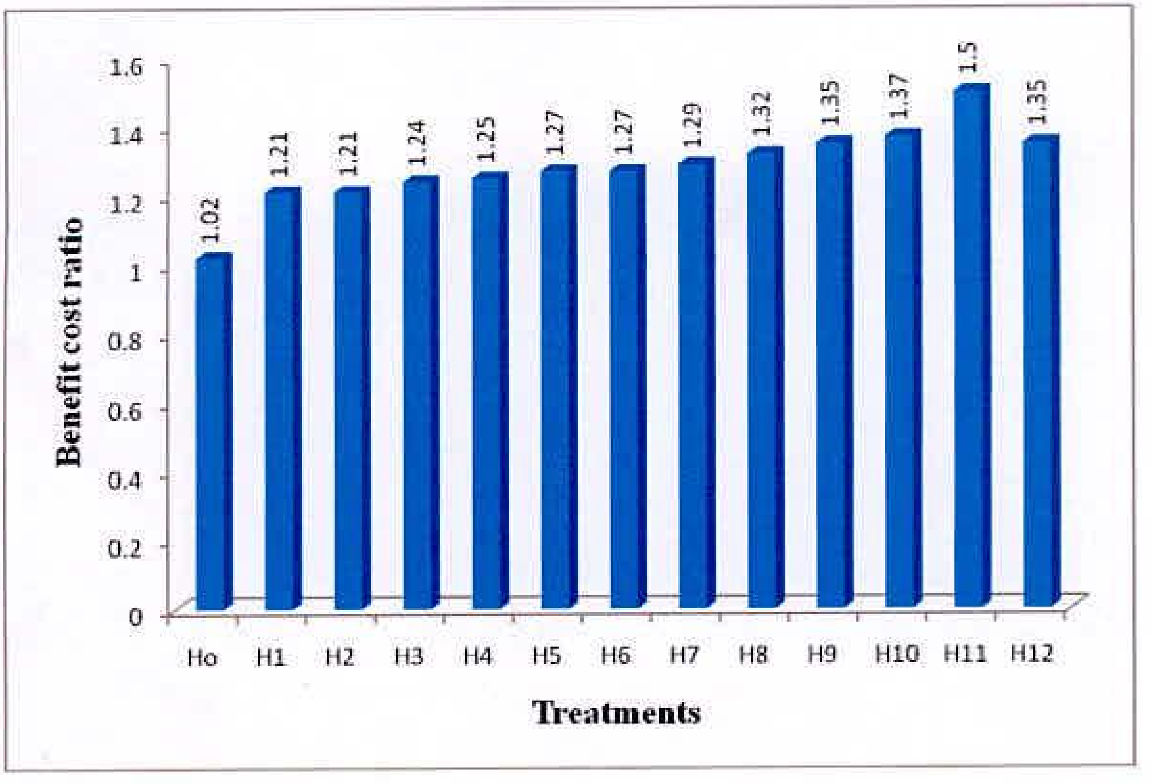


Fig. 2. Cost effectivity in cultivating wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur) (LSD = 0.1071)

Here,

Ho	=	Weedy Control	H_7	=	Lintur 70WG @ 0.30 Kg/ha
H_1	=	Ronstar 25EC @ 1.0Lt/ha	H_8	=	Lintur 70WG @ 0.35 Kg/ha
H_2	=	Ronstar 25 EC @ 1.5Lt/ha	H_9	=	Sencor 70WG @ 0.30 Kg/ha
H_3	=	Ronstar 25EC @ 2.0Lt/ha	H_{10}	=	Sencor 70WG @ 0.40 Kg/ha
H_4	=	Ronstar 25EC @ 2.5 Lt/ha	H_{11}	=	Sencor 70WG @ 0.50 Kg/ha
H_5	=	Lintur 70WG @ 0.20 Kg/ha	H_{12}	=	Sencor 70WG @0.60Kg/ha
H_6	=	Lintur 70WG @ 0.25Kg/ha			

Chapter 5
Summary and Conclusion

CHAPTER 5

SUMMERY AND CONCLUSION

The experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University (SAU) during the period from November, 2007 to March, 2008 to study the performance of herbicide (Ronstar, Sencor and Lintur) on weed suppression towards growth and yield of wheat .The experiment comprises twelve treatments viz.(i) Ronstar 25EC @ 1.0Lt/ha, (ii)Ronstar 25 EC @ 1.5Lt/ha, (iii) Ronstar 25EC @ 2.0Lt/ha, (iv) Ronstar 25EC @ 2.5 Lt/ha, (v) Lintur 70WG @ 0.20 Kg/ha, (vi) Lintur 70WG @ 0.25 Kg/ha, (vii) Lintur 70WG @ 0.30 Kg/ha, (viii) Lintur 70WG @ 0.35 Kg/ha, (ix) Sencor 70WG @ 0.30 Kg/ha, (x) Sencor 70WG @ 0.40 Kg/ha, (xi) Sencor 70WG @ 0.50 Kg/ha and (xii) Sencor 70WG @ 0.60Kg/ha along with control (weedy). The experiment was conducted in randomized complete block design (RCBD) with three replications.

The results showed that some of the crop characters such as plant height, number of tillers/plant, number of spikelets/spike, spike length, dry weight/plant, grain weight/spike, 1000 seed weight and yield were significantly affected due to application of different rates of different herbicides. The other parameters such as harvest index benefit cost ratio and dry weight of weed collected from the field was also significantly influenced by application of different rates of different herbicides.

The best plant height (91.39 cm), number of tillers/plant (6.10), number of spikes/plant (6.08), spike length (12.47 cm), dry weight/plant (42.58 g), 1000 seed weight (45.84 g) at harvest and grain yield (3.51 t/ha) was shown with Sencor 70WG @ 0.50 Kg/ha treated crop.

The results obtained from the experiment about harvest index, total net return and benefit cost ratio were remarkable. The highest harvest index (46.69%), total net return (23500.00 Tk/ha) and benefit cost ratio (1.50) was also achieved with the same treatment.

The experiment was conducted to know the effectiveness of herbicide at different rates of application. From this point of view it is revealed that the lowest weed infestation was observed from the two stages of weeding at 20 and 45 days after sowing (12.27 and 7.11 kg/ha respectively i.e. total dry weight of weed 19.38 kg/ha) with Sencor 70WG @ 0.60kg/ha treated plots and as a result of the lowest nutrient competition between crop and weed and was achieved comparatively higher growth, yield and yield contributing characters.

Thus the results obtained exhibited that all the treatments gave encouraging results in respect of yield and effectiveness of herbicide. Considering the cost of production and other associate functions it can be recommended that among the twelve treatments, Sencor 70WG @ 0.50 Kg/ha considered as the best treatment.

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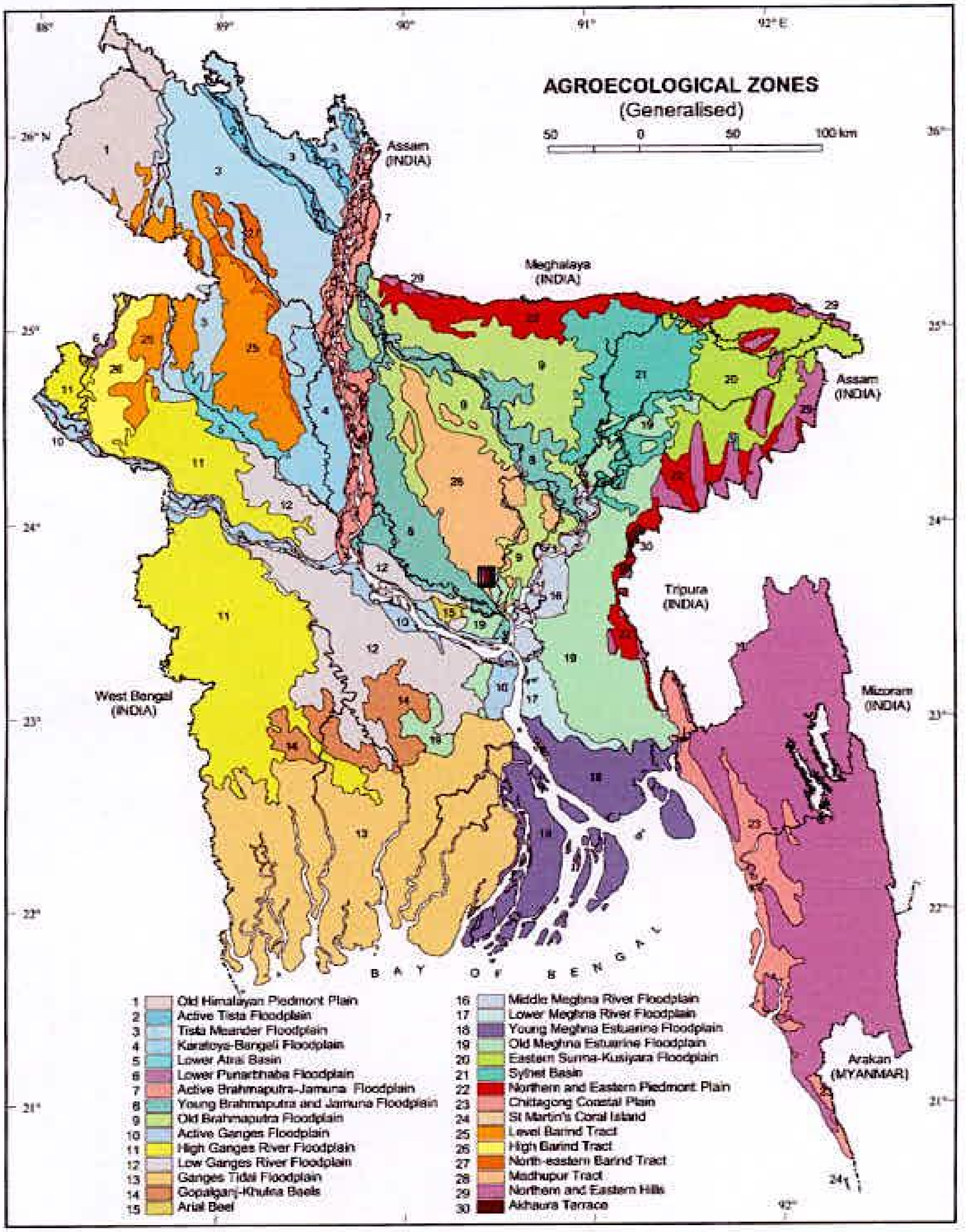
Appendices

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 [Source: Bangladesh Metrological Department, Agargaon, Dhaka]

Month	Year	Monthly average air temperature (^0C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
November	2007	36.00	29.50	32.75	69.11	318	1307.00
December	2007	34.80	30.80	32.80	70.00	288	1302.00
January	2008	24.31	13.65	18.978	72.90	159	1455.00
February	2008	25.92	14.11	20.015	62.78	170	1827.50
March	2008	31.59	22.15	26.867	59.13	258	1821.00

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

Appendix IV. Performance on plant height as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.692	9.316	0.02	1.01
Factor A	12	23.17*	72.64*	28.31*	29.04*
Error	24	3.859	2.807	2.667	1.052

Appendix V. Effect of herbicidal rates on tillers/plant in wheat

Source of variation	Degrees of Freedom	Mean square values of number of tillers/plant			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.008	0.002	0.002	0.001
Factor A	12	0.205	1.036	0.964	0.988
Error	24	0.008	0.011	0.002	0.002

Appendix VI. Performance on spike length of wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of spike length (cm)		
		60 DAS	90 DAS	At harvest
Replication	2	0.012	0.012	0.005
Factor A	12	0.93**	1.39*	2.01*
Error	24	0.017	0.013	0.051

Appendix VII. Performance on number of spikelets/spike as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of spikelets/spike		
		60 DAS	90 DAS	At harvest
Replication	2	0.014	0.022	0.201
Factor A	12	4.86*	2.84*	1.84**
Error	24	1.014	1.016	0.921

Appendix VIII. Dry matter yield (g/plant) of wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of dry weight/plant)			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.003	0.001	0.667	6.75
Factor A	12	2.014**	16.73*	28.64*	55.22*
Error	24	0.016	0.007	4.40	5.66

Appendix IX. Grain yield and yield parameters in wheat as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of grain yield and yield parameters				
		Grain weight/ spike (g)	1000 seed weight (g)	Grain yield (t/ha)	Harvest index (%)	Benefit cost ratio
Replication	2	0.02	1.00	1.12	6.75	1.28
Factor A	12	0.049**	16.30*	2.14*	31.57*	2.84*
Error	24	0.016	3.18	0.18	5.295	1.04

Appendix X. Dry matter yield of weed (kg/ha) as evaluated by the application rate of herbicides (Ronstar, Sencor and Lintur)

Source of variation	Degrees of Freedom	Mean square values of dry matter yield of weed (kg/ha)	
		20 DAS	45 DAS
Replication	2	0.001	2.05
Factor A	12	36.70*	12.58**
Error	24	2.112	0.786

Appendix XI. Rate of different input and output cost for the determination of cost of production

A. Rate of input cost

Sl. No.	Description	Rate
1.	Ploughing with tractor	3000.00 Tk./ploughing/ha
2.	Labour	120.00 Tk./labour/day
3.	Fertilizer	
	i. Compost	350.00 Tk./ton
	ii. Urea	12.50 Tk./kg
	iii. TSP	76.00 Tk./kg
	iv. MP	46.00 Tk./kg
	v. Gypsum	10.00 Tk./kg
	vi. Boric acid	10.00 Tk./kg
4.	Seeds (for sowing)	
	Wheat	30.00 Tk./kg
5.	Herbicide	
	a) Ronstar 25EC	250.00 Tk./100 ml
	b) Lintur 70WG	200.00 Tk./100 g
	c) Sencor 70 WG	300.00 Tk./100 g
6.	Irrigation	600.00 Tk./irrigation
7.	Interest of total input	12.00%
8.	Interest of cost of land	12.00%
9.	Miscellaneous	500.0 Tk./ha

B. Rate of output cost

Sl. No.	Description	Rate
1.	Wheat	20.00 Tk./kg