GROWTH AND YIELD OF HYBRID AND INBRED BORO RICE AFFECTED BY DIFFERENT WEED CONTROL METHODS

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CERTIFICATE

This is to certify that the thesis entitled, "**GROWTH AND YIELD OF HYBRID AND INBRED BORO RICE AFFECTED BY DIFFERENT WEED CONTROL METHODS"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY,** embodies the result of a piece of *bona fide* research work carried out by **SHAMIM AHAMED,** Registration No. **04-01430** 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 of during the course of this investigation has duly been acknowledged.

(Dr. Md. Hazrat Ali)

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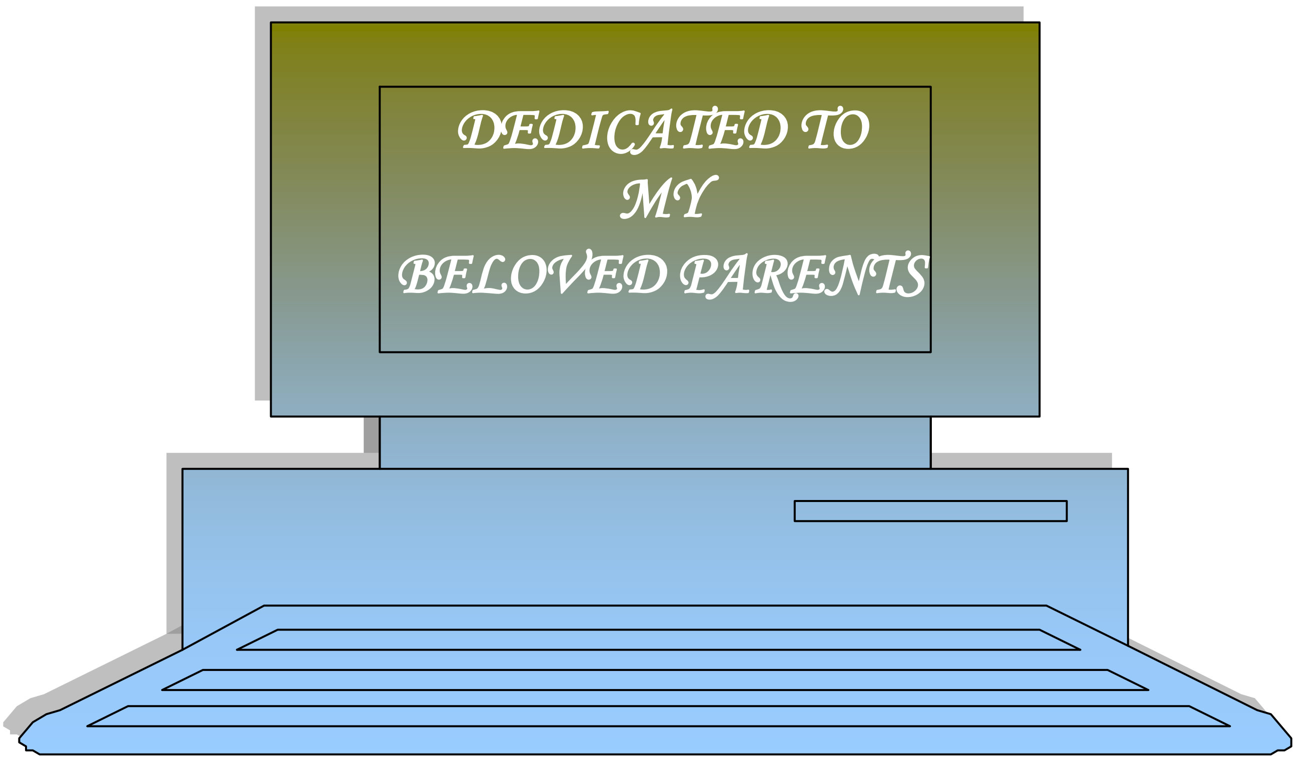
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The Author

GROWTH AND YIELD OF HYBRID AND INBRED BORO RICE AFFECTED BY DIFFERENT WEED CONTROL METHODS

ABSTRACT

A field experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2008 to May, 2009 to evaluate the Growth and yield of hybrid and inbred boro rice affected by different weed control methods. The experiment comprised of seven weeding treatments viz. no weeding, one weeding at 30 DAT (Days after transplanting), two weeding at 30 DAT and 50 DAT, application of herbicides: Sunrise 150WP recommended dose at 100g ha^{-1}, Sunrise 150 WP 25% higher than the recommended dose, Commit 500EC recommended dose at 1000ml ha^{-1}, Commit 500EC 25% lower than the recommended dose; boro rice varieties viz. Hira-6(hybrid), Sonarbangla-6(hybrid) and BRRI dhan29(inbred). The experiment was carried out in RCBD with three replications. Eight weed species belonging to four families were identified in the experimental field of which *Echinochloa colonum*, *Leersia hexandra, Cynodon dactylon, Cyperus rotundus, Scirpus mucronatus, Spilanthes acmella, Enhydra fluctuans* and *Desmodium trifolium.* Population density of weeds was recorded from 7 DAT to 50 DAT at 7 days interval. It was evident that among the weed control treatments, application of Sunrise 150 WP 25% higher than the recommended dose showed best performance in respect of the highest plant height (103.35cm), maximum tillers $hill^{-1}$ (22.00), the maximum plant dry matter (192.8g $hill^{-1}$), effective tillers $hill^{-1}$(20.34), lowest number of ineffective tiller $hill^{-1}$(1.33) and consequently produced highest grain yield (9.50 t ha^{-1}), straw yield (10.25 t ha^{-1}) and harvest index (41.16) in comparison all other treatments. Among the weed control treatments, Sunrise 150WP at 25% higher than the recommended dose control 81% weed population, where as Commit 500EC 55% and hand weeding only 52% which was costlier than others. The highest grain yield, straw yield as well as benefit cost ratio was obtained from the variety Sonarbangla-6(hybrid). Application of Sunrise 150 WP 25% higher than the recommended dose increased 22.63% higher grain yield than Commit 500EC 25% lower than the recommended dose and 34.9% higher grain yield than two hand weeding due to higher number of panicles $hill^{-1}$ and higher number grains $panicle^{-1}$.

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CHAPTER I

INTRODUCTION

Bangladesh is mainly an agricultural country and agriculture is the single largest producing sector of the economy and it contributes about 22% to the total Gross Domestic Product (GDP) of the country (BBS, 2008). Geographical and agronomic conditions of Bangladesh are favorable for rice (*Oryza sativa L.*) cultivation. Rice is the leading food for more than two billion people in Asia and for hundreds of millions of people in Africa and Latin America (IRRI, 1985). In Bangladesh rice occupies 10.58 million hectares of land which is about 77 percent of the cultivated area of rice (BBS, 2008). The population of Bangladesh will increase to 173 million in 2020 which is 31 percent higher than the present level (FAO, 1998). National Agricultural Commission says that to feed the increased population in 2020, about 47 million tons of rice will be needed to produce in the country. For food security of the country, rice production is needed to be increased from 3 tons ha^{-1} to 5 tons ha^{-1} in next 20 years (Mahbub *et al*., 2001).

In Bangladesh *boro* rice occupies around 4.61 million hectares of land which is around 43.57 percent of the total rice cultivation area (BBS, 2008).The yield of *boro* rice in Bangladesh is increasing than in other rice growing countries of the world (FAO, 2004). But the prevailing climatic and edaphic conditions are favorable for luxuriant growth of numerous species of weeds which offer a keen competition with rice crop. Different weed control methods are used to control weeds; depending on weed morphology, crops character management practices and other factors. Weed control and management practices also change with the development of agriculture and discovery of different mechanical and chemical weed control methods (Hutson and Roberts, 1987).

Weeds are the most destructive crop pest. Most of the weeds derive their nourishment through rapid development and manifested by quick root and shoot development. For the competitive abilities of weeds have a serious negative effect in crop production and responsible for marked losses in crop yield (Mamun *et al*., 1993). Weed competes with rice plants severely for space, nutrients, air, water and light. Weeds under adverse condition affects plant height, leaf architecture, tillering habit shading ability, growth pattern and life duration of rice cultivars. Poor weed control is one of the major factor for yield reduction of rice depending on the type of weed flora and their intensity (Amarjit *et al*., 1994). According to Isley (1960), the losses due to infestation of weeds are greater than the combined losses caused by insect, pest and diseases in rice. Mamun (1990) reported that weed growth reduced the grain yield by 68-100% for direct seeded aus rice, 22.36% for modern boro rice and 16-48% for transplanted aman rice. This loss is, therefore, a serious threat for the food deficit countries like Bangladesh. So, proper weed management is essential for rice production in Bangladesh.

To ensure proper rice growth and yield, weed control at optimum growing period is very important. Weed control efficiency depends on weed control method, time of weeding, nature of weeds and crops. The traditional methods of weed control in Bangladesh are tillage, hand weeding and racking in rice field which are time consuming, labour intensive and expensive as well (Chowdhury *et al*., 1995). Traditional weed control methods are effective when weeds are enough taller, land tillaging and laddering control weeds before planting but at early stage of growth these methods are not effective (Ahmed and Islam, 1983). Therefore, an effective, low cost and less labour intensive weed control method is essential for successful weed control in *boro* rice field which can ensure higher yield and profitable rice production. Chemical weed control has become popular in many rice growing countries in recent years due to its effectiveness and low cost. In Bangladesh, farmers have been practicing herbicidal control methods at very limited scale in rice field since the last decade.

A number of studies (Mandal *et al*., 1995; Gill *et al*., 1992; Panwar *et al*., 1992) showed that weed control through both traditional and chemical methods influence plant height, tiller number, crop growth rate, yield attributes and yield of boro rice. In some method while phytotoxicity was observed when chemical weed control treatment was used due to nonselective nature of herbicides as well as higher doses (Mercado, 1979). A weed control method will be sustainable and popular to farmers when it is economically beneficial for crop production. In boro rice cultivation a considerable portion of production costs is involved in weed control. Hand weeding and other traditional weed control methods involve high cost labour. In addition, at the peak period, availability of labour is getting season day by day a big problem. On the other hand, herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low cost involvement in comparison to the traditional methods of hand weeding (Mian and Mamun, 1969). From the above scenario, it was felt necessary to evaluate different weed control methods including chemical control in different boro rice cultivars in terms of crop growth, productivity, profitability and soil environment.

Therefore, the present experiment was conducted to achieve the following objectives:

1. Compare the efficiency of different weed management techniques on the growth and yield of hybrid and inbred *boro* rice.

2. Find out the effect of different methods of weed control in different *boro* rice varieties.

3. Determine the effect of different herbicides on weed control in growth and yield of *boro* rice.

4. Find out the economic benefit in controlling weeds with herbicides, hand weeding on different varieties of *boro* rice.

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice considerably depends on manipulation of basic ingredients of agriculture. The basic ingredients include variety, environment and agronomic practices (planting density, fertilizer, irrigation, weed management etc.). Among the above factors variety and weed management are more responsible for the growth and yield of rice. Hybrid and High yielding varieties (HYV) are generally more sensitive to weeds, they produce higher yield with weed free condition. The available relevant reviews related to variety and weed management in the recent past with rice and other crops have been presented and discussed under the following headings:

2.1 Effect of variety

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

2.1.1 Effect on growth characters

Plant height

Om *et al.* (1998) in an experiment with hybrid rice cultivars ORI 161 and PMS 2A x IR 31802 found taller plants, more productive tillers, in ORI 161 than in PMS 2A x IR 31802. BINA (1993) evaluated the performance of four rice varieties- IRATOM 24, BR14, BINA13 and BINA19. It was found that varieties differed significantly in respect of plant height.

BRRI (1991) reported that plant height differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in *boro* season. Hosain and Alam (1991) found that the plant height in modern rice varieties in *boro* season BR3, BR11, BR14 and pajam were 90.4, 94.5, 81.3 and 100.7 cm respectively.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mut. NSI and Mut. NSS were planted and found that plant height were greater in Mut. NSI than Nizersail. Shamsuddin *et al*. (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among varieties. Sawant *et al.* (1986) conducted an experiment with the new rice lines R-73-1-1, R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest.

Tillering pattern

Devaraju *et al.* (1998) in a study with two rice hybrids such as Karnataka Rice Hybrid 1 (KRH1) and Karnataka Rice Hybrid-2 (KRI42) using HYV IR20 as the check variety and found that KRH2 out yielded than IR20. In IR20, the tiller number was higher than that of KRH2.

Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10. Hossain and Alam (1991) also found that the growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in *boro* season. Idris and Matin (1990) stated that number of total tillers hill^{-1} was identical among the six varieties studied.

Leaf area index

Swain *et al.* (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index. Roy (1999) reported that in Nizersail, leaf area index peaked around panicle initiation stage and in BRRI Dhan 31, although maximum leaf area index was attained at or just before heading stage, the increase of leaf area index from panicle initiation stage to heading stage was only small.

Total dry matter production

Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) and was compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Son *et al.* (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, were evaluated at plant densities of 10 to 300 plants m^{-2} and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo regardless of plant density.

2.1.2 Effect on yield contributing characters

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling $hill^{-1}$, equal row spacing and 3 seedlings $hill^{-1}$, wide-narrow row spacing and one seedling $hill^{-1}$, and wide-narrow row spacing and 3 seedlings $hill^{-1}$) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Guilani *et al.* (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran, during 1997. Grain number $panicle^{-1}$ was not significantly different among cultivars. The highest grain number $panicle^{-1}$ was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

Devaraju *et al.* (1998) also reported that the increased yield of KRH2 was mainly attributed to the higher number of productive tillers $plant^{-1}$. Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23. BRRI (1994) studied the performance of BR14, BR5, Pajam, and Tulsimala and reported that Tulsimala produced the highest number of filled grains $panicle^{-1}$ and BR14 produced the lowest number of filled grains $penicle^{-1}$.

BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19. They found that varieties differed significantly on panicle length and sterile spikelets $panicle^{-1}$. It was also reported that varieties BINA13 and BINA19 each had better morphological characters like more grains $panicle^{-1}$ compared to their better parents which contributed to yield improvement in these hybrid lines of rice.

Chowdhury *et al.* (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers $hill^{-1}$. BRRI (1991) also reported that the filled grains $penicle^{-1}$ of different modern varieties were 95-100 in BR3, 125 in BR4, 120-130 in BR22 and 110-120 in BR23 when they were cultivated in transplant *aman* season.

Idris and Matin (1990) also observed that panicle length differed among the six rice varieties and it was longer in IR20 than in indigenous high yielding varieties.
Singh and Gangwer (1989) conducted an experiment with rice cultivars C-14-8, CR-1009, IET-5656 and IET-6314 and reported that grain number $panicle^{-1}$, 1000 grain weight were higher for C-14-8 than those of any other three varieties. Rafey *et al.* (1989) carried out an experiment with three different rice cultivars and reported that weight of 1000 grains differed among the cultivars studied. Shamsuddin *et al.* (1988) also observed that panicle number $hill^{-1}$ and 1000-grain weight differed significantly among the varieties. Kamal *et al.* (1988) evaluated BR3, IR20, and Pajam2 and found that number of grain $panicle^{-1}$ were 107.6, 123.0 and 170.9 respectively, for the varieties.

Costa and Hoque (1986) studied during kharif-II season, 1985 at Tangail FSR site, Palima, Bangladesh with five different varieties of T. *aman* BR4, BR10, BR11, Nizersail and Indrasail. Significant differences were observed in panicle length and number of unfilled grains panicle^{-1} among the tested varieties. BRRI (1979) reported that weight of 1000 grains of Haloi, Tilocha-Chari, Nizersail and Latisail were 26.5, 27.7, 19.6 and 25.0 g respectively.

2.1.3 Effect on grain yield and straw yield

Swain *et al.* (2006) also reported that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was at par with hybrid PA6201.

Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains panicle^{-1} and greater seed weight. Patel (2000) studied that the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively.

Julfiquar *et al*. (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *boro* season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. They also reported that thirteen rice hybrids were evaluated in three locations of BADC farm during the boro season of 1995-96. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}. Rajendra *et al.* (1998) carried out an experiment with hybrid rice cv. Pusa 834 and Pusa HR3 and observed that mean grain yields of Pusa 834 and Pusa HR3 were 3.3 t ha^{-1} and 5.6 t ha^{-1}, respectively.

BRRI (1997) reported that three modern upland rice varieties namely, BR 20, BR 21, BR 24 was suitable for high rainfall belts of Bangladesh. Under proper management, the grain yield was 3.5 ton for BR20, 3.0 ton for BR21 and 3.5 ton for BR24 ha^{-1}.

Nematzadeh *et al.* (1997) reported that local high quality rice cultivars Hassan Sarai and Sang-Tarom were crossed with improved high yielding cultivars Amol 3, PND160-2-1 and RNR1446 in all possible combinations and released in 1996 under the name Nemat, it gives an average grain yield of 8 t ha^{-1}, twice as much as local cultivars.

BRRI (1995) conducted an experiment to find out varietal performances of BR4, BR10, BR11, BR22, BR23 and BR25 varieties including to local checks Challish and Nizersail produced yields of 4.38, 3.18, 3.12, 3.12 and 2.70 5 t ha^{-1}, respectively. Chowdhury *et al.* (1995) studied on seven varieties of rice, of which three were native (Maloti, Nizersail and Chandrashail) and four were improved (BR3, BR11, Pasam and Mala). Straw and grain yields were recorded and found that both the grain and straw yields were higher in the improved than the native varieties. Liu (1995) conducted a field trial with new indica hybrid rice II-You 92 and found an average yield of 7.5 t ha^{-1} which was 10% higher than that of standard hybrid Shanyou 64.

In field experiments at Gazipur in 1989-1990 rice cv. BR11 (weakly photosensitive), BR22, BR23 and Nizersail (strongly photosensitive) were sown at various intervals from July to Sept. and transplanted from Aug. to Oct. Among the cv. BR22 gave the highest grain yield from most of the sowing dates in both years (Ali *et al.,* 1993). Chowdhury *et al*. (1993) also reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e., grain yield and straw yield.

Suprihatno and Sutaryo (1992) conducted an experiment with seven IRRI hybrids and 13 Indonesian hybrids using 1R64 and way-seputih. They observed that TR64 was highest yielding, significantly out yielding IR64616H, IR64618, IR64610H and IR62829A/IR54 which in turn out yielded way-seputih. Chandra *et al.* (1992) reported that hybrid IR58025A out yielded the IR62829A hybrids and the three control varieties Jaya, IR36 and hybrids IR58025A x 9761-191R and IR58025A IR58025Ax 1R35366-62-1-2-2-3R.

Hossain and Alam (1991) also studied farmers production technology in haor area and found that the grain yield of modern varieties of *boro* rice were 2.12, 2.18, 3.17, 2.27 and 3.05 t ha^{-1}, with BR14, BR11, BR9, IR8 and BR3, respectively.

In evaluation of performance of four HYV and local varieties-BR4, BR16, Rajasail and Kajalsail in *aman* season, BR4 and BR16 were found to produce more grain yield among four varieties (BRRI, 1985).

2.2 Effect of weeding

Weed is one of the limiting factors for successful rice production. Among various cultural practices, plant spacing play a vital role in the production and yield of rice through controlling the weeds as well as make the environment favourable for rice production. To justify the present study attempts have been made to incorporate some of the important findings of renowned scientists and research workers in this country and elsewhere of the world.

Weed vegetation in rice

Weed vegetation in crops is the result of cropping, cropping season, topography of land and management practices like time and degree of land preparation, plant spacing, time of planting date, fertilizer management, weeding method and intensities.

Venkatarama.n and Goplan (1995) observed that the most important weed species in transplanted low land rice in Tamil Nadu, India were *Echmochloa crus-galli*, *Cyperus difformis*, *Echinochloa Colonum*, *Cyperus iria*, *Fimbristylis miliacea*, *Scirpus* spp, *Echlipta alba*, *Ludwigia parviflora*, *Marsilea quatadrifolia* and *Monochoria vaginaliz*.

Bari *et al.* (1995) observed 53 weed species to grow in transplanted rice field. In respect of abundance value the three most important weeds were *Fimbristylis miliacea*, *Paspalum scrobiculaturm* and *Cyperus rotundus*. Mamun *et al.* (1993) from the same location identified 60 weed species in T. aman rice of which

Fimbristylis miliacea, *Lindernia antipoda* and *Eriocaulen cinereesm* were the most important weed species.

Elliot *et al*. (1984) reported that in transplanted rice *Monochoria vaginalis* was the important weed and other weed species were *Ischaemum rogusum*, *Scirpus supinus*, *Cyperus difformis*, *Ipomoea aquatica* and *Marsilea minuta*.

In the irrigated and rainfed area, Carbonell and Moody (1983) observed various weed species in transplanted rice in Nueva Ecija, Philippines. The most important weeds in the rainfed area were *Ischaemum rogusum*, *Fimbristylis miliacea*, *Echinochloa cars-galli* and *Monochoria vaginalis*.

Weed control efficiency

Weed control efficiency is one of the important measurements of weed control in crop field. High weed control efficiency throughout the growing period by a weed control treatment ensures proper crop growth and profitable weed control. Weed control efficiency varies with weed control technology.

Sharma and Bhunia (1999) reported that Pendimethalin @ 1.5 kg ha^{-1} plus one hand weeding resulted in highest weed control efficiency than any other treatments. Ahmed *et al*. (1997) reported that higher weed control efficiency (90.35%) was observed in herbicides with one hand weeding treatment than sole herbicides or conventional weed control methods. Weed control efficiency was higher in two hand weeding (90.67%) than dose of Oxadiazon and Cinosulfuron treatments (Alam *et al*., 1996).

In another experiment Singh and Bhan (1992) found that two hand weeding resulted better weed control efficiency (72.3%) than Butachlor @, 1.5 kg ha^{-1} (54.40%) in transplanted rice under medium land condition. Burhan *et al*. (1989) reported that Cinosulfuron @ 20 kg ha^{-1} resulted in 85% control of *Monochoria vaginalis*, *Marsileaa crenata*, *Cyperus* spp. *Fimbristylis miliacea* and *Scirpus juncoides* but only 50-60% control of *Echinochloa crus-galli* in transplanted rice.

Effect of no weeding

Gogoi *et al*. (2000) from Assam reported that different weed control practices significantly reduced the dry matter accumulation of weed and increased the rice yield over the unweeded control in transplanted rice.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest a grain yield was observed in the unweeded control in the scented rice variety Pusa Basmati-1. Singh *et al*. (1999) studied the effect of various weed management practices on the weed growth and yield and nitrogen uptake in transplanted rice and weeds and reported that weed control until maturity removed significantly higher amount of nitrogen through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT. Sanioy *et al*. (1999) observed that control of weeds played a key role in improving the yield of rice because of panicle m^{-2} increased 18% due to weed control over its lower level, number of filled grains $panicle^{-1}$ increased 32% due to weed control over its lower level and significant yield increase was observed (43%) with weed control.

Thomas *et al*. (1997) reported that rice weed competition for moisture was heavy during initial stages and yield losses from uncontrolled weeds might be as high as 74%. Kamalam and Bridgit (1993) reported that the average reduction in grain vield due to weed competition was 56 percent.

Effect of hand weeding

Ashraf *et al*. (2006) made an experiment in Lahore, Pakistan, during 2004 and 2005 kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000). In the second year the maximum control of weeds was 94.67% in the case of hand weeding. Regarding the number of tillers plant-1, hand weeding resulted in 20.8 weeding to 16.6 for the control in second year, whereas the highest number of grains per panicle was 135.50 during the second year. In terms of paddy yield, hand weeding gave the highest grain yield but remained statistically at par with certain herbicides.

Baloch *et al*. (2006) made an experiment in NWFP, Pakistan to evaluate the effect of weed control practices on the productivity of transplanted rice. Among weed management tools, the maximum paddy yield was obtained in hand weeding, closely followed by Butachlor (Machete 60EQ during both cropping seasons.

Manish *et al*. (2006) said that *Alternanthera triandra*, *Echinochloa colorer*, *Fimhristylis miliacea* and *Xanthium strumarium* were the dominant weeds associated with the transplanted rice crop. Results revealed that hand weeding at 15 and 30 DAT (days after transplanting) gave the highest grain yield, straw yield and harvest index. Maximum weed density and dry matter were recorded in the unweeded control, while the minimum values were obtained with hand weeding at 15 and 30 0 DAT.

Other than weed free condition, the highest grain yield (5.9 t ha^{-1}) was produced by BR 11 under two hand weeding. It was further identified to reduce the weed seed bank status in rice soils and rice grains to the lowest extent in both farmer's field as well as experimental field (Bijon, 2004).

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. The treatments were two hand weeding, Butachlor 2.0 kg ha^{-1} and Oxadiazon 0.8 kg ha^{-1}. They found that two hand weeding produced the highest ear length (23.49cm), number of grains ear^{-1}, grain yield (33.65 g ear^{-1}), straw yield (65.35 g ear^{-1}) and harvest index (33.97%).

Bhowmick (2002) said two hands weeding at 20 and 40 days after transplanting (DAT) in transplanted rice showed the highest control of weeds. Bhowmick *et al*. (2002) revealed that *Echinochloa crus-galli*, *Cyperus iria*, *Cyperus rotundus* were the dominant weeds in transplanted rice. He observed that two hand weeding at 20 and 40 days after transplanting were able to control almost all categories of weeds.

Chandra and Pandey (2001) showed that hand weeding was the most effective in mitigating the weed dry matter accumulation and also reported that higher grain and straw yield were obtained with hand weeding. Hossain (2000) observed experiment oriented impact of different weeding approaches on rice like one hand weeding, two hand weeding, three hand weeding, Oxadiazon, Oxadiazon in combination with one hand weeding and observed that yield and yield contributing traits in rice production had upgraded by degrees with the higher frequency of hand weeding.

Balaswamy (1999) found that hand weeding twice at 20 and 40 days after transplanting resulted in low weed numbers, followed by herbicides. Gogoi (1998) observed that Anilofos at 0.4 kg, ha^{-1} gave significantly higher yield and the yield was not significantly different from the hand weeding at 20 days after transplanting.

Nandal *et al*. (1998) evaluated the herbicide in direct seeded paddled rice during Kharif season. They observed that Pretilachlor (1.0 kg ha^{-1}) + hand weeding reduced weed population and weed dry weight significantly than other treatments. They also found that the highest grain yield and gross margin was obtained from the Pretilachlor (1.0 kg ha^{-1}) + hand weeding.

Angiras and Rana (1998) observed that greatest yield and desired weed control was achieved form the Pretilachlor (0.8 kg ha^{-1}) + hand weeding. BRRI (1997) reported that two hand weeding performed best than chemical treatments but two hand weeding gave the higher weeding cost than herbicidal treatments. Navarez *et al*. (1982) showed in rainfed condition that the lack of weed control in tall rice cultivars resulted in the yield reduction by 41% but one hand weeding at 40 days after transplanting reduced the grain yield by 31%.

Effect of mechanical weeding

Singh (2005) conducted an experiment at Bihar, India, during the wet season to assess the effectiveness of Beushening (a kind of mechanical weed control) in controlling weeds under rainfed lowland conditions as well as to make a comparison between Beushening and chemical weed control (i.e. 2,4-D and Butachlor). It was found that common practice of Beushening alone was not effective in controlling weeds of rainfed lowland rice but standard practice of Beushening along with one hand weeding 40 days after sowing, (DAS) was better in controlling weeds than other chemical treatments with or without one hand weeding 40 DAS and both (common and standard) practices of Beushening as effective as two hand weedings (25 and 40 DAS) in terms of grain yield, net return and benefit cost ratio.

Ahmed *et al*. (2003) said that Cinosulfuron, Pretilachlor and the BRRI push weeder performed better than farmer existing weed control practices of hand weeding with reduced weeding cost.

Sharma and Gogoi (1995) observed that the peg type dry land weeder and a twin wheel hoe gave best weed control which was comparable to that achieved with Butachor + hand weeding. Moorthy and Das (1992) stated that the paddy wheel hoe use twice resulted in the greatest weed control (80%), higher grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80%), highest grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80.7%) and grain yield (2.81 t ha^{-1}) but the paddy wheel hoe used gave twice higher straw yield (4.68 t ha^{-1}).

Kulmi (1990) stated that plots receiving cultural control methods, manual or rotary weeding at 40 and 35 days after transplanting resulted in lower weed densities (8.9-9.7 plants m^{-2}) and higher grain yield (18.5-20.3% above the unweeded control value of 2.36 t ha^{-1}) than the plot treated with 0.75-2.0 kg ha^{-1} Oxadiazon as pre-emergence at 6 days after transplanting or with 0.75-2.0 kg ha^{-1} Pretilachlor as post- emergence at 30 days after transplanting.

Chandra and Mama (1990) observed that rotary weeder controlled weeds effectively and increased grain yield by 29.7% and hand weeding also controlled weed successfully and increased yields. Islam and Haq (1987) concluded that use of a low cost weeder could eliminate 90% weeds in the sandy loam soil with a weed density of 375 m^{-2}

Singh *et al*. (1985) reported that two inter row cultivation with hand hoe plus hand, weeding in the row 14 and 28 days after emergence (DAE) resulted in equivalent yields with those from the weed control and there was no significant differences in grain yields between the plots where hand weeder used twice.

Effect of M.chlor 5 G (Common name: Butachlor)

Rangaraju (2002) in India determined the effect of herbicide application and application time on weed flora and weed dynamics of dry seeded rainfed rice and observed that application of either Butachlor at 1.5 kg a.i. ha^{-1} effectively controlled the weeds.

Gnanasambandan and Murthy (2001) studied the efficiency of pre-emergence herbicide Butachlor @1250 g ha^{-1} which was applied at 4 days after transplanting and reported that treatments effectively controlled weed density and increased grain yield. Rajkhowa *et al*. (2001) reported Butachlor 1.0 kg ha^{-1} applied three days after transplanting (DAT) significantly reduced weed infestation till 45 DAT and resulted in higher yield of rice over weedy check.

BRRI (1998) evaluated a new pre-emergence herbicide Golteer 5G (Butachlor) at Gazipur in transplanted aus rice and results indicated that hand weeding produced a slightly higher grain yield than Golteer application and weed biomass was lower in hand weeded plots followed by Golteer (Butachlor) treated plots.

Madhu *et al*. (1996) at Bangalore, to evaluate the effectiveness of four herbicides, pendimethylin, Anilofos, Butachlor and oxyfluorfen at 2 application rates during dry and wet seasons in paddled seeded rice field and the results showed that grain and straw yields were higher in the plots treated with Butachlor @ 1.5 kg, ha^{-1}.

Bhattacharya *et al*. (1996) reported that although the hand weeding treatment gave the highest grain yield, the results indicated that this was laborious, time consuming and costly and hand weeding, could be replaced by application of Butachlor at 1 kg a.i. ha^{-1}.

Savithri *et al*. (1994) observed the efficiency of different pre emergence herbicides in transplanted rice and they concluded that among the different herbicides, application of granular formulation of Butachlor @ 1.5 kg a.i. ha^{-1} six day after transplantation was found to be the most effective for controlling weeds in transplanted rice.

Effect of Oxastar 25 EC (Common name: Oxadiazon)

Jena *et al*. (2002) observed that weed control treatments reduced weed density, dry matter and increased rice yield and Oxadiazon gave better weed control. They also found that application of Oxadiazon with hand weeding gave the highest weed control efficiency, grain and straw yield and harvest index.

Gogoi *et al*. (2000) observed that combined weed control treatment like Oxadiazon 2.01 ha^{-1} + 1 hand weeding significantly reduced weed density and dry mater accumulation of weed and also increased grain yield (5.12 t ha^{-1}). Ahmed *et al*. (1999) compared Oxadiazon and Cinosulfuron with hand weeding control and observed that Oxadiazon and Cinsolfuron controlled weeds in rice effectively providing 91-92% and 90-92% weed control efficiency, respectively.

Agazzani *et al*. (1999) determined the best chemical control program against weeds in irrigated fields of dry sown rice. They found that effective weed control was obtained with pre emergence application 0f pendimethalin alone or mixed with thiobencarb and Oxadiazon followed by post-emargence treatment.

Chandra *et al*. (1998) observed that Oxadiazon 0.8 kg ha^{-1}, Butachlor 2 kg ha^{-1} and thiobencarb 2 kg ha^{-1} provided 80.5, 78.3 and 35.1% weed control respectively. They found that Oxadiazon and Thiobencarb increased grain yield. Among the herbicides, Oxadiazon was the most effective herbicidal treatments.

Razzaque *et al*. (1998) evaluated the efficiency of Oxadiazon as herbicide in transplanted aman rice. They observed that the application of Oxadiazon 2.01 ha^{-1} achieved effective control of all the weed masses growing in the field and produced significantly higher grain yield. Also they observed that application of Oxadiazon 2.01 ha^{-1} achieved the greatest profit.

Cinosulfuron and Oxadiazon showed better performance than Butachlor in terms of biomass and plant population and also stated two hand weeding gave the highest weeding highest weeding cost of herbicide treatment (BRRI, 1998).

Brar *et al*. (1997) assessed the efficacy of 0.5 kg Oxadiazon applied 5-15 days after transplanting compared to 0.3 kg Anilofos applied 3 days after transplanting (DAT) and hand weeding twice, for control of Echinochloa crus-gali in rice cv. PR-110 in sandy loam soil. Results indicated that best weed control and crop yield were achieved with Oxadiazon treatment applied < 10 DAT, these results were comparable to those achieved with Anilofos or hand weeding.

Samanta *et al*. (1995) observed the effectiveness of weed control by manual weeding and with Oxadiazon in transplanted aman rice (BR 11). Oxadiazon 2.0-4.0 1 ha^{-1} and manual weeding twice were found effective in reducing the dry matter of total weeds significantly over the control, but none of the treatments except manual weeding twice controlled Paspalum distichum effectively.

Prasad and Rafey (1995) observed that application of Oxadiazon at pre emergence and hoeing 30 days after sowing gave the maximum net return and showed a higher benefit cost ratio of 1.71. Chowdhury *et al*. (1995) observed the effect of Oxadiazon in weed management and growth and. yield of rice. Six different doses of Oxadiazon viz. 0, 1.5, 1.75, 2, 2.25 and 2.50 ha^{-1} were used to control weeds in rice. They found that Oxadiazon significantly reduced weed infestation and increased the yield of rice irrespective of the doses used. Out of these doses 2.0 ha^{-1} was found to be most effective with respect to all the studied parameters.

Singh and Singh (1994) observed that all weed control treatments decreased weed number and weed dry weight. The best weed control was given by Oxadiazon 0.4 kg a.i. ha^{-1} which gave the highest grain yield. Haque (1993) evaluated the efficiency of Oxadiazon in transplanted aman rice and observed that Oxadiazon 2.0 1 ha^{-1} controlled the weeds effectively and produced significantly the tallest plant, maximum effective tillers $hill^{-1}$ and grains $panicle^{-1}$. Biswas *et al*. (1991) evaluated that Oxadiazon 1.0 and 0.5 kc, a.i. ha^{-1} applied at 30 days after sowing with or without one supplemental hand weeding was compared with normal hand weeding and the results indicated that the use of Oxadiazon at 0.5 kg a.i. ha^{-1} was more economic than hand weeding for effective weed management.

Effect of Riffit 500 EC (Common name: Pretilachlor)

Samar *et al*. (2007) conducted an experiment to evaluate the effects of herbicides for managing weeds and optimizing the yield of wet seeded rice. It was concluded that application of Pendimethalin (1000 g a.i. ha^{-1}) or pretilachlor with Safener (500 g a.i. ha^{-1}) as pre-emergence applications followed by one hand-weeding were effective in controlling weeds, increasing grain yield of rice, and resulting in higher net returns than the weed-free treatment.

Raju *et al*. (2003) observed the effect of pre emergence application of Pretilachlor as Safener 0.3 kg ha^{-1}, Butachlor 1 kg ha^{-1} and post emergence herbicide like Butanil 3.0 kg ha-1 on 4, 8 and 15 days after Sowing. They found that Pretilachinr plus Safener 03 kg ha^{-1} gave the highest yield attributes (productive tillers m^{-2} number of grains $panicle^{-1}$ and 1000 grain weight) and gain yield. Mahajan *et al*. (2003) observed that application of Pretilachlor alone or in combination with Safener and hand weeding resulted in the lowest total weed density and dry matter and gain yield and number of panicles.

Kalhirvelan and Vaiyapuri (2003) observed the effect of weed management practices on transplanted rice. The application of Pretilachlor at 187, 250 or 375 g ha-1, Pretilachlor and 2, 4 D at 180 + 180, 240+ 240 and 300+ 300 g ha^{-1} with twice hand weeding. They found that and weeding recorded the lowest weed population (2.78 m^{-2}) and weed dry weight (155.7 g ha^{-1}). Pretilachlor and 2, 4-D at 300 00 + 300 g ha^{-1} caused the lowest weed density and weed dry weight. Hand weeding recorded the highest grain and straw yields (5.81 and 7. 26 t ha^{-1}, respectively), than Pretilachlor and 2, 4-D (5. 55 and 6.89 t ha^{-1})

Moorthy *et al*. (2002) investigated the efficacy of pre and post emergence herbicides in controlling weeds in rainfed upland direct sown rice. The application of Pretilachlor 625 g ha^{-1} and Butachlor 1600 g ha^{-1} on 2 days after sowing and the treatments gave effective weed control and produced highest grain yield compared with twice hand weeding on 20 and 40 DAT.

Islam *et al*. (2001) investigated the application of few doses of Pretilachlor (312.50-562.50 g a.i. ha^{-1} and one hand weeding in transplanted rice. They found that Pretilachlor (312.50-562.50 a.i. ha^{-1}) and hand weeding reduced weed population and dry matter weight.

Moorthy *et al*. (1999) observed the performance of the pre emergence herbicides pretilachlor + safener, Butachlor+ safener, Butachlor, Anilofos + ethoxysulfuron, thiobencarb and Anilofos for their efficiency to control weeds in direct sown rice under puddled soil condition. They observed that Pretilachlor + safener (0.4 kg ha^{-1} and 0.6 kg ha^{-1} Butachlor + safener (1.5 kg ha^{-1}) and Anilofos+ ethoxysulfuron (0.37+0.04 kg ha^{-1}) controlled the most dominant weeds (*Cyperits difforniis* and *Fimbristylis miliacea*) and produced yields comparable to those of the hand weeded control.

Rajendran and Kempuchetty (1998) observed the application of Thiobencarb 1.5 kg and hand weeding at 25 days after sowing, Pretilachlor 0.3 kg and hand weeding at 25 days after sowing as well as two hand weeding (25 and 45 days after sowing) in dry seeded low land rice cv. ADT 38. They found that the highest grain yield (5.5 t ha^{-1}) was achieved with Pretilachlor 0.3 kg + hand weeding treatment compared with Thiobencarb+ hand weeding (4.7 t ha^{-1} and 74.9%, respectively).

Mandal *et al*. (1995) reported the efficacy Pretilachlor as herbicide in comparison to hand weeding in BR 11 variety. The major weeds in the rice field were Cyperus iria, Scirpus muronatus, Monochoria hastata and Eletisine indica. The lower doses of Pretilachlor at 1.1 kg ha^{-1} failed to kill the weeds properly. The grain yield reduction due to weed infestation was 20.3 percent.

Effect of integrated weed management

Belz (2007) said since varietal differences in allelopathy of crops against weeds were discovered in the 1970s, much research has documented the potential that allelopathic crops offer for integrated weed management with substantially reduced herbicide rates. Research group worldwide have identified several crop species possessing potent allelopathic interference mediated by root exudation of allelochemicals. Rice, wheat, barley and sorghum have attracted most attention.

Otsuka *et al*. (2006) made an experiment to clarify the characteristics of the floristic composition with 3 different weed management techniques in Chiba, Japan. The mean number of species at quadrates in herbicide non-application paddy was significantly bigger than that in the herbicide application paddy fields.

Dhiman *et al*. (2006) showed that preemergence application of 1.5 kg Butachlor ha^{-1}+ hand weeding at 35 DAT reduced weed biomass significantly and recorded the lowest weed dry weight (31.77 g m^{-2}) and the highest weed control efficiency (81.40). All the other weed control methods recorded higher 1000-seed weight than the control while butachlor + one hand weeding recorded significantly higher filled grain (136.00 $panicle^{-1}$) and effective tillers (246.10 m^{-2}) than the other treatments. Butachlor + one hand weeding gave the highest grain yield (70.61 q ha^{-1}) straw yield inputs (84.13 q ha^{-1}) and additional net return (Rs. 3756 ha^{-1}).

Kalyanasundaram *et al*. (2006) conducted field experiments in Tamil Nadu, India, during the 2000 and 2001 kharif season to determine the suitable integrated weed management practice without causing any phytotoxicity to rice seedlings. 1.5 kg Butachlor ha^{-1} with Safener at 4 DAS + hand weeding at 30 DAS gave the highest number of panicles m^{-2}, filled grains $penicle^{-1}$, test weight and grain yield. All the Butachlorr with Safener combinations decreased weed dry weight significantly. Butachlor at 1.5 kg a.i. ha^{-1} without Safener applied at 4 or 8 DAS exhibited toxicity to rice seedlings.

A field experiment was conducted by Subramanian *et al*. (2006) in Tamil Nadu, India to study the effect of integrated weed management practices on weed control and yield of wet-seeded rice. Presowing application of Glyphosate (1.5 kg a.i. ha^{-1}) effectively reduced the sedges when combined with pre emergence application of Pretilachlor + Safener (0.4 a.i. ha^{-1}) followed by two hand weeding at 25 and 45 days after sowing.

Ranjit and Suwanketnikom (2005) initiated an experiment in 2002, Nepal to assess the performance of rice (*Oryza satires*) under dry direct seeded environment with different weed management treatments. Both Anilofos and Bispyribac-sodium reduced narrow leaf and broad leaf weeds compared with the unweeded control. No phytotoxic effect on the rice plants was observed due to herbicides, Anilofos + one hand weeding, hand weeded twice and Bispyribac-sodium alone gave higher yield compared with the unweeded control. Promising grain yield could be achieved with the Anilofos or Bispyribac- sodium with additional physical or mechanical control methods in dry direct seeded rice.

The maximum weed dry matter reduction was achieved under herbicide (Butachlor at 1.5 kg ha^{-1} plus two hands weeding in transplanted rice. The highest yield (4623 kg ha-1) was obtained with the application of herbicide supplemented with hand weeding in transplanted rice (Singh *et al.*, 2005).

Jena *et al*. (2002) reported that all weed control treatment reduced weed density, dry matter and nutrient uptake increased thus rice yield increased. Oxadiazon had better weed control than Thiobencarb and the preemergence application of Oxadiazon supplemented with hand weeding at 45 DAT recorded the highest weed control efficiency, grain and straw yields and harvest index.

Nair *et al*. (2002) observed that application of Butachlor @ 1.25 kg ha^{-1} along with one hand weeding 40 days after transplanting (DAT) recorded higher panicle m^{-2}, panicle length, grains $panicle^{-1}$ and 1000 grain weight and ultimately increased the grain yield. Singh *et al*. (1999) concluded that pre emergence spray of Anilofos + one had weeding at 40 days after transplanting significantly reduced the weed density and dry weight and resulted in higher net income and benefit: cost ratio.

Prasad and Rafey (1995) stated that integrated weed management was compared with weed free practice upto 60 days after sowing (DAS) and hoeing, three times with a wheel hoe for rice grain yield. Combined application of Oxadiazon at pre emergence + hoeing 30 DAS gave the maximum net return and showed a higher benefit: cost ratio of 1.71.

Kathiresan and Veerabadran (1991) studied the integrated weed management system of herbicide plus one hand weeding which was compared with manual weeding and herbicides alone, along with unweeded control. They observed that weed infestation was lower on integrated weed management plots which affected higher nutrient uptake by crop and consequently increased yield.

CHAPTER III

MATERIALS AND METHODS

Details of different materials used and methodologies followed in the experiment are presented in this chapter.

3.1 Description of the experimental site

3.1.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2008 to May, 2009. The location of the experimental site has been shown in Appendix I.

3.1.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcareous dark grey soil. The pH value of the soil was 5.6. The characteristics of the experimental soil have been shown in Appendix II.

3.1.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from April to September, but scanty rainfall associated with moderately low temperature prevailed during the period from October to March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the Dhaka meteorology centre, Dhaka for the period of experimentation have been presented in Appendix III.

3.2 Treatment

The experiment consisted of two factors as mentioned below:

1) Variety = V

V_1 = Hira-6 (hybrid)

V_2 =BRRI dhan29 (inbred)

V_3 = Sonarbangla-6 (hybrid)

2) Weed control methods=W

W_0 =No weeding (Control)

W_1= One weeding (30 Days after transplanting)

W_2= Two weeding (30 DAT & 50 DAT)

W_3= Sunrise 150 WG at recommended dose (100g ha^{-1})

W_4= Sunrise 150 WG at 25% higher than the recommended dose

W_5= Commit 500 EC at recommended dose (1000 ml ha^{-1})

W_6= Commit 500 EC at 25% lower than the recommended dose

The description of the weeding treatments is given below.

1) No weeding: Weeds were allowed to grow in the plots from transplanting to harvesting of the crop. No weeding was done.

2) One weeding: One hand weeding was done at 30 DAT.

3) Two weeding: One hand weeding was done at 30 DAT and second hand weeding was done at 50 DAT.

4) Sunrise 150 WG at the recommended dose: Sunrise 150 WG was applied at 100 g ha^{-1} at 7 DAT in 4-5 cm standing water.

5) Sunrise 150 WG at 25% higher than the recommended dose: Sunrise 150 WG was applied at 125 g ha^{-1} at 7 DAT in 4-5 cm standing water.

6) Commit 500 EC at the recommended dose: Commit 500 EC was applied at 1000 ml ha^{-1} at 7 DAT in 4-5 cm standing water.

7) Commit 500 EC at 25% lower than the recommended dose: Commit 500 EC was applied at 750 ml ha^{-1} at 7 DAT in 4-5 cm standing water.

3.3 Description of herbicides

A short description of the herbicides used in the experiment given below:

Trade name	Common name	Mode of action	Selectivity	Time of application
Sunrise 150 WG	Ethoxysulfuran	Systemic	For rice	Post emergence
Commit 500 EC	Pretilachlor	Systemic	For rice	Pre emergence

3.4 Planting Material and their description

Three rice varieties (Hira-6, Sonarbangla-6 and BRRI dhan29) were used as planting material.

Hira-6 (Hybrid)

Hira-6 (HS-48) is a high yielding hybrid variety of boro rice which was developed by the scientist of China. This variety was imported and marketed in Bangladesh by Supreme Seed Company Ltd. The unique character of this variety is that the plant is strong and stout, leaves are erect, broad leaved and plant height is 85 to 115 cm. It matures at 135-140 days after transplanting. It is shattering resistant. Grains are moderately course and white coloured. Under favorable environment its grain yield may be 7 to 11 ton ha^{-1}.

Sonarbangle-6 (Hybrid)

Sonarbangle-6 (HTM-4), a hybrid rice variety which produce higher yield than modern varieties, was imported and marketed in Bangladesh by A.R.Malik Seed Company, 145, Siddique Bazar, Dhaka-1000, Bangladesh from Hefei Fengle Seed Co. Ltd., China. The variety is photoperiod insensitive and could be cultivated in aus, aman and boro seasons. This variety has a yield potential of 36 to 45% over the conventional HYV. The variety matures within 120 to 130 days in boro season. It attains at a height of 90 to 100 cm with 15 to 20 or more tillers $hill^{-1}$. Its panicle length is higher than the HYV and local varieties and each panicle contains about 120 to 150 grains. Unfilled grains and shattering do not occur. The weight of 1000 grains weight of this variety 27 to 29 g and gives an average yield of 8.30 to 9.50 ton ha^{-1}.

BRRI Dhan29 (Inbred)

BRRI dhan29, a high yielding variety of *born* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line (BR802-118-4-2) of the variety was derived from a cross (BG902/BR51-46-5) and was released in 1994. It takes about 155 to 160 days to mature. It attains at a plant height of 95-100 cm and at maturity the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its bold grains, with a 1000-grain weight of about 29 g, grain length of 5.9 mm and grain width of 2.5 mm. The cultivar gives an average grain yield of 7.5 t ha^{-1} but its potentiality is more than that yield. The milled rice is medium fine and white. It is resistant to damping off and moderately resistant to blast and bacterial blight in terms of yield, this is the best variety so far released by BRRI (Anon., 2003).

3.5 Design and layout

The experiment was laid out in a randomized complete block design (factorial) with three replications. The size of the individual plot was 3.5 m x 2.5 m and total number of plots was 63. There were 21 treatment combinations. Each block was divided into 21 unit plots and the treatments were assigned in the unit plots at random. Lay out of the experiment was done on December 2, 2008 with inter-plot spacing of 0.75 m and inter block spacing of 1.0 m.

3.6 Seed collection, sprouting and sowing

Seeds of BRRI dhan29 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur and Sonarbangle-6 and Hira-6 were collected from A.R. Malik Seed Company and Supreme Seed Company respectively. Initially seed soaking was done in water for 24 hours and after wards they were kept tightly in jute sack air for 2 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed on December 04, 2008. Seed bed size was 10 m long and 1.5 m wide.

3.7 Land preparation

The experimental field was opened by a tractor driven rotavator 15 days before transplanting. It was then ploughed well to make the soil nearly ready for transplanting. Weeds and stubble were removed and the field was leveled by laddering. The experimental field was then divided into unit plots that were spaded one day before transplanting for incorporating the fertilizers applied as basal. Finally individual plot was prepared before transplantation.

3.8 Fertilizer application

The field was fertilized with urea, triple super phosphate, muriate of potash, and gypsum and zinc sulphate at the rate of 150, 100, 70, 60 and 10 kg ha^{-1} respectively. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated in soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT (BRRI, 2000).

3.9 Uprooting and transplanting of seedling

The seedbeds were made wet by the application of water both in the morning and evening on the previous day before uprooting. The seedlings were then uprooted carefully to minimize mechanical injury to the roots and kept on soft mud in shade before they were transplanted. The twenty five days old seedlings were transplanted on the well puddled experimental plots on December 30, 2008 by using three seedlings $hill^{-1}$in BRRI dhan29 and two seedlings $hill^{-1}$in Sonarbangle-6 and Hira-6.

3.10 Intercultural operations

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

3.10.1 Gap filling

Seedlings in some hills died off and those were replaced by healthy seedling within seven days of transplantation.

3.10.2 Weeding

Weeding was done as per the experimental treatment.

3.10.3 Irrigation and drainage

The experimental plots required two irrigations during the crop growth season and drainage was provided at the time of heavy rainfall or to remove excess water from the experimental field.

3.10.4 Plant protection measure

There were negligible infestations of insect-pests during the crop growth period. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 7.5 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control stem borer and rice bug.

3.11 Harvest and post-harvest operation

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. The crop was harvested plot wise at maturity on May 4, 2009 by cutting the whole plants at the ground level with sickle. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun. Before harvesting, five hills were selected randomly for each plot and cut at the ground level for collecting data on yield contributing characters.

3.12 General observations

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots. The crop started flowering at 80 DAT.

3.13 Detecting the panicle initiation stage and observation of heading

With experience, it was felt that identifying the panicle initiation stage should need to follow some special technique rather than mere field observations. Therefore, arrangements were made accordingly. The method of detection the panicle initiation stage involved the selection, dissection and inspection to the rice stems starting from maximum tillering stage (about 50 DAT) onwards. A tiller from the middle of the border hills of the unit plot was cut off at the base of the plant where the stem and root join. Then with a sharp blade carefully slice the stem lengthwise at the centre starting from the base up. If the panicle has started to develop a small growth, the beginning of the panicle like a tiny swollen spongy tip will be seen.

3.14 Collection of data

3.14. A Weed parameters

3.14.1 Weed density

The data on weed infestation as well as density were collected from each unit plot from 7 DAT to 50 DAT at 7 days interval. A plant quadrate of 1 m^2 was placed in each plot. The infesting species of weeds within each quadrate were identified and their number was counted species wise.

3.14.2 Crop growth parameters

i. Plant height (cm)

ii. Total number of tillers $hill^{-1}$

iii. Leaf area index (LAI)

iv. Total dry matter $hill^{-1}$(g)

v. Crop growth rate (g $hill^{-1}$ day^{-1})

vi. Relative growth rate (mg $hill^{-1}$ day^{-1})

3.14. 3 Yield and yield components

i. Plant height at harvest (cm)

ii. Total number of tillers $hill^{-1}$

iii. Number of effective tillers $hill^{-1}$

iv. Number of non effective tillers $hill^{-1}$

v. Total number of grains $panicle^{-1}$

vi. Number of filled grains $panicle^{-1}$

vii. Number of sterile grains $panicle^{-1}$

viii. 1000 gain weight (g)

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

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

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

xii. Harvest index (%)

3.15 Procedure of data collection for growth during the crop growth period

3.15.1 Plant height (cm)

The height of the rice plants was recorded from 20 days after transplanting (DAT) at 25 days interval up to 95 DAT, beginning from the ground level up to tip of the flag leaf was counted as height of the plant. The average height of five hills was considered as the height of the plant for each plot.

3.15.2 Total number tillers $hill^{-1}$

Total tiller number was taken from 20 DAT at 25 days interval up to 95 DAT. The average number of tillers of five hills was considered as the total tillers $hill^{-1}$.

3.15.3 Leaf area index (LAI)

Leaf area index were estimated measuring the length and width of the leaf and multiplying by a factor of 0.75 followed by Yoshida (1981).

3.15.4 Crop growth rate (g hill^{-1} day^{-1})

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

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ g hill}^{-1} \text{ day}^{-1}$$

Where, W_1= Total plant dry matter at time T_1

W_2 = Total plant dry matter at time T_2

3.15.5 Relative growth rate (mg hill^{-1} day^{-1})

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

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1} \text{ mg hill}^{-1} \text{ day}^{-1}$$

Where, W_1 = Total plant dry matter at time T_1

W_2 = Total plant dry matter at time T_2

Ln = Natural logarithm

3.16 Procedure of data collection for yield and yield components

For assessing yield parameters except the grain and straw yields data were collected from 5 randomly selected hills from each of the plots. For yield measurement, an area of 2 m^2 was harvested.

3.16.1 Plant height

Plant height was measured from the soil level to the apex of the leaf or panicle randomly 5 hills of each plot.

3.16.2 Total number of tillers hill^{-1}

The total number of tillers hill^{-1} was counted from selected samples and were grouped in effective and non effective tillers hill^{-1}.

3.16.3 Total grains panicle^{-1}

The number of filled grains panicle^{-1} plus the number of sterile grains panicle^{-1} gave the total number of grains panicle^{-1}.

3.16.4 Number of filled grains and sterile grains panicle^{-1}

Number of filled grains and sterile grains from randomly selected 5 hills were counted and average of which gave the number of filled grains and sterile grains panicle^{-1}. Presence of any food material in the grains was considered as filled grain and lacking of any food material in the grains was considered as sterile grains.

3.16.5 Weight of 1000 grains (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 5 hills of each plot and were dried in an oven at 14% moisture content and weight by using an electric balance.

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

Grain yield was determined from the central 2 m^2 area of each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis.

3.16.7 Straw yield (t ha^{-1})

Straw yield was determined from the central 2 m^2 area of each plot after separation of grains. Sub-samples were dried in the sun to a constant weight and finally expressed as t ha^{-1}.

3.16.8 Biological yield

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

3.16.9 Harvest index (%)

Harvest index is the relationship between grain yield and biological yield (Gardner *el al.*, 1985). It was calculated by using the following formula:

$$HI (\%) = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.17 Statistical analysis

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

3.18 Economic analysis

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

3.18.1 Input cost

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

A. Non-material cost (labour)

The human labour was obtained from adult male labourers. Eight working hours of a labourer was considered as a man day. The animal labour was obtained from bullocks. A period of eight working hours of a pair of bullocks was taken to be an animal day. The mechanical labour came from the tractor. A period of eight working hours of a tractor was taken to be tractor day.

B. Material inputs

The seed of test rice varieties (Hira-6, BRRI dhan29 and Sonarbangle-6) were purchased from BRRI Headquarter @ Tk.35 per kg (BRRI dhan29) and from the authorized dealer at local market @ Tk.240 per kg (Hira-6 and Sonarbangle-6). Chemical fertilizers eg. Urea, TSP, MoP, Gypsum and Zinc sulphate were bought from the authorized dealer at local market. Irrigation was given from the existing facilities of irrigation system of the Sher-e-Bangla Agricultural University field. Herbicides, fungicide and insecticide were bought from the respective dealers at local market.

3.18.2 Overhead cost

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

3.18.3 Miscellaneous overhead cost (common cost)

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

3.18.4 Gross return

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

3.18.5 Net return

Net return was calculated by using the following formula:

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

3.18.6 Benefit cost ratio (BCR)

Benefit cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Cost of production (Tk. ha}^{-1}\text{)}}$$

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from a study to investigate growth and yield of hybrid and inbred *boro* rice affected by different weed control methods. The results of the weed parameters, crop characters and economic evaluation of the production of the crop as influenced by different weed control treatments and varieties have been presented and discussed in this chapter.

4.1 Weed species infested in the experimental field

It is a general observation that conditions favourable for growing *boro* rice are also favourable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases. There were eight weed species belonging to four families were found to infest the experimental crop. Local name, scientific name, family, morphological type and life cycle of the weed species have been presented in Table 1. The density of weeds varied considerably in different weed control treatments and variety. The most important weeds of the experimental plot were *Echinochloa colonum, Cyperus rotundus, Scirpus mucronatus, Spilanthes acmella*. Among the eight species seven were grasses one was sedge (Table 1).

Table 1. Weed species found in the experimental plots in boro rice

Local name		Scientific name	Family	Lifecycle	Type
1	Khude shama	*Echinochloa colonum*	Gramineae	Annual	Grass
2	Arail	*Leersia hexandra*	Gramineae	Perennial	Grass
3	Durba	*Cynodon dactylon*	Gramineae	Perennial	Grass
4	Mutha	*Cyperus rotundus*	Cyperaceae	Perennial	Grass
5	Chechra	*Scirpus mucronatus*	Cyperaceae	Perennial	Sedge
6	Girakata	*Spilanthes acmella*	Compositae	Perennial	Grass
7	Helancha	*Enhydra fluctuans*	Compositae	Annual	Grass
8	Tripatri shak	*Desmodium trifolium*	Leguminosae	Annual	Grass

4.1.1 Weed density

4.1.1.1 Effect of variety

Weed density also varied considerably due to different varieties (Table 2). Among the varieties, the maximum weed density (100.50 m^{-2}) was found at 35 DAT in the inbred variety BRRI dhan29 (V_2) that was significantly different from other varieties. The lowest weed density was found in the hybrid variety Sonarbangle-6 (V_3) and then in the variety Hira-6 (V_1) in all DAT. In case of variety Sonarbangle-6 (V_3) and Hira-6 (V_3), weed density was increasing in 7 to 28 DAT but thereafter weed density sharply decreased at 35 to 49 DAT. From the experimental results it was evident that inbred (BRRI dhan29) variety allowed more weed population than hybrid varieties (Hira-6 and Sonarbangle-6).

Table 2. Weed density affected by different varieties on boro rice

Treatment	Weed density m^{-2}						
	7 DAT	**14DAT**	**21 DAT**	**28 DAT**	**35 DAT**	**42 DAT**	**49 DAT**
V_1	25.00	52.00	68.00	76.50	36.50	30.00	23.00
V_2	30.00	70.00	83.00	95.00	100.50	85.50	70.00
V_3	22.00	50.00	67.00	74.00	35.50	29.50	21.00
$LSD_{0,05}$	5.783	5.067	10.65	8.869	10.15	12.53	11.13
CV (%)	14.23	10.75	16.57	10.05	12.80	17.96	18.95

4.1.1.2 Effect of weed control methods

Weed density varied considerably due to different weed control treatments (Table 3). At 7 DAT, the highest weed density (30.00 m^{-2}) was found in the unweeded plot (W_0) which was significantly highest than that in other treatments. Ahmed *et al.* (1997) also reported similar results. The least number of weeds were found in the herbicidal treatments than hand weeding at 7 DAT. At 14 DAT, the highest weed density (64.33 m^{-2}) was found in the unweeded plot (W_0), which was significantly highest than that in other treatments. At 14 DAT, the weed density (no. m^{-2}) was sharply decreased in the herbicidal treatments but it increased in the hand weeding treatment plots. The treatment W_4 control 81% weeds population, where as W_6 Control 55%.

At 21 DAT, the highest weed density (85.67 m^{-2}) was found in the unweeded plot (W_0). The weed density (no. m^{-2}) was slowly increased in the herbicidal treatments. At 28 DAT, the highest weed density (113.00 m^{-2}) was found in the unweeded plot (W_0). The weed density (number m^{-2}) was increased in all other treatments. At 35 DAT, after one hand weeding the highest weed density (123.80 m^{-2}) was found in the unweeded plot (W_0) and only 52% weeds were controlled by the hand weeding. The weed density (number m^{-2}) was decreased in all other treatments at 42 DAT and 49 DAT due to the crop weed competition and weed mortality. Relatively lowest weed density (number m^{-2}) was found in the herbicidal treatment W_4 (Post emergence herbicide) than all other treatments. Similar findings were also reported by Trivedi *et al.* (1986), Rekha *et al.* (2002) and Bijon (2004).

Table 3. Weed density affected by different weed control methods on boro rice

Treatment	**Weed density m^{-2}**						
	7 DAT	**14DAT**	**21 DAT**	**28 DAT**	**35 DAT**	**42 DAT**	**49 DAT**
W_0	30.00	66.33	85.67	113.00	123.80	112.90	100.70
W_1	25.00	44.00	67.83	76.50	36.33	30.17	23.67
W_2	25.00	51.67	59.67	70.17	33.61	28.83	22.50
W_3	21.00	11.17	17.33	34.50	39.17	31.83	25.67
W_4	22.00	4.05	9.67	19.50	26.67	23.67	18.67
W_5	27.33	13.67	20.00	38.83	46.67	41.67	35.67
W_6	20.67	9.12	12.50	21.67	30.28	26.83	22.33
$LSD_{0,05}$	5.783	5.067	10.65	8.869	10.15	12.53	11.13
CV (%)	14.23	10.75	16.57	10.05	12.80	17.96	18.95

4.1.1.3 Interaction effect of variety and weed control methods

The interaction between different weed control treatments and varieties had significant effect on weed density at 7 to 49 DAT (Table 4). At 7 DAT, the highest weed density (35.00 m^{-2}) was found in V_2W_0 treatment combination (unweeded at BRRI dhan29 variety). Unweeded treatment resulted the highest weed density in all varieties throughout the growing season. At 14 DAT, the highest weed density (70.00 m^{-2}) was found in V_2W_0 treatment which was superior to the other treatment combinations. At 14 DAT, all the herbicidal treatments (W_3, W_4, W_5 and W_6) contributed to the lowest weed density. For the treatment combination of V_2W_4 (Sunrise 150 WG at 25% higher than the recommended dose in BRRI dhan29) contributed to the lowest weed density (3.65 m^{-2}) than the other weed management treatments. This was happened due to the herbicidal effect. Then the weed density (no. m^{-2}) was increased in all other treatments upto 35 DAT. The weed density (no. m^{-2}) was slowly increased in the herbicidal treatments. The weed density (no. m^{-2}) was decreased in all other treatments at 42 DAT and 49 DAT due to the crop weed competition and weed mortality.

Table 4. Interaction effect of variety and weed control methods on boro rice

Treatment	Weed density m^{-2}						
	7 DAT	14DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT
V_1W_0	30	70	83	95	100.5	85.5	70
V_1W_1	25	52	68	76.5	36.5	30	23
V_1W_2	22	62	67	74	35.5	29.5	21
V_1W_3	20	11	13	29.5	40.5	30	22.5
V_1W_4	22	4	9.5	16	20	15	9
V_1W_5	25	11	16	36	45	38.5	30
V_1W_6	22	8.35	12.5	19	27.5	22	17.5
V_2W_0	35	70	93	134	146	133.3	118.5
V_2W_1	20	35	75.5	78	37	30	23.5
V_2W_2	30	58	65	71.5	34	28.5	21.5
V_2W_3	15	7.5	13.5	34.5	42	37.5	30
V_2W_4	20	3.65	9	12.5	20	18.5	15
V_2W_5	22	12	17	43.5	50	45.5	40
V_2W_6	24	9	12	16	22	20	17.5
V_3W_0	25	59	81	110	125	120	113.5
V_3W_1	30	45	60	75	35.5	30.5	24.5
V_3W_2	25	35	47	65	31.33	25	21
V_3W_3	30	15	25.5	39.5	35.5	30	24
V_3W_4	24	4.5	10.5	30	40	37.5	32
V_3W_5	35	18	27	37	45	41	37
V_3W_6	16	10	13	30	41.33	38.5	32
$LSD_{0,05}$	**5.78**	**5.067**	**10.65**	**8.869**	**10.15**	**12.53**	**11.13**
CV (%)	**14.23**	**10.75**	**16.57**	**10.05**	**12.80**	**17.96**	**18.95**

4.2 Crop growth characters

4.2.1 Plant height

4.2.1.1 Effect of variety

The plant height of boro rice was significantly influenced by different varieties at 20, 45, 70 and 95 days after transplanting (DAT) (Fig. 1). The result revealed that at 95 DAT, the highest plant height (92.34 cm) was recorded in the hybrid variety (Sonarbangla-6) and the lowest height (89.09 cm) was in the inbred variety (BRRI dhan29) and the same trend of plant height for another hybrid variety (Hira-6) over inbred variety was obtained at 20, 45 and 70 DAT. In the initial stage of growth, the increase of plant height was very slow and then the crop remained in vegetative stage. The rapid increase of plant height was observed from 45 to 95 DAT. After reaching the maximum vegetative stage, the growth of plant became very slow. The inbred variety was about 4% taller at harvest compared to the hybrid variety. Anonymous (1998) and Rahman (2001) also observed tallest plant in the inbred varieties and shortest plant height in Sonarbangla-1.

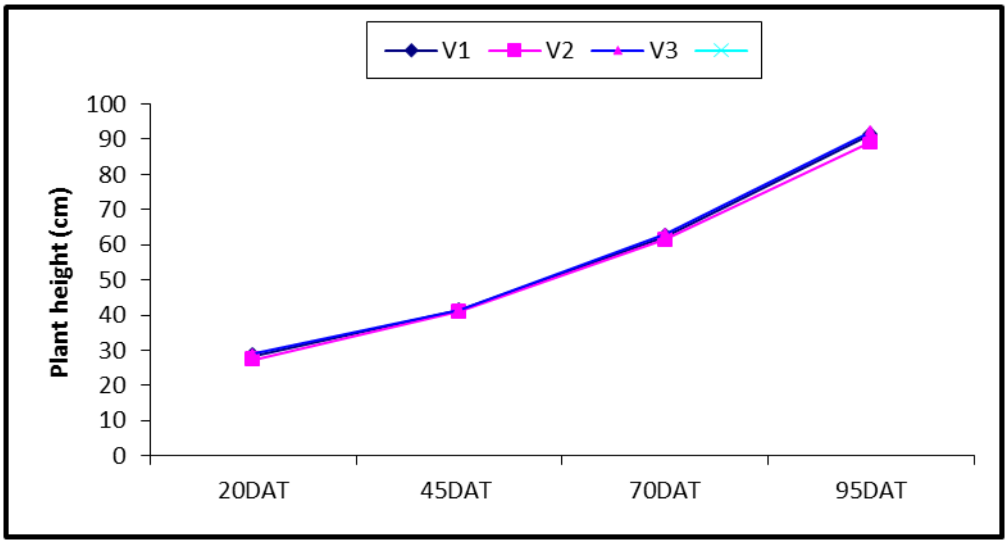


Figure 1. Effect of variety on plant height (cm) of boro rice at different days after transplanting ($LSD_{0.05}$ = 3.506, 5.137 10.55 and 7.526 at 20, 45, 70 and 95 DAT, respectively)

4.2.1.2 Effect of weed control methods

The height of the plant was significantly influenced by different weed control methods during the periods from 20 DAT to 95 DAT. The Fig. 2 showed that W_4 treatment produced the tallest plant in all dates of sampling and attained to its highest value (94.89 cm) at 95 DAT. The lowest plant height was observed at every sampling period in no weeding treatment (W_0). Results indicated that heavy weed infestation in the no weeding treatment might hamper the normal growth and development of rice and ultimately plants became shorter. Similar findings were also observed by Toufiq (2003) and Attalla and Kholosy (2002).

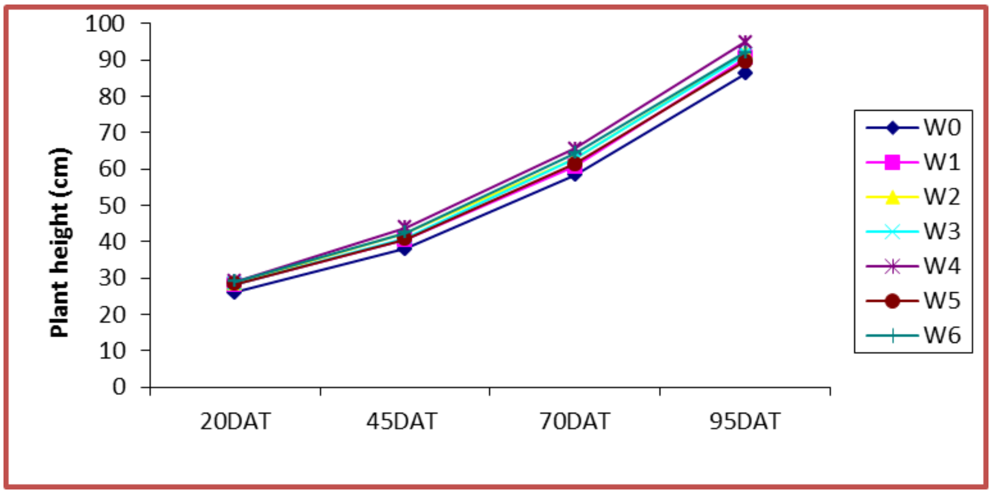


Figure 2. Effect of weed control methods on plant height (cm) of boro rice at different days after transplanting ($LSD_{0.05}$= 3.506, 5.137, 10.55 and 7.526 at 20, 45, 70 and 95 DAT, respectively)

4.2.1.3 Interaction effect of variety and weed control methods

Interaction effect of varieties and different weed control treatments had significant effect on plant height (Table 5). Plant height increased over time in all the treatment combinations of weed control and variety. In most of the cases the unweeded plot with all varieties (V_1W_0, V_2W_0 and V_3W_0) obtained the lowest plant height over day's upto 95 DAT. The treatments of V_1W_4, V_2W_4 and V_3W_4 contributed to almost highest plant height from 20 DAT to 95 DAT and V_3W_4 produced the height plant height among the three treatments. From the result it was clear that the herbicidal weed control treatments contributed to the maximum plant height than another weed control treatments.

Table 5. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	Plant height (cm)				
	20 DAT	45 DAT	70 DAT	95 DAT	AT HARVEST
V_1W_0	26.87	39.00	60.17	85.56	88.22
V_1W_1	27.00	40.00	60.32	89.78	89.11
V_1W_2	29.67	41.33	64.12	92.33	92.33
V_1W_3	28.33	40.01	61.20	91.89	90.89
V_1W_4	29.93	43.33	65.38	94.67	97.67
V_1W_5	27.13	40.67	62.45	91.55	91.56
V_1W_6	29.73	41.67	64.63	93.89	92.55
V_2W_0	25.73	38.00	57.45	87.00	90.00
V_2W_1	27.13	39.22	58.10	87.45	90.74
V_2W_2	27.60	39.78	61.90	90.00	92.37
V_2W_3	27.33	41.56	60.76	88.78	91.24
V_2W_4	28.20	43.34	66.52	92.00	95.11
V_2W_5	27.20	41.56	60.87	88.11	92.11
V_2W_6	27.73	42.45	64.74	90.22	93.56
V_3W_0	25.53	37.22	56.64	85.89	97.89
V_3W_1	29.00	41.89	61.24	88.78	98.11
V_3W_2	29.73	42.11	65.48	95.22	100.60
V_3W_3	29.67	41.67	60.09	92.89	100.35
V_3W_4	30.27	44.45	67.96	98.00	103.35
V_3W_5	28.73	42.33	61.75	90.00	99.89
V_3W_6	30.13	43.89	66.52	95.60	100.80
$LSD_{0,05}$	3.506	5.137	10.55	7.526	5.843
CV (%)	7.53	7.54	10.26	5.02	3.75

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.2.2 Total number of tillers hill^{-1}

4.2.2.1 Effect of variety

The production of total number of tillers hill^{-1} of *boro* rice was significantly influenced by different varieties at 20, 45, 70 and 95 DAT (Fig. 3). At 20, 45, 70 and 95 DAT, the maximum tiller number hill^{-1} was observed in the hybrid variety (Sonarbangla-6 and Hira-6) and the minimum number of tiller was obtained from the inbred variety (BRRI dhan29). Yoshida (1972) and Anon (1998a and I998b) reported that hybrid variety had more tillering capacity than inbred variety. Akbar (2004) and Rahman (2001) also reported that Sonarbangla variety ranked first in respect of total tillers hill^{-1} among the other studied cultivars.

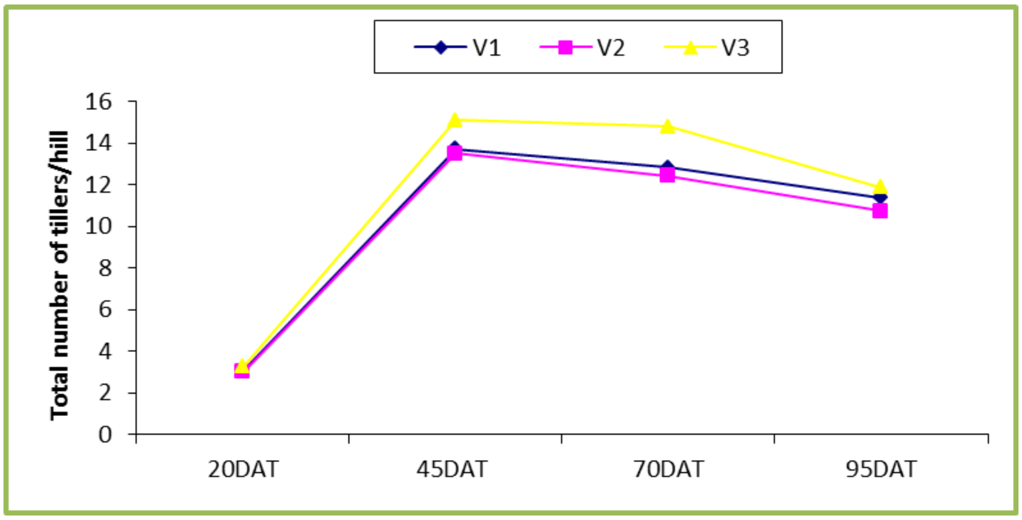


Figure 3. Effect of variety on total number of tillers hill^{-1} of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.489, 1.476, 1.926, and 1.934 at 20, 45, 70 and 95 DAT, respectively)

4.2.2.2 Effect of weed control methods

Different weed control treatments affected tiller production significantly. Tillers hill^{-1} increased gradually upto 45 DAT and then decreased in the all weed control treatments except W_2 and W_6 at 70 DAT due to Mortality of ineffective tillers at later stages (Fig. 4).Incase of unweeded treatment (W_0) tillers hill^{-1} decreased dramatically after 45 DAT, it might be due to high crop weed competition for light and nutrients. All weed control treatments contributed to significantly higher number of tillers hill^{-1} than unweeded and that trend continued throughout the growing period. At 45 DAT the highest number of tiller hill^{-1}(18.07) was found in W_4 (Ethoxysulfuran at 25% higher than the recommended dose) treatment which was significantly higher than all other treatments.

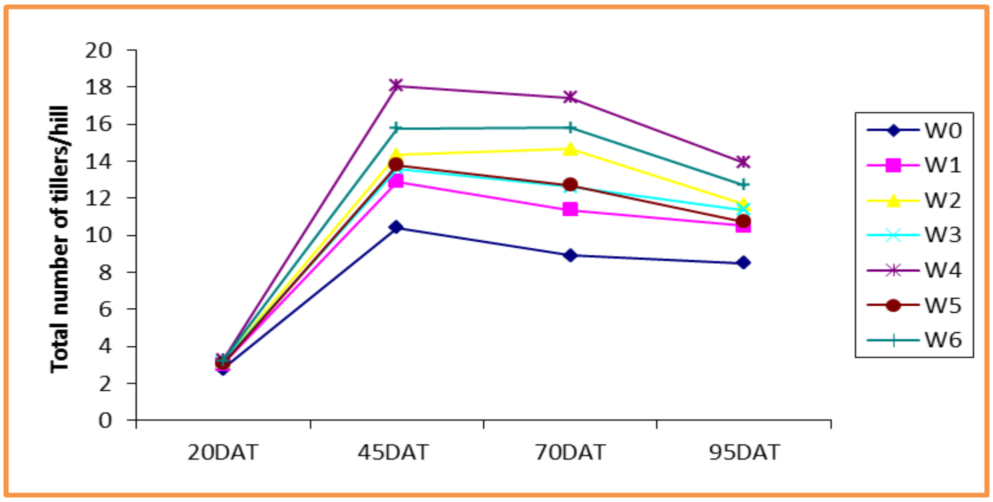


Figure 4. Effect of weed control methods on total number of tillers hill^{-1} of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.489, 1.476, 1.926 and 1.934 at 20, 45, 70 and 95 DAT, respectively)

4.2.2.3 Interaction effect of variety and weed control methods

The interaction effect of different weed control treatments and varieties significantly influenced the number of total tillers hill^{-1} at different DAT (Table 6). The hybrid variety (Sonarbangla-6) in each weed control treatment had the highest total tillers hill^{-1} at each sampling period and it reached maximum at 45 DAT and afterwards it declined with the advancement of crop growth duration. On the contrary, the inbred variety (BRRI dhan29) (V_2) in combination with all weeding treatments produced the lowest number of tillers hill^{-1} at each period. The treatments of V_1W_4, V_2W_4 and V_3W_4 contributed to almost maximum number of tillers hill^{-1} (16.89, 16.22 and 22.11 respectively) from 20 DAT to 95 DAT (Table 4). The highest number of tillers hill^{-1} (22.11) which was produced by the treatment W_4 (Ethoxysulfuran at 25% higher than the recommended dose) in combination with the hybrid variety (Sonarbangla-6).

Table 6. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	Total number of tillers $hill^{-1}$			
	20 DAT	**45 DAT**	**70 DAT**	**95 DAT**
V_1W_0	2.87	10.44	9.33	9.00
V_1W_1	2.93	13.11	11.22	10.45
V_1W_2	3.13	14.56	14.00	11.67
V_1W_3	3.00	13.56	12.89	11.11
V_1W_4	3.40	16.89	15.43	14.43
V_1W_5	3.00	13.67	12.45	10.89
V_1W_6	3.20	14.89	14.56	12.23
V_2W_0	2.73	10.22	8.11	7.78
V_2W_1	2.73	12.56	11.66	10.78
V_2W_2	3.07	14.00	13.55	11.33
V_2W_3	3.00	13.56	12.00	11.00
V_2W_4	3.20	16.22	14.89	11.67
V_2W_5	3.07	13.89	12.78	11.00
V_2W_6	3.20	14.22	14.00	11.55
V_3W_0	2.80	10.56	9.33	8.66
V_3W_1	3.13	13.00	11.26	10.00
V_3W_2	3.33	14.44	16.36	12.00
V_3W_3	3.20	13.67	12.90	11.69
V_3W_4	3.60	22.11	22.00	15.67
V_3W_5	3.33	13.78	12.83	10.33
V_3W_6	3.40	18.23	18.86	14.86
$LSD_{0,05}$	0.489	1.476	1.926	1.934
CV (%)	9.52	6.33	8.74	10.34

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.2.3 Leaf area index (LAI)

4.2.3.1 Effect of variety

Varietals effect significantly influenced leaf area index (LAI) of boro rice at 45 and 70 DAT, however it was not significantly influenced at 30 DAT (Fig. 5). At 45 and 70 DAT, the highest leaf area index (4.69, 5.65 and 4.36, 5.63 respectively) was found in the hybrid variety (Hira-6 and Sonarbangla-6 respectively) and the lowest leaf area index (4.10 and 5.40, respectively) was found in the inbred variety (BRRI dhan29). This might be due to the production of comparatively higher tillers hill^{-1} in the hybrid variety than the inbred variety which consequently decreased the number of leaves plant^{-1} and leaf area index. Takeda *et al.*, (1983) observed that high yielding rice varieties had higher LAI.

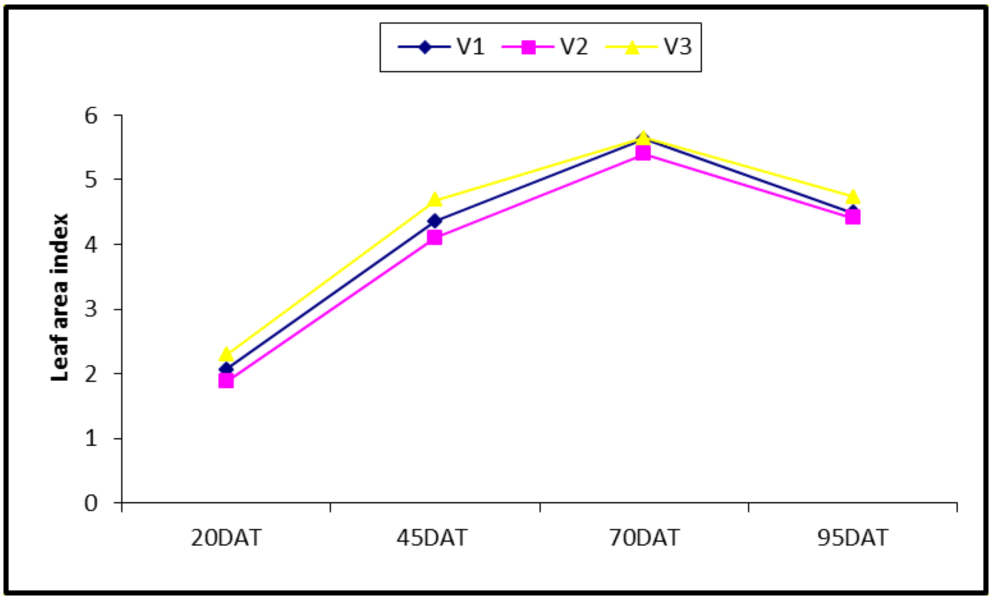


Figure 5. Changes in leaf area index of boro rice due to the effect of variety at different days after transplanting ($LSD_{0.05}$ = 0.565, 0.452, 0.215 and 1.09 at 20, 45, 70 and 95 DAT, respectively)

4.2.3.2 Effect of weed control methods

The rice crop under the experiment reached maximum LAI at 70 DAT. Weed control treatments showed significant variations in LAI throughout the growing periods. LAI increased upto 70 DAT for all weed control treatments and then decreased gradually (Fig. 6). AT 20 DAT, W_4 treatment gave the highest LAI (2.28) which was statistically similar to W_6 and W_2 but significantly different from other treatments. At 45 and 70

DAT, W_4 treatment gave the highest LAI (5.10 and 5.88 respectively) which was statistically similar with W_2 but significantly different from other treatments. At 95 DAT, W_4 treatment also gave the highest LAI but statistically similar to all other treatments. In all cases unweeded treatment gave the lowest LAI.

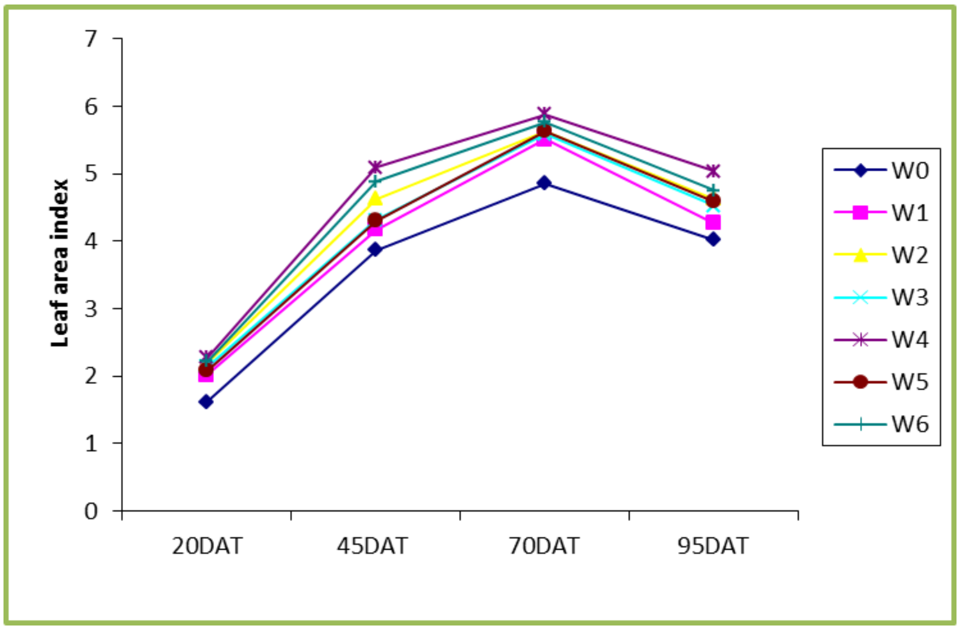


Figure 6. Changes in leaf area index of boro rice due to the effect of weed control methods at different days after transplanting ($LSD_{0.05}$ = 0.565, 0.452, 0.215 and 1.09 at 20, 45, 70 and 95 DAT, respectively)

4.2.3.3 Interaction effect of variety and weed control methods

The interaction of different weed management and variety had significant effect on LAI at all dates of observations (Table 7). Unweeded treatment in combination with all varieties produced the lowest LAI. Maximum LAI was found in all treatment combinations at 70 DAT. AT 70 DAT. the highest LAI (6.03) was found in V_3W_4 treatment which was statistically similar to V_1W_4 and V_3W_6 treatments (5.94 and 5.82 respectively). This result indicated that higher leaf area development occurred in the hybrid variety than the inbred variety in combination with herbicidal treatments.

Table 7. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	LAI			
	20 DAT	45 DAT	70 DAT	95 DAT
V_1W_0	1.61	3.66	4.94	4.08
V_1W_1	1.98	4.06	5.52	4.26
V_1W_2	2.16	4.57	5.72	4.54
V_1W_3	2.16	4.24	5.67	4.53
V_1W_4	2.25	5.00	5.94	4.88
V_1W_5	2.16	4.22	5.65	4.53
V_1W_6	2.18	4.75	5.58	4.64
V_2W_0	1.56	3.65	4.62	3.83
V_2W_1	1.94	4.15	5.40	4.12
V_2W_2	1.95	4.58	5.53	4.59
V_2W_3	1.95	4.16	5.47	4.39
V_2W_4	2.06	4.96	5.67	4.76
V_2W_5	1.70	4.26	5.44	4.50
V_2W_6	2.00	4.77	5.64	4.65
V_3W_0	1.68	4.29	5.03	4.16
V_3W_1	2.13	4.33	5.55	4.42
V_3W_2	2.47	4.74	5.77	4.75
V_3W_3	2.31	4.56	5.69	4.66
V_3W_4	2.54	5.34	6.03	4.48
V_3W_5	2.41	4.44	5.75	4.73
V_3W_6	2.49	5.14	5.82	4.96
$LSD_{0,05}$	0.565	0.452	0.215	1.09
CV (%)	16.41	6.12	2.32	14.53

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.2.4 Total dry matter hill^{-1}

4.2.4.1 Effect of variety

The total dry weight of plant was significantly influenced by variety at 70 DAT and 95 DAT but was similar at 20 and 45 DAT (Fig. 7). At 95 DAT, the hybrid variety Sonarbangla-6 produced higher dry weight (55.84 g hill^{-1}) compared to the inbred variety BRRI dhan29 (49.25 g hill^{-1}). At 20, 45, 70 and 95 DAT, the higher dry matter production was observed in the hybrid variety (Sonarbangla-6 and Hira-6) and the lower dry matter production was obtained from the inbred variety (BRRI dhan29).

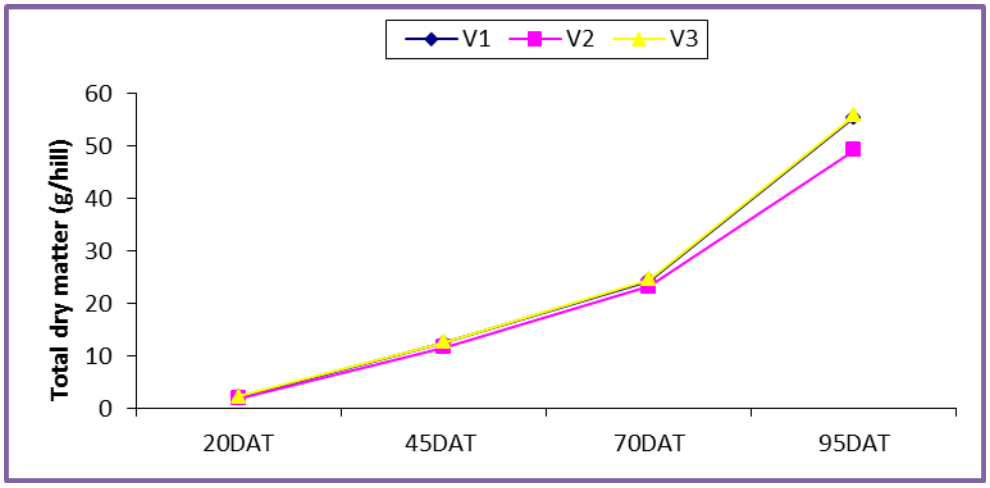


Figure 7. Effect of variety on total dry matter (g hill^{-1}) of boro rice at different days after transplanting (LSD$_{0.05}$ = 0.670, 2.536, 4.311 and 6.717 at 20, 45, 70 and 95 DAT, respectively)

4.2.4.2 Effect of weed control methods

Total dry matter (TDM) increased exponentially with time. TDM was significantly affected by different weed control treatments (Fig. 8). From the early stages distinct differences were visible among the weed control treatments in TDM production. The TDM production was increased upto 95 DAT. The lowest TDM throughout the growing period was observed in unweeded treatment (W_0). AT 95 DAT, W_4 treatment gave the highest TDM (60.57) which was statistically similar to W_6 but significantly different from other treatments.

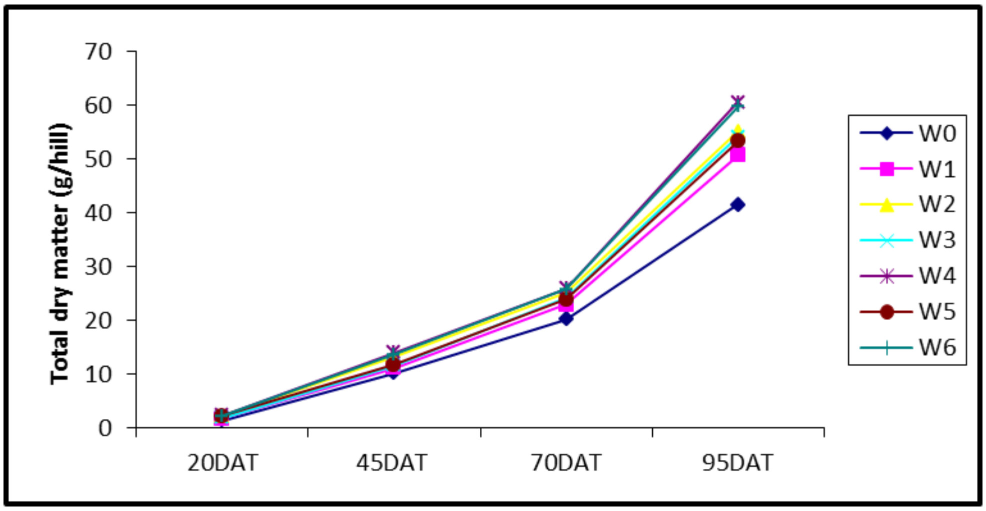


Figure 8. Effect of weed control methods on total dry matter (g hill^{-1}) of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.670, 2.536, 4.311 and 6.717 at 20, 45, 70 and 95 DAT, respectively)

4.2.4.3 Interaction effect of variety and weed control methods

The interaction of weed control treatments and variety had significant effect on TDM production throughout the growing period (Table 8). All the weed control treatments gave higher TDM over time at the hybrid variety and gave lower TDM at inbred variety. The V_3W_4 treatment produced the higher TDM from 20 DAT to 95 DAT (2.78, 14.85, 27.05 and 64.67 g hill^{-1} respectively). It might be due to the luxuriant growth of weeds in the treatment plot was well controlled by herbicide.

Table 8. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	Total dry matter (g $hill^{-1}$)			
	20 DAT	45 DAT	70 DAT	95 DAT
V_1W_0	1.06	11.09	21.83	39.60
V_1W_1	1.97	11.50	23.03	47.69
V_1W_2	1.81	13.54	25.00	55.57
V_1W_3	2.56	11.99	24.22	50.10
V_1W_4	2.20	14.03	26.45	63.50
V_1W_5	1.78	12.11	23.81	50.33
V_1W_6	2.01	13.86	25.74	58.03
V_2W_0	1.62	9.51	18.10	44.07
V_2W_1	2.06	10.93	22.82	50.70
V_2W_2	2.26	12.57	24.46	56.27
V_2W_3	2.76	10.96	23.79	55.23
V_2W_4	1.93	13.33	25.21	56.73
V_2W_5	2.12	11.32	23.51	52.93
V_2W_6	1.66	13.12	24.63	56.50
V_3W_0	1.70	10.19	20.73	40.97
V_3W_1	1.70	11.00	23.03	49.00
V_3W_2	2.69	13.68	25.45	62.97
V_3W_3	1.76	11.90	24.77	52.73
V_3W_4	2.78	14.85	27.05	64.27
V_3W_5	1.81	11.77	24.38	53.57
V_3W_6	2.77	13.94	26.83	63.87
$LSD_{0,05}$	0.670	2.536	4.311	6.717
CV (%)	19.78	12.55	10.87	7.60

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.2.5 Crop growth rate (CGR)

4.2.5.1 Effect of variety

The growth rate of rice crop was significantly influenced by variety at 20-45, 45-70 and 70-95 DAT (Fig. 9). At 70-95 DAT, the hybrid variety Sonarbangla-6 produced the highest CGR (1.305 g $hill^{-1}day^{-1}$) which was statistically similar to other hybrid variety Hira-6 but the inbred variety BRRI dhan29 produced the lowest CGR (0.998 g $hill^{-1}day^{-1}$). Same result found in the 20-45, 45-70 DAT.

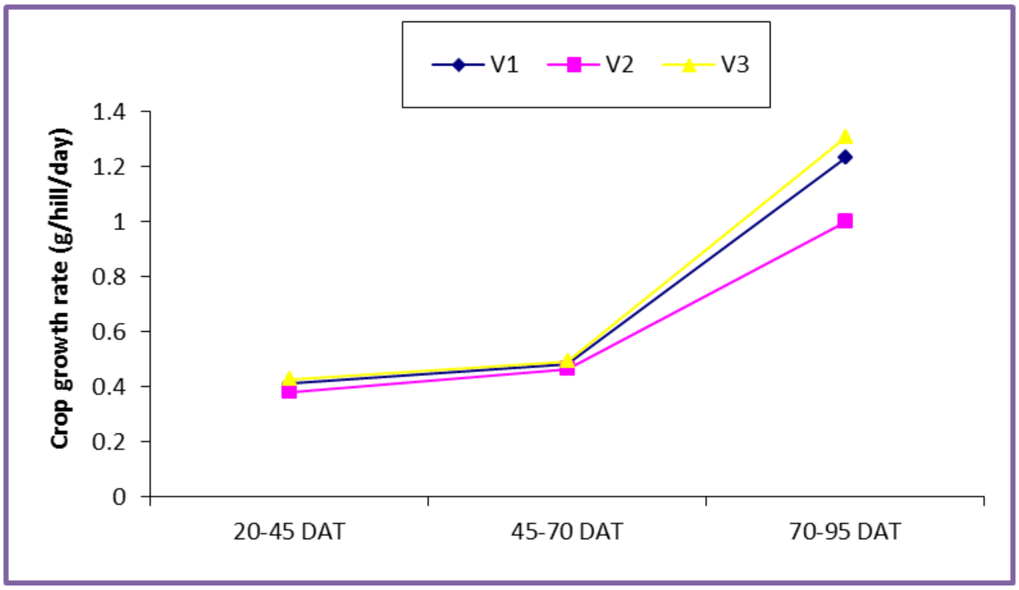


Figure 9. Effect of variety on crop growth rate (g $hill^{-1}$ day^{-1}) of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.1167, 0.1167 and 0.1731 at 20-45, 45-70 and 70-95 DAT, respectively)

4.2.5.2 Effect of weed control methods

The growth rate of rice crop was significantly influenced by different weed control treatments over time at 20-95 DAT. Unweeded treatment showed the lowest CGR throughout the growing period. It revealed that severe weed infestation might hamper the growth and development of rice plants drastically (Fig. 10). At 20-45 DAT, the treatment W_4 gave the highest CGR (0.472 g $hill^{-1}day^{-1}$) which was statistically similar to W_6 and statistically different from other weed control treatments. At 45-70 DAT, all the weed control treatments contributed to the superior CGR over the control treatment and the treatment W_4

gave the highest CGR (0.512 g hill^{-1}day^{-1}) which was statistically similar to other weed control treatments. At 70-95 DAT, treatment W_4 also gave the highest CGR (1.35 g hill^{-1}day^{-1}) which was statistically similar to W_6. From the results, it was seen that the higher CGR was obtained from 70-95 DAT. It might be due to the late season weed infestation which put adverse impact on CGR.

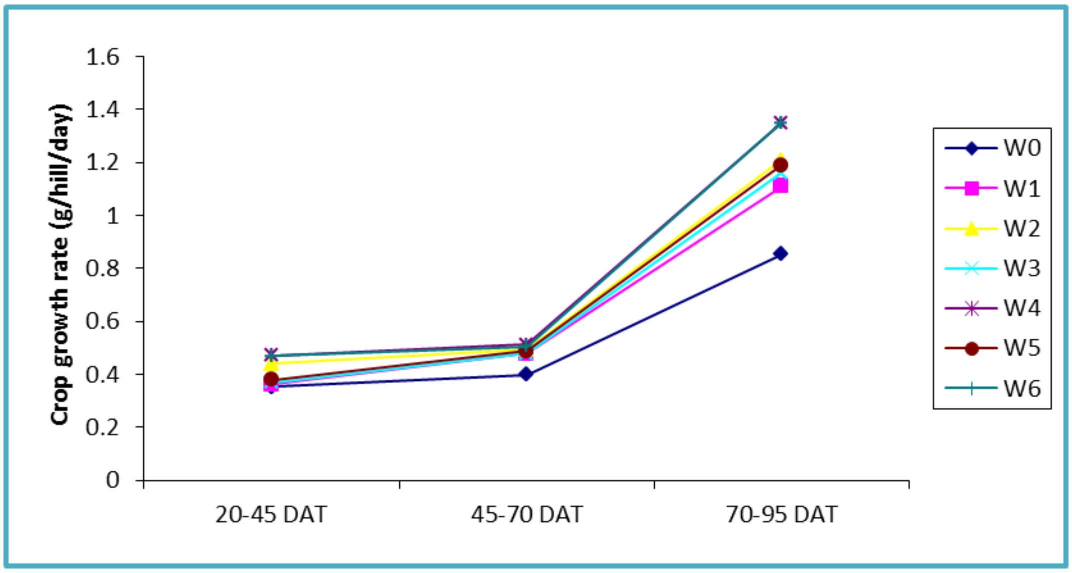


Figure 10. Effect of weed control methods on crop growth rate (g hill^{-1} day^{-1}) of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.1167, 0.1167 and 0.1731 at 20-45, 45-70 and 70-95 DAT, respectively)

4.2.5.3 Interaction effect of variety and weed control methods

The interaction of weed control treatments and variety significantly influenced the CGR throughout the growing period (Table 9). In most of the treatment combinations, CGR increased gradually upto 70-95 DAT. At the beginning of the crop growth (20-45 DAT), V_3W_4 showed the highest CGR (0.485 g hill^{-1}day^{-1}) which was statistically similar to W_6 and statistically different from other weed control treatments. At 45-70 DAT, V_3W_4 showed the highest CGR (0.539 g hill^{-1}day^{-1}). At 70-95 DAT, V_3W_4 gave the highest CGR (1.546 g hill^{-1}day^{-1}) among all the treatment combinations. It implied that several weed management effectively controlled the weeds in the hybrid variety than the inbred variety with the combination of herbicidal treatment.

Table 9. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	CGR (g hill^{-1} day^{-1})		
	20-45 DAT	45-70 DAT	70-95 DAT
V_1W_0	0.377	0.430	1.039
V_1W_1	0.381	0.461	1.166
V_1W_2	0.469	0.489	1.296
V_1W_3	0.401	0.488	1.272
V_1W_4	0.474	0.515	1.467
V_1W_5	0.413	0.468	1.282
V_1W_6	0.472	0.504	1.438
V_2W_0	0.316	0.344	0.711
V_2W_1	0.328	0.462	0.998
V_2W_2	0.412	0.488	1.051
V_2W_3	0.335	0.475	1.035
V_2W_4	0.458	0.513	1.061
V_2W_5	0.368	0.476	0.999
V_2W_6	0.456	0.496	1.061
V_3W_0	0.340	0.422	0.809
V_3W_1	0.360	0.471	1.039
V_3W_2	0.476	0.516	1.303
V_3W_3	0.406	0.481	1.278
V_3W_4	0.485	0.539	1.546
V_3W_5	0.372	0.504	1.285
V_3W_6	0.483	0.522	1.532
$LSD_{0,05}$	0.1167	0.1167	0.1731
CV (%)	16.70	14.18	8.93

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.2.6 Relative growth rate (RGR)

4.2.6.1 Effect of variety

The growth rate of rice crop was significantly influenced by variety at 20-45, 45-70 and 70-95 DAT (Fig. 11). At 20-45 DAT, the hybrid variety Sonarbangla-6 (V_3) produced the highest RGR (33.18 mg hill^{-1} day^{-1}) which was statistically similar to other hybrid variety Hira-6 (V_1) and the inbred variety BRRI dhan29 (V_2). At 45-70 DAT, the hybrid variety Sonarbangla-6 (V_3) produced the highest RGR (12.08 mg hill^{-1} day^{-1}) which was statistically similar to other hybrid variety Hira-6 (V_1) and the inbred variety BRRI dhan29 (V_2). At 70-95 DAT, the hybrid variety Sonarbangla-6 (V_3) produced the highest RGR (15.22 mg hill^{-1} day^{-1}) which was statistically similar to other hybrid variety Hira-6 (V_1) and statistically different from the inbred variety BRRI dhan29 (V_2).

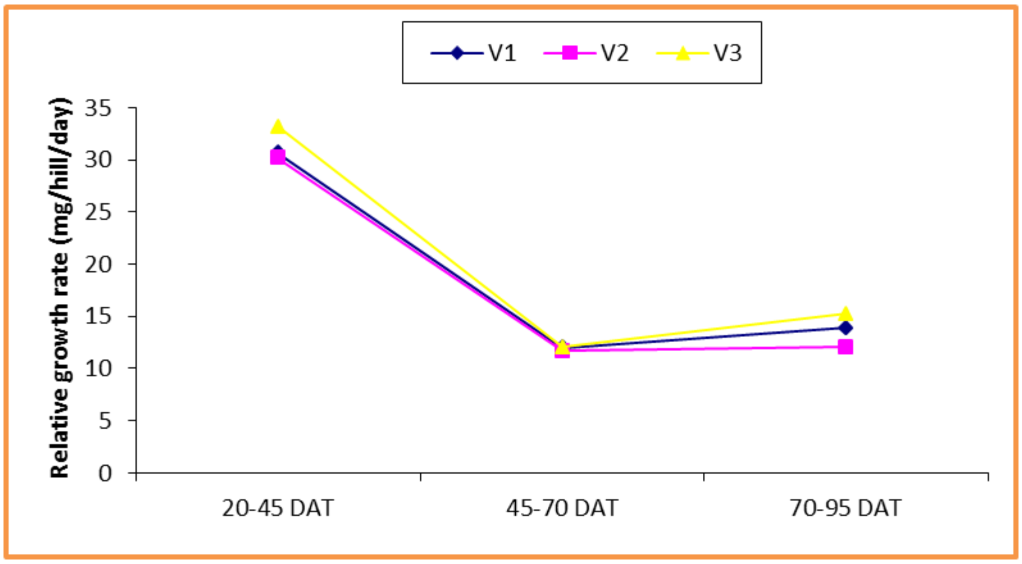


Figure 11. Effect of variety on relative growth rate (mg hill^{-1} day^{-1}) of boro rice at different days after transplanting ($LSD_{0.05}$ = 0.1167, 0.1167 and 0.1731 at 20-45, 45-70 and 70-95 DAT, respectively)

4.2.6.2 Effect of weed control methods

Relative growth rate was significantly affected by different weed control treatments over time. At 20-45 DAT, W_4 treatment gave the highest RGR (34.97 mg hill^{-1}day^{-1}) which was statistically similar with W_6 and statistically different from other weed control treatments. At 45-70 DAT, W_4 treatment gave the highest RGR (12.83 mg hill^{-1}day^{-1}) which was statistically similar to the other treatments. At 70-95 DAT, W_4 treatment gave the highest RGR (14.42 mg hill^{-1}day^{-1}) which was statistically similar to the other treatments RGR increased highly at 20-45 DAT and then it declined sharply at 45-70 DAT and very negligible increase at 70-95 DAT than 45-70 DAT (Fig.12). The highest RGR value (34.97 mg hill^{-1}day^{-1}) at 20-45 DAT came down to 11.15 mg hill^{-1}day^{-1} at 45-70 DAT. It revealed that weeds affected RGR of boro rice in the later stages of the crop. A similar finding was also reported by Ahmed *et al.* (1997).

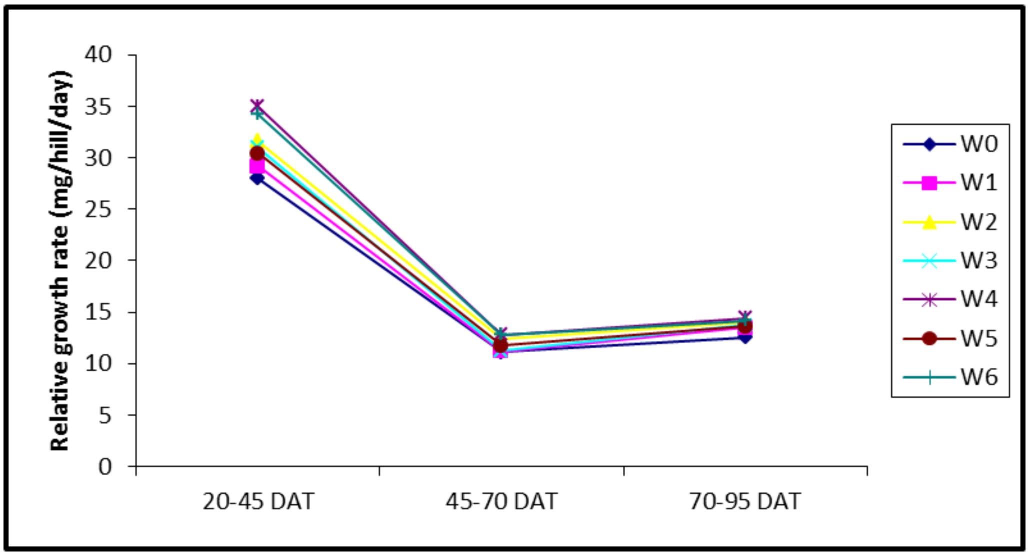


Figure 12. Effect of weed control methods on relative growth rate (mg hill^{-1} day^{-1}) of boro rice at different days after transplanting ($LSD_{0.05}$ = 5.311, 2.107 and 2.118 at 20-45, 45-70 and 70-95 DAT, respectively

4.2.6.3 Interaction effect of variety and weed control methods

The interaction between the weed control treatments and variety significantly influenced RGR in all dates of observations. During 20-45 DAT, highest RGR (40.79 mg hill^{-1} day^{-1}) was found by the treatment V_3W_4. During 45-70 DAT, highest RGR (13.76 mg hill^{-1}day^{-1}) was found by the treatment V_3W_4. During 70-95 DAT, highest RGR (16.29 mg hill^{-1}day^{-1}) was found in the treatment $V_3W_{4.}$ The initial high rate of RGR during the period of 20-45 DAT was observed from the results (Table 10). This might be due to the rapid tiller emergence of the crop during this period. A growing organ is consumer of photosynthetic and RGR is balanced between sources and sink (Khan *et al*,. 1981).

Table 10. Interaction effect of variety and weed control methods on growth attributes of boro rice

Treatment	RGR (mg hill^{-1} day^{-1})		
	20-45 DAT	45-70 DAT	70-95 DAT
V_1W_0	26.82	11.16	10.35
V_1W_1	30.65	11.23	11.78
V_1W_2	33.54	12.65	13.00
V_1W_3	32.16	11.43	12.63
V_1W_4	35.46	12.74	15.35
V_1W_5	33.31	11.76	12.77
V_1W_6	34.96	12.70	14.97
V_2W_0	23.96	10.98	11.78
V_2W_1	28.18	11.07	11.87
V_2W_2	30.75	11.76	14.47
V_2W_3	29.81	11.18	11.99
V_2W_4	33.57	12.34	14.94
V_2W_5	29.10	11.56	13.89
V_2W_6	33.20	12.06	14.60
V_3W_0	25.13	10.78	11.83
V_3W_1	28.25	11.22	13.12
V_3W_2	32.44	12.84	15.46
V_3W_3	29.11	11.25	14.40
V_3W_4	40.79	13.76	16.29
V_3W_5	31.11	12.12	14.60
V_3W_6	35.90	13.60	16.15
$LSD_{0,05}$	5.311	2.107	2.118
CV (%)	10.27	10.73	9.35

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.3 Yield and yield contributing characters

4.3.1. Plant height at harvest

4.3.1.1 Effect of variety

Plant height was significantly influenced by variety. The hybrid variety Sonarbangla-6 (V_3) produced the highest plant height (99.29 cm) compared to the other hybrid variety Hira-6 (V_1) (92.16 cm) and the inbred variety BRRI dhan29 (V_2) (91.76 cm) (Fig. 13). Interplant competition for nutrients, space, water and light might be responsible for this stunted growth. Similar results were also found by Ayub *et al*. (1987) and Nurujjaman (2001).

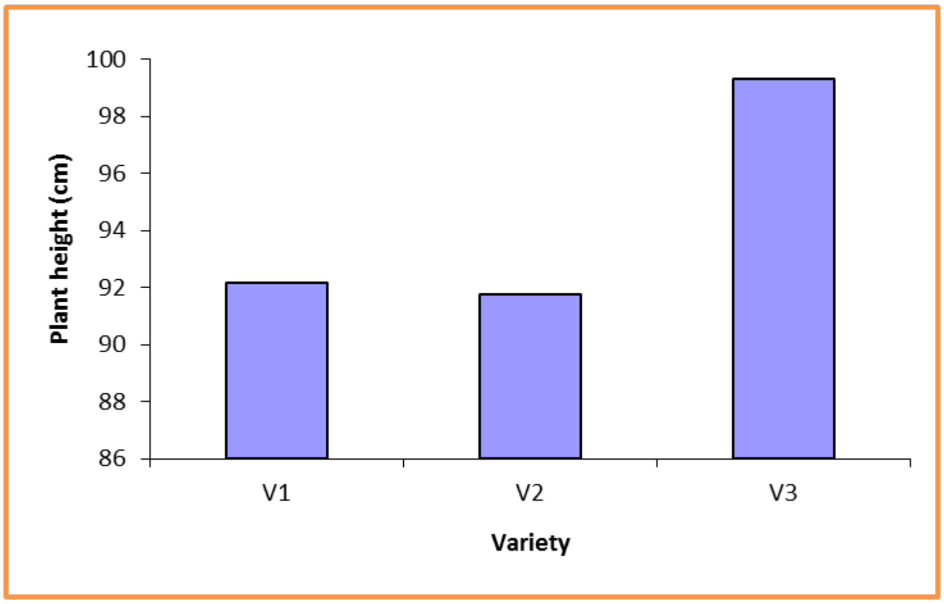


Figure 13. Effect of variety on plant height (cm) at harvest of boro rice ($LSD_{0.05}$ = 5.843 at harvest)

4.3.1.2 Effect of weed control methods

Plant height was significantly influenced by weed control treatments (Fig. 14). There were no significant differences among the treatments. Numerically W_4 the herbicidal treatment gave the maximum plant height (95.97 cm). The lowest plant height (93.64 cm) produced in no weeding treatment (W_0) which was significantly inferior to rest of the weed control treatments. Treatment W_2 and W_5 produced similar plant height (94.59 cm and 94.56 cm respectively) which were superior to W_1 and W_3 treatments but inferior to herbicidal treatments W_4 and W_6. Similar results were also reported by Patil *et al.* (1986), Atalla and Kholosy (2002) and Toufiq (2003).

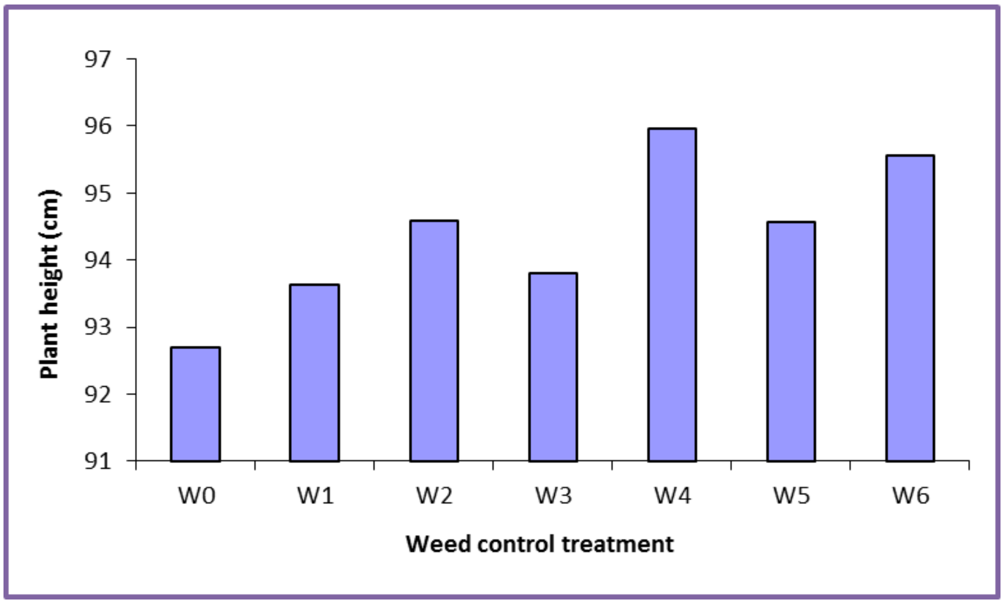


Figure 14. Effect of weed control methods on plant height (cm) at harvest of boro rice ($LSD_{0.05}$ = 5.843 at harvest)

4.3.1.3 Interaction effect of variety and weed control methods

Interaction effect of plant variety and different weed control treatments had significant effect on plant height (Table 11). It was found that the hybrid variety Sonarbangla-6 (V_3) produced the highest plant height with the combination effect of the herbicidal treatment (W_4). From the overall treatment combinations, V_3W_4 gave the highest plant height (103.35 cm) which was statistically dissimilar to the other treatment combinations. In all the varieties plant height was lower in no weeding treatment (W_0) compared to weeded treatments. Similar observation was found by Nurujjaman (2001).

Table 11. Interaction effect of variety and weed control methods on yield and yield contributing characters of boro rice

Treatment	Plant height (cm)	Total tillers $hill^{-1}$ (No.)	Effective tillers $hill^{-1}$ (No.)	Ineffective tillers $hill^{-1}$ (No.)
V_1W_0	88.22	10.87	8.87	2.00
V_1W_1	89.11	12.00	10.22	1.78
V_1W_2	92.33	13.92	12.48	1.44
V_1W_3	90.89	12.77	11.22	1.55
V_1W_4	97.67	16.47	15.80	0.67
V_1W_5	91.56	13.81	12.26	1.55
V_1W_6	92.55	14.66	13.44	1.22
V_2W_0	90.00	11.39	8.06	3.33
V_2W_1	90.74	14.23	11.56	3.33
V_2W_2	92.37	16.97	15.08	1.71
V_2W_3	91.24	16.00	14.11	2.67
V_2W_4	95.11	18.14	16.78	1.56
V_2W_5	92.11	15.67	13.78	2.00
V_2W_6	93.56	17.30	15.55	1.74
V_3W_0	97.89	10.11	7.67	2.44
V_3W_1	98.11	12.34	10.45	1.89
V_3W_2	100.60	15.96	14.52	1.44
V_3W_3	100.35	14.34	12.45	1.89
V_3W_4	103.35	21.56	20.34	1.22
V_3W_5	99.89	12.89	11.33	1.56
V_3W_6	100.80	18.10	16.77	1.33
$LSD_{0,05}$	5.843	2.053	1.408	0.509
CV (%)	3.75	8.44	6.57	16.88

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.3.2 Total number of tillers hill^{-1}

4.3.2.1 Effect of variety

Production of total tillers hill^{-1} was significantly affected by variety (Fig 15). Results showed that, the hybrid variety Sonarbangla-6 (V_3) produced maximum number of tillers hill^{-1} and the minimum was obtained from the inbred variety BRRI dhan29 (V_2). The variation in the production of total tillers might be due to genetic constituents of the varieties.

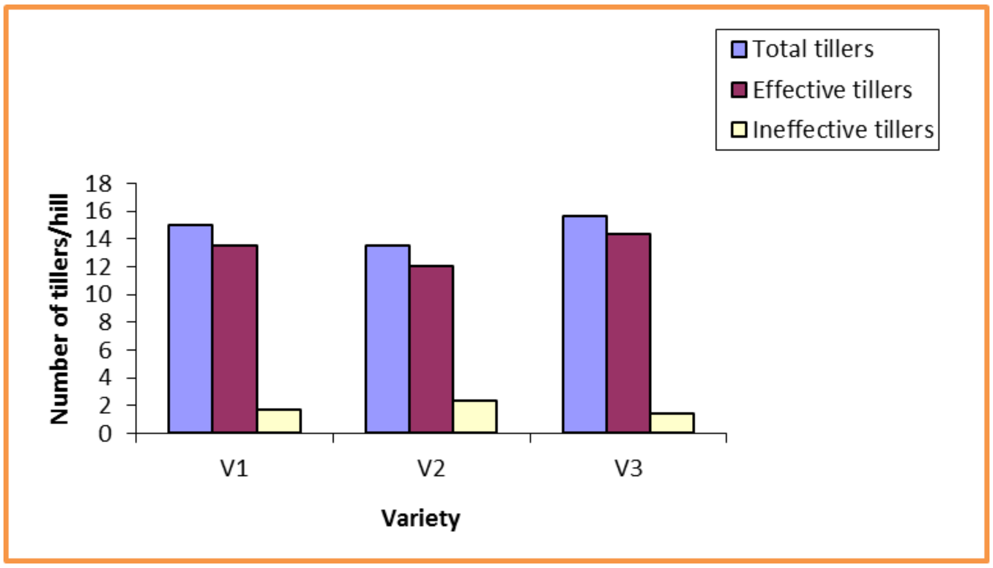


Figure 15. Effect of variety on total number of tillers hill^{-1}, effective tillers hill^{-1} and ineffective tillers hill^{-1} at harvest of boro rice ($LSD_{0.05}$ = 2.053, 1.408 and 0.509 for total number of tillers hill^{-1}, effective tillers hill^{-1} and ineffective tillers hill^{-1} at harvest, respectively)

4.3.2.2 Effect of weed control methods

Total number of tillers hill^{-1} was significantly affected by different weed control treatments (Fig. 16). Among the weed control treatments, the highest number of total tillers hill^{-1} (18.72) was observed by W_4 treatment which was statistically similar to W_6 (16.69) treatment but superior to W_1, W_2, W_3 and W_5 treatments (12.86, 15.62, 14.37 and 14.12 respectively). The W_0 (unweeded) treatment gave the lowest number of total tillers hill^{-1} (10.79). Unweeded treatment failed to produce more tillers due to severe weed infestation in the experimental plots. Similar results were also reported by BRRI (1998) and Atalla and kholosy (2002).

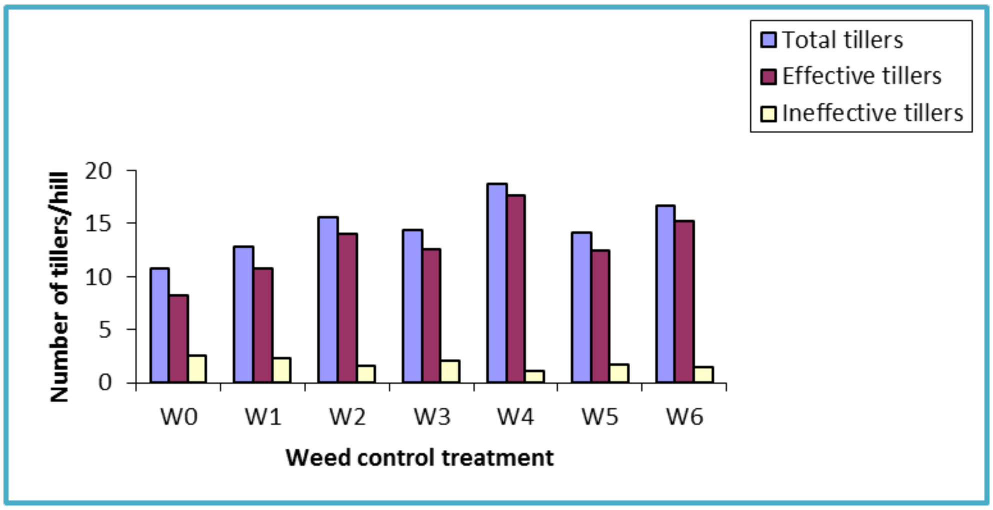


Figure 16. Effect of weed control methods on total number of tillers hill^{-1} at harvest of boro rice ($LSD_{0.05}$ = 2.053, 1.408 and 0.509 for total number of tillers hill^{-1}, effective tillers hill^{-1}and ineffective tillers hill^{-1} at harvest, respectively)

4.3.2.3 Interaction effect of variety and weed control methods

Interaction effect of variety and different weed control treatments significantly influenced the number of total tillers hill^{-1} (Table 12). The highest number of total tillers hill^{-1} produced by the interaction between the hybrid varieties Sonarbangla-6 (V_3) along with the herbicidal weed management (W_4). The lowest number of total tillers hill^{-1} was found in interaction between the inbred variety BRRI dhan29 (V_2) and unweeded treatment (W_0)

4.3.3 Effective tillers hill^{-1}

4.3.3.1 Effect of variety

The number of effective tillers hill^{-1} was significantly influenced by variety (Fig. 15). Results showed that, the hybrid variety Sonarbangla-6 (V_3) produced maximum number of tillers hill^{-1} and the minimum was obtained from the inbred variety BRRI dhan29 (V_2). The variation in the production of effective tillers might be due to genetic constituents of the varieties. Anon. (1992) reported that the proportion of effective tillers was more or less similar in BRRI dhan29 and Sonarbangla-6. However, Anon. (1998) suggested that high yielding variety had more bearing tillers m^{-2} over the inbred variety.

4.3.3.2 Effect of weed control methods

Weed control treatments caused considerable variations in the number of effective tillers hill^{-1} (Fig. 16). Effective tillers varied from 8.20 to 17.64 hill^{-1} among the treatment approaches. The highest number of effective tillers hill^{-1} was obtained in W_4 treatment (17.64) which was superior to the other weed management treatments. Unweeded treatment produced the lowest number of effective tillers hill^{-1} (8.20). Tiller mortality from maximum tillering stage to harvesting was not significantly influenced by variety. This might be due to the fact that the reduction of tiller number from maximum tillering stage to the final tiller number at maturity is a genetical behavior of the crop (Yoshida, 1981; Anon., 1970; Matsuo and Hoshikawa, 1993).

4.3.3.3 Interaction effect of variety and weed control methods

Interaction effect of different weed control treatments and variety had significant effect on number of tillers hill^{-1} (Table 12). It was found that the hybrid variety Sonarbangla-6 (V_3) produced the highest number of effective tillers hill^{-1} than the other two varieties along with the herbicidal weed management (W_4). The highest number of effective tillers hill^{-1} (20.34) was observed in the treatment combination of V_3W_4 which was statistically different from other treatments.

4.3.4 Ineffective tillers hill^{-1}

4.3.4.1 Effect of variety

The hybrid variety Sonarbangla-6 (V_3) showed minimum number of ineffective tillers hill^{-1}(1.46) and the maximum (2.34) was obtained from the inbred variety BRRI dhan29 (V_2) (Fig. 15). However, there was small numerical variation (1.46 to 2.34) observed among them.

4.3.4.2 Effect of weed control methods

The number of ineffective tillers hill^{-1} was not significantly influenced by weed control treatments (Fig. 16). Numerically the highest number of ineffective tillers (2.59) was obtained by the unweeded treatment (W_0) and the lowest number of ineffective tillers (1.15) was obtained by the W_4 treatment.

4.3.4.3 Interaction effect of variety and weed control methods

There was significant variation on the number of ineffective tillers hill^{-1} due to different weed control treatments and varieties. The treatment combination of V_2W_0 gave the highest ineffective tillers hill^{-1} (3.33) and V_1W_4 gave the lowest ineffective tillers hill^{-1} (0.67). The rest treatment combinations were statistically similar with each other (Table 12).

4.3.5 Panicle length

4.3.5.1. Effect of variety

The panicle length was not varied significantly due to the variety (Fig. 17). The maximum (24.02 cm) and minimum (24.34 cm) panicle length was obtained from Sonarbangla-6 (V_3) and BRRI dhan29 (V_2) respectively. Such findings might be due to the genetic make-up of the varieties though Babiker (1986) observed that panicle length differed due to the varietals variation.

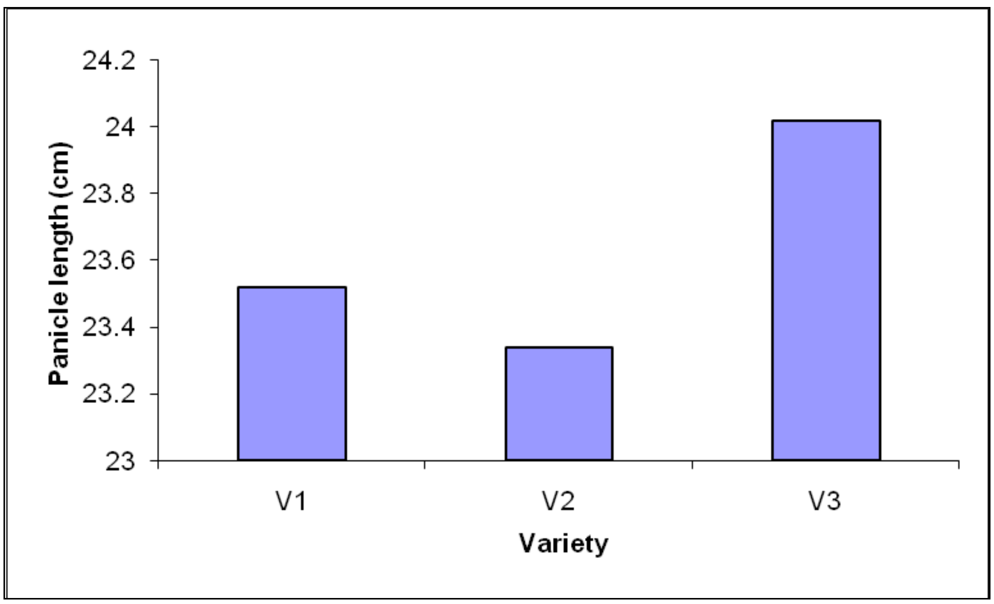


Figure 17. Effect of variety on panicle length (cm) at harvest of boro rice ($LSD_{0.05}$ = 1.346)

4.3.5.2 Effect of weed control methods

The weed control treatments not significantly influenced by the panicle length (Fig. 18). The maximum panicle length was obtained from W_4 treatment (25.41 cm) which was statistically superior to other weed managements while the minimum panicle length was obtained from W_0 treatment (24.16 cm).

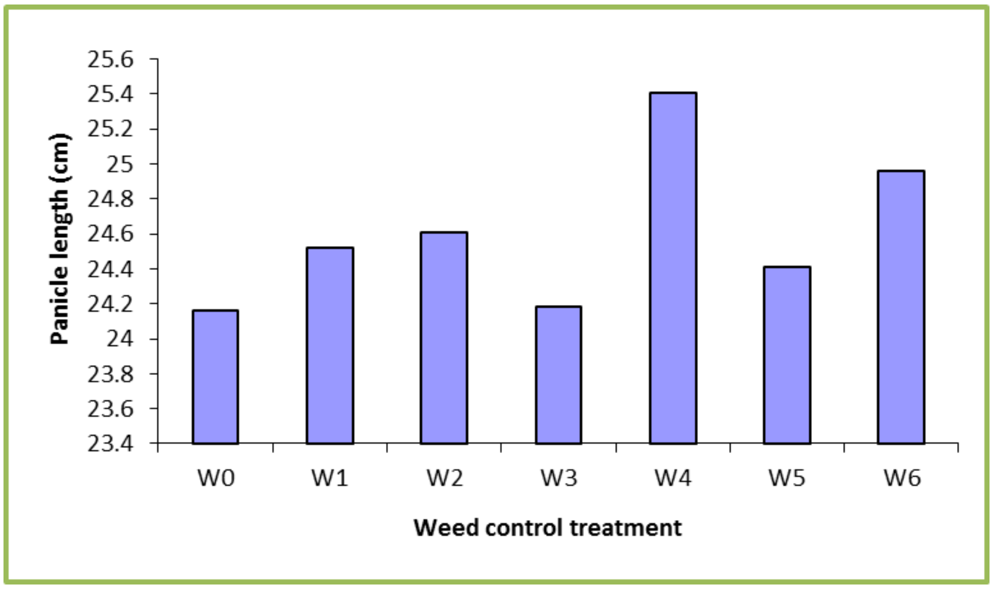


Figure 18. Effect of weed control methods on panicle length (cm) at harvest of boro rice ($LSD_{0.05}$ =1.346)

4.3.5.3 Interaction effect of variety and weed control methods

The interaction between different weed control treatments and varieties had no significant effect on the panicle length (Table 12). The maximum length of panicle (25.11cm) was obtained in V_3W_4 treatment combination which was statistically superior to the other treatment combinations. The minimum length of panicle (22.74 cm) was obtained in V_1W_0 treatment combination.

Table 12. Interaction effect of variety and weed control methods on yield and yield contributing characters of boro rice

Treatment	Panicle length (cm)	Total grains panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	1000 grain weight (g)
V_1W_0	22.74	131.10	108.9	21.55	22.19
V_1W_1	22.78	151.90	133.1	18.78	23.35
V_1W_2	23.78	189.90	174.7	15.24	25.06
V_1W_3	23.78	163.20	145.5	17.67	22.95
V_1W_4	24.87	190.00	180.0	10.02	26.16
V_1W_5	23.89	165.60	148.2	17.45	24.64
V_1W_6	24.55	191.20	176.9	14.33	25.67
V_2W_0	23.86	125.20	105.6	27.45	22.08
V_2W_1	24.44	159.40	140.4	19.00	23.63
V_2W_2	25.34	190.90	175.4	15.45	25.43
V_2W_3	24.67	176.60	159.4	17.25	24.83
V_2W_4	26.27	193.50	180.8	12.67	27.90
V_2W_5	25.00	168.00	150.7	17.34	22.52
V_2W_6	25.56	193.60	178.8	14.78	27.71
V_3W_0	23.22	133.10	100.8	24.44	23.98
V_3W_1	23.33	168.20	148.9	19.44	24.17
V_3W_2	24.72	189.50	177.3	12.22	27.80
V_3W_3	24.11	173.00	158.0	15.67	26.90
V_3W_4	25.11	197.10	187.2	9.89	29.58
V_3W_5	24.34	174.80	159.8	15.33	24.13
V_3W_6	24.78	194.00	182.4	11.56	29.12
$LSD_{0,05}$	**1.346**	**23.83**	**25.62**	**3.380**	**2.98**
CV (%)	**3.40**	**8.38**	**9.96**	**12.38**	**7.26**

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.3.6 Total number of grains panicle^{-1}

4.3.6.1 Effect of variety

The total number of grains panicle^{-1} was not significantly influenced by the variety (Fig. 19) though the maximum number of grains panicle^{-1} (174.50) was obtained from the hybrid variety Sonarbangla-6 (V_3) which was statistically similar to the other hybrid variety Hira-6 (V_1) and the minimum number of grains panicle^{-1} (169.00) was obtained from the inbred variety BRRI dhan29 (V_2). Hussain and Alam (1991) reported varietals variation in number of grains panicle^{-1} and Anon. (1998) found higher number of grains panicle^{-1} in the hybrid varieties.

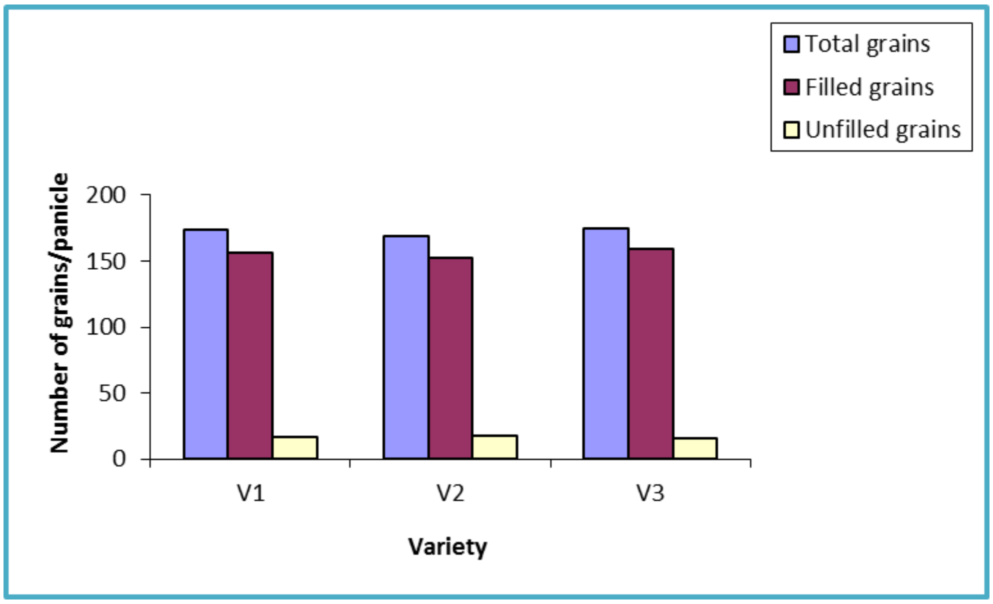


Figure 19. Effect of variety on total grains panicle^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1} at harvest of boro rice ($LSD_{0.05}$ = 23.83, 25.62 and 3.380 for total grains panicle^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1}, respectively)

4.3.6.2 Effect of weed control methods

The weed control treatments significantly affected the total number of grains panicle^{-1} (Fig. 20). The total number of grains panicle^{-1} was highest in W_4 treatment (193.50) which was statistically superior to other weed managements while the lowest number of grains panicle^{-1} was observed in the W_0 (unweeded) treatment (129.80).

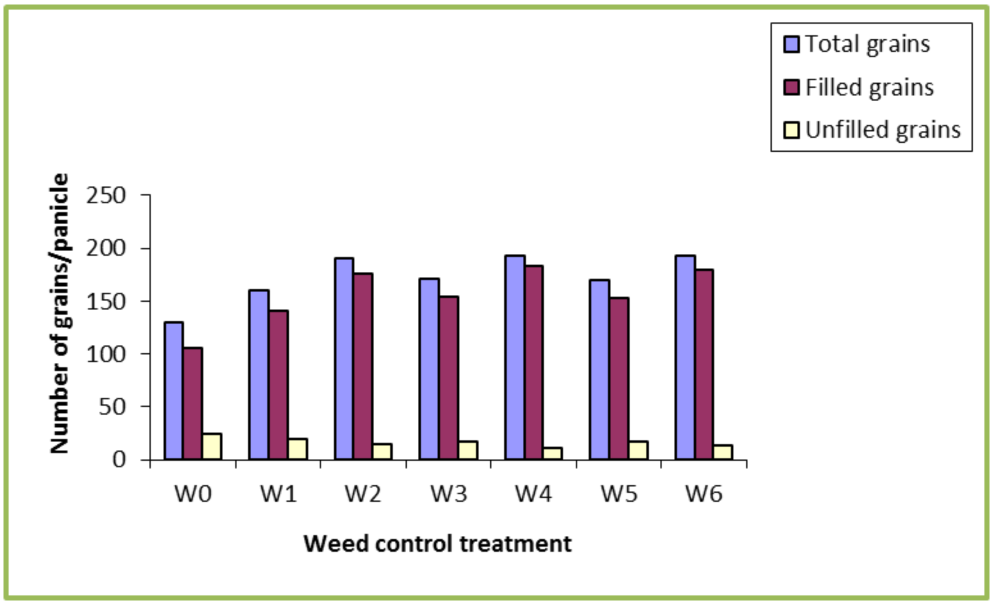


Figure 20. Effect of weed control methods on total grains panicle^{-1}, filled grains panicle^{-1}and unfilled grains panicle^{-1} at harvest of boro rice ($LSD_{0.05}$ = 23.83, 25.62 and 3.380 for total grains panicle^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1}, respectively)

4.3.6.3 Interaction effect of variety and weed control methods

The interaction effect of different weed control treatments with different varieties had highly significant interaction on total number of grains panicle^{-1}. It was evident from Table 12 that treatment combination V_3W_4 (hybrid variety Sonarbangla-6 with Ethoxysulfuran) produced the highest grains panicle^{-1} (197.10) which was statistically superior to the other treatment combinations. The W_4 (Ethoxysulfuran) in hybrid and inbred varieties produced comparatively higher number of total grains panicle^{-1} compared to other weed control treatments. The lowest grains panicle^{-1} was obtained from the unweeded treatment (W_0) with the three varieties.

4.3.7 Filled grains panicle^{-1}

4.3.7.1 Effect of variety

The filled grains panicle^{-1} differed significantly for variation of the variety (Fig. 19). The maximum number of filled grains panicle^{-1} (159.20) was found in the hybrid variety Sonarbangla-6 (V_3) and the lowest number of filled grains panicle^{-1} (152.50) was obtained from the inbred variety BRRI dhan29 (V_2).

4.3.7.2 Effect of weed control methods

The influence of different weed control treatments was significant on the number of filled grains panicle^{-1} (Fig. 20). The highest number of grains panicle^{-1} (182.70) was obtained from W_4 treatment which was statistically superior to the other treatments. It might be due to least crop weed competition that ensured sufficient nutrients and other growth resources, which enhanced higher filled grain production. The lowest number of grains panicle^{-1} (105.10) was observed in the no weeding treatment (W_0). This might be due to higher crop weed competition in the no weeding treatment where weeds shared with the crop for their nutrients, water, light or other necessary growth factors and consequently reduced grains panicle^{-1}. Similar findings were also reported by Polthanee *et al. (1996)* and Sanjoy *et al.* (1999) where the number of filled grains panicle^{-1} were increased due to weed control over no weeding.

4.3.7.3 Interaction effect of variety and weed control methods

The interaction between different weed control treatments and varieties had significant effect on filled grains panicle^{-1} (Table 12). The highest number of grains panicle^{-1}(187.20) was obtained in V_3W_4 treatment combination which was statistically superior to the other treatment combinations. The lowest number of grains panicle^{-1} (125.20) was recorded in V_2W_0. It was evident from the findings that the hybrid variety produced more filled grains panicle^{-1} with the herbicidal weed management (Ethoxysulfuran) than the inbred variety with no weeding treatment.

4.3.8 Unfilled grains panicle^{-1}

4.3.8.1 Effect of variety

The unfilled grains panicle^{-1} was significantly differed between the inbred and hybrid variety (Fig. 19). The maximum number of unfilled grains panicle^{-1} (17.71) was counted in the inbred variety BRRI dhan29 (V_2) and the minimum number of unfilled grains panicle^{-1} (15.51) was counted in the hybrid variety Sonarbangla-6 (V_3). Akbar (2004) found highest number of unfilled grains panicle^{-1} in Sonarbangla variety.

4.3.8.2 Effect of weed control methods

The number of unfilled grains panicle^{-1} varied significantly due to the effect of weed control treatments (Fig. 20). The highest number of unfilled grains panicle^{-1} (24.48) was observed in the no weeding treatment (W_0) which was significantly higher than all other weed control treatments. The lowest number of unfilled grains panicle^{-1} (10.86) was produced by W_4 (Ethoxysulfuran) treatment which was inferior to other weed control treatments.

4.3.8.3 Interaction effect of variety and weed control methods

The interaction effect between the weed control treatments and variety was highly significant on the number of unfilled grains panicle^{-1} (Table 12). It was observed that the inbred variety BRRI dhan29 (V_2) and unweeded plot (W_0) produced the highest number of unfilled grains panicle^{-1}(27.45). The lowest number of unfilled grains panicle^{-1} (15.93) was obtained from the treatment combination of $V_3W_{4.}$ From the results, it was observed that the unweeded plot with the inbred variety produced the highest number of unfilled grains panicle^{-1} but the hybrid variety with the herbicidal weed management (Ethoxysulfuran) produced the lowest unfilled grains panicle^{-1}. This might be due to the severe infestation of weeds in the inbred variety than the hybrid variety.

4.3.9 Weight of 1000 grain

4.3.9.1 Effect of variety

The weight of 1000-grains was not significantly influenced by the variety (Fig. 21). The highest weight of 1000-grains (25.14 g) was obtained from the hybrid variety Sonarbangla-6 (V_3) and the lowest weight of 1000-grains (24.29 g) was obtained from the inbred variety BRRI dhan29 (V_2). The little variation of 1000-grains weight among varieties might be due to genetic constituents. The result supports the findings of Akbar (2004) and Rahman (2001) who found highest weight of 1000-grains in Sonarbangla variety than the other studied varieties.

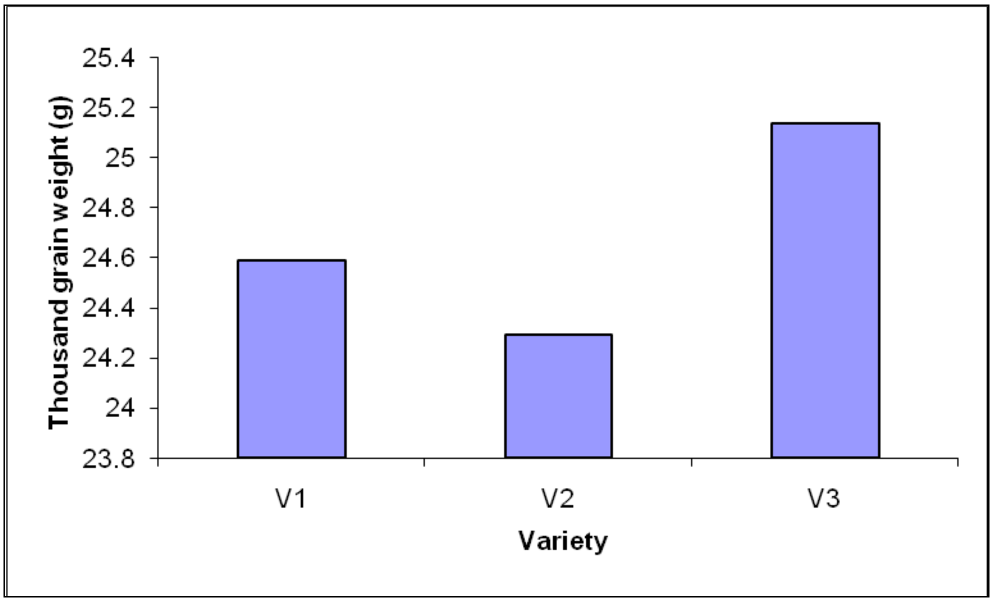


Figure 21. Effect of variety on thousand grain weight (g) at harvest of boro rice ($LSD_{0.05}$ = 2.98)

4.3.9.2 Effect of weed control methods

Thousand grains weight was significantly influenced by weed control treatments (Fig. 22). The thousand grain weight was highest in W_4 treatment (27.88 g) which was statistically similar to W_6 (27.50 g) and W_2 (26.10 g) but was superior to the other treatments. The thousand grains weight was lowest (24.25 g) in the unweeded plot (W_0). Similar finding were also observed by Yuan *et al.* (1991).

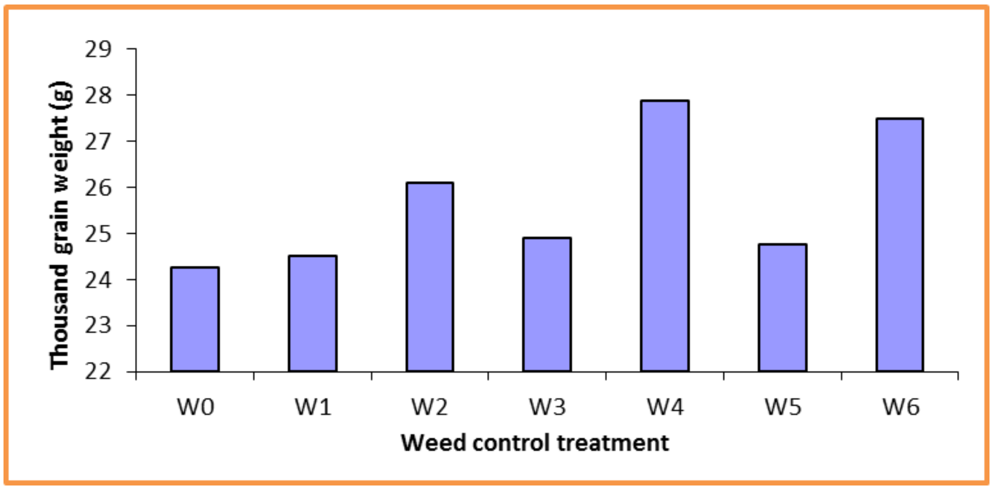


Figure 22. Effect of weed control methods on thousand grain weight (g) at harvest of boro rice ($LSD_{0.05}$ = 2.98)

4.3.9.3 Interaction effect of variety and weed control methods

The interaction between the different weed control treatments and variety was significant for thousand grain weight (Table 12). The highest thousand grain weight was observed in the treatment combination of V_3W_4 (29.58 g) and the lowest thousand grain weight was observed in the treatment combination of V_2W_0 (22.08 g).

4.3.10 Grain yield

4.3.10.1 Effect of variety

Grain yield was significantly influenced by the variety (Fig. 23). The highest grain yield (6.51 t ha^{-1}) was obtained from the hybrid variety Sonarbangla-6 compared to the yield of other hybrid variety Hira-6 (6.28 t ha^{-1}) and inbred variety BRRI dhan29 (5.47 t ha^{-1}). The hybrid variety gave 15.97% higher yield than the inbred variety. The yield improvement in the hybrid variety has been associated with an increase in total biomass as well as higher harvest index (Damodaran, 2001). Lafarge *et al.* (2004) reported that grain yield was significantly higher for hybrid rice as hybrid variety increased assimilates allocation towards productive tillers. Davaraju *et al.* (1998) also found higher grain yield from the hybrid varieties over the inbred varieties.

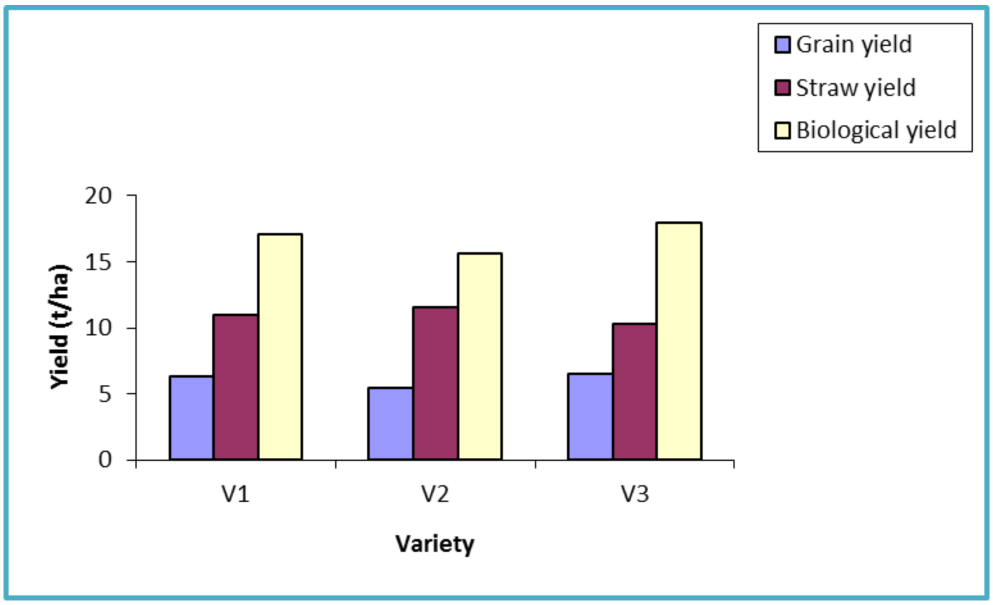


Figure 23. Effect of variety on grain yield, straw yield and biological yield (t ha^{-1}) at harvest of boro rice ($LSD_{0.05}$ = 1.394, 1.900 and 1.658).

Table 13. Interaction effect of variety and weed control methods on yield and yield contributing characters of boro rice

Treatment	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
V_1W_0	22.19	3.19	5.29	8.48	30.44
V_1W_1	23.35	4.88	8.21	13.09	33.94
V_1W_2	25.06	5.93	10.92	16.18	35.19
V_1W_3	22.95	6.98	14.92	21.90	32.94
V_1W_4	26.16	9.10	13.15	22.25	40.23
V_1W_5	24.64	6.81	11.89	18.70	34.57
V_1W_6	25.67	7.04	12.15	19.19	36.69
V_2W_0	22.08	2.49	5.03	7.52	30.93
V_2W_1	23.63	4.18	7.91	12.09	34.57
V_2W_2	25.43	5.23	9.82	14.38	34.75
V_2W_3	24.83	6.17	11.68	17.85	34.57
V_2W_4	27.90	8.03	15.19	23.22	36.14
V_2W_5	22.52	5.98	10.20	16.18	34.21
V_2W_6	27.71	6.21	11.98	17.86	35.06
V_3W_0	23.98	3.45	6.58	9.69	30.53
V_3W_1	24.17	5.14	9.11	14.25	34.75
V_3W_2	27.80	6.19	11.20	17.39	35.60
V_3W_3	26.90	7.11	13.60	20.38	34.33
V_3W_4	29.58	9.50	14.22	23.72	41.16
V_3W_5	24.13	6.84	12.67	19.51	35.06
V_3W_6	29.12	7.35	13.50	20.54	36.75
$LSD_{0,05}$	2.98	1.394	1.900	1.658	1.955
CV (%)	7.26	13.89	10.55	5.95	3.40

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

4.3.10.2 Effect of weed control methods

Crop management practices are among the factors responsible to get higher yield. Proper weed management in *boro* rice field ensures higher yield. Grain yield was considerably affected by weed control treatments (Fig. 24). The highest grain yield (8.88 t ha^{-1}) was obtained from W4 treatment which was statistically different from other weed management treatments. The lowest grain yield (3.04 t ha^{-1}) was obtained from W_0 treatment. Grain yield 6.87 t ha^{-1} and 5.78 t ha^{-1} was obtained from W6 and W_2 treatments respectively. W_4 contributes 22.63% higher grain yield than W6 and 34.9% higher grain yield than W_2 treatment due to higher number of panicles $hill^{-1}$ and higher number grains $panicle^{-1}$. This was also happened due to severe weed infestation with various species of weeds and competition for moisture, space, air, light and nutrients between weeds and rice plants which had adverse effect on all the yield components and finally on grain yield. Similar findings were also reported by Polthanee *et al.* (1996), Thomas *et al*. (1997), Sanjoy *et al*. (1999), Gogoi *et al*. (2000) and Attalla and Kholosy (2002).

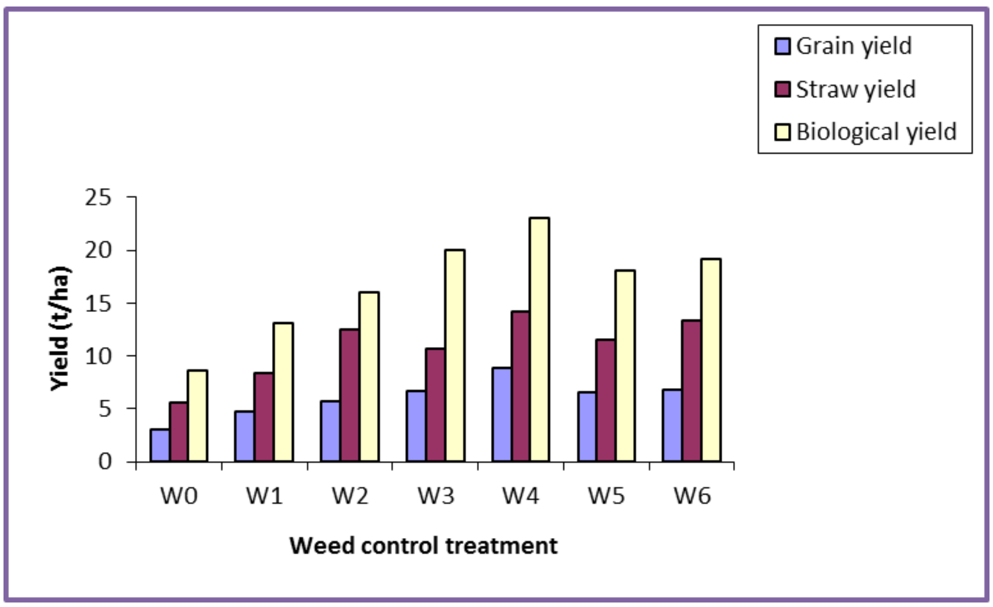


Figure 24. Effect of weed control methods on grain yield, straw yield and biological yield (t ha^{-1}) at harvest of boro rice ($LSD_{0.05}$ = 1.394, 1.900 and 1.658)

4.3.10.3 Interaction effect of variety and weed control methods

Interaction effect between different weed control treatments and varieties significantly influenced grain yield (Table 13). The highest grain yield (9.50 t ha^{-1}) was obtained from the treatment combination of V_3W_4 which was statistically superior to the other treatments. The lowest yield (2.49 t ha^{-1}) was obtained from the unweeded plot (W_0) with the inbred variety BRRI dhan29 (V_2) which was statistically inferior from other treatments. This happened due to the more number of tillers $hill^{-1}$ was present in the hybrid variety Sonarbangla-6 than in the inbred variety BRRI dhan29.

4.3.11 Straw yield

4.3.11.1 Effect of variety

Straw yield was not significantly affected by the variety (Fig. 23) though the higher straw yield (11.55 t ha^{-1}) was obtained from inbred variety BRRI dhan29 compared to the yield of other hybrid variety Hira-6 (10.93 t ha^{-1}) and Sonarbangla-6 (10.26 t ha^{-1}). The straw yield was 11.17% higher in the inbred variety compared to the hybrid variety. This might be due to the highest plant height of the inbred variety than the hybrid variety. Akbar (2004) reported that inbred variety produced higher straw yield than the hybrid varieties.

4.3.11.2 Effect of weed control methods

Straw yield of rice was significantly influenced by different weed control treatments (Fig. 24). The highest straw yield (14.19 t ha^{-1}) was obtained from the treatment W_4 which was statistically similar with the treatment W_6 (13.40 t ha^{-1}) and W_2 (12.54 t ha^{-1}). Significantly the lowest straw yield (4.20 t ha^{-1}) was obtained from the unweeded treatment (W_2). Similar observations were found by Islam (1995) and Toufiq (2003).

4.3.11.3 Interaction effect of variety and weed control methods

Straw yield was significantly affected due to interaction between different weed control treatments and varieties (Table 13). The highest straw yield (15.19 t ha^{-1}) was obtained from the interaction between the inbred variety BRRI dhan29 and Sunrise 150 WG at the recommended dose (Ethoxysulfuran). The lowest straw yield (5.03 t ha^{-1}) was observed from the interaction between the inbred variety BRRI dhan29 and unweeded treatment. Similar observation was found by Nurujjaman (2001).

4.3.12 Biological yield

4.3.12.1 Effect of variety

Variety had significant effect on biological yield (Fig. 23). The maximum biological yield (17.93 t ha^{-1}) was found from the hybrid variety Sonarbangla-6 which was statistically similar to the other hybrid variety Hira-6 (17.11). The lowest biological yield (15.59 t ha^{-1}) was found from the inbred variety BRRI dhan29. However, Rahman (2001) reported that Sonarbangla variety produced higher biological yield compared to the inbred varieties which was supported by Singh and Gangwer (1989).

4.3.12.2 Effect of weed control methods

Biological yield was significantly influenced by different weed control treatments (Fig. 24). The highest biological yield (23.06 t ha^{-1}) was observed in the W_4 treatment which was statistically superior to other treatments. The unweeded plot (W_0) gave the lowest biological yield (8.57 t ha^{-1}) among the treatments.

4.3.12.3 Interaction effect of variety and weed control methods

The interaction between different weed control treatments and variety had significant influence on biological yield (Table 13). The highest biological yield (23.72 t ha^{-1}) was obtained from the treatment combination of V_3W_4 which was statistically similar with the V_2W_4 and V_1W_4. The lowest biological yield (7.52 t ha^{-1}) was observed in the V_2W_0. Higher weed infestation not only reduced the grain yield but also hampered the plant growth and tillering capacity and ultimately reduced straw yield and also biological yield.

4.3.13 Harvest index

4.3.13.1 Effect of variety

Harvest index was not significantly influenced by the variety (Fig. 25). The highest harvest index (35.45%) was found from the hybrid variety Sonarbangla-6 and the lowest harvest index (34.32%) was found from the inbred variety BRRI dhan29. Higher grain yield and biological yield was the probable reason for the maximum harvest index in Sonarbangla-6. Muir (1998) reported that hybrid varieties generally have a higher harvest index than conventional varieties. Rahman (2001) also observed highest harvest index in Sonarbangla-1 than the inbred varieties. Similar result was also reported by Cui *et al.* (2000).

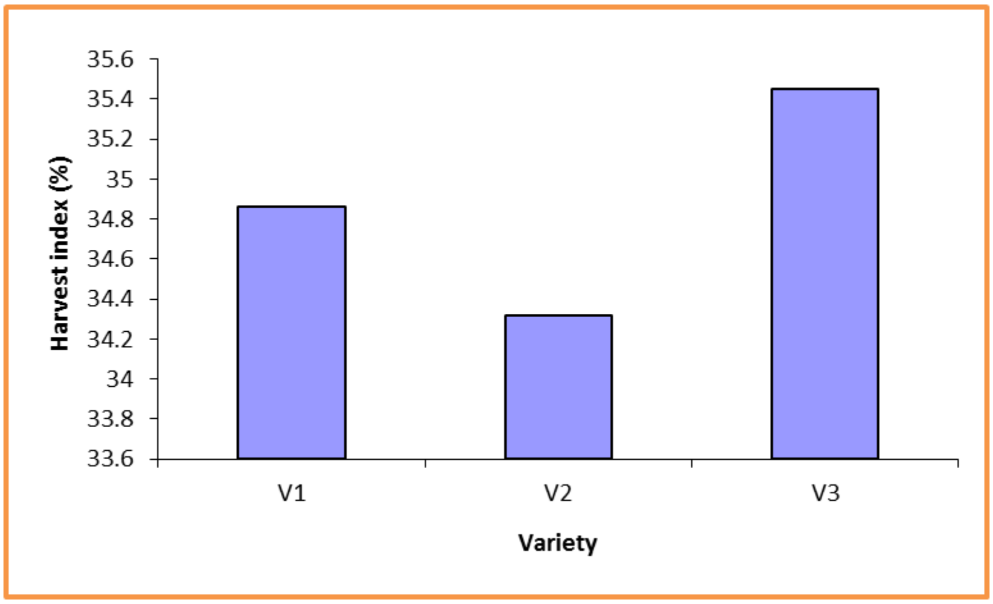


Figure 25. Effect of variety on harvest index (%) at harvest of boro rice ($LSD_{0.05}$ = 1.955)

4.3.13.2 Effect of weed control methods

Harvest index was significantly affected by the different weed control treatments (Fig. 26). The highest harvest index (39.18%) was observed in the W_4 treatment which was statistically different from other treatments. The lowest harvest index (30.63%) was observed in the treatment W_0 (unweeded).

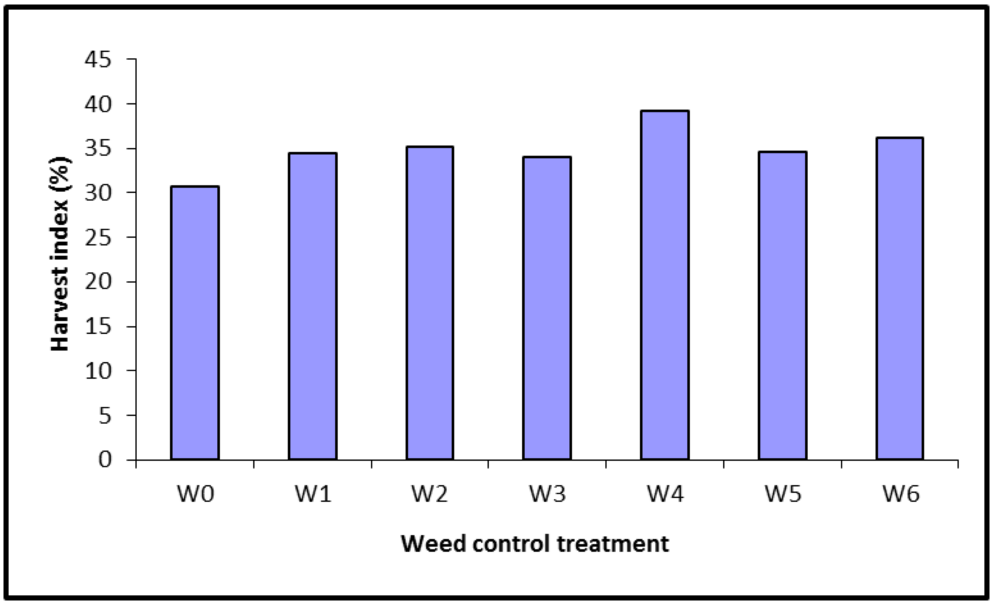


Figure 26. Effect of weed control methods on harvest index (%) at harvest of boro rice ($LSD_{0.05}$ = 1.955)

4.3.13.3 Interaction effect of variety and weed control methods

The interaction between different weed control treatments and varieties had significant effect on harvest index (Table 13). The highest harvest index (41.16%) was observed in the treatment combination of V_3W_4 which was statistically similar with the treatment V_1W_4. The lowest harvest index (30.44%) was found in the V_1W_0 (hybrid variety Hira-6 with unweeded treatment). It was observed that the unweeded plot along with all the varieties gave the minimum harvest index than the hand weeding and herbicidal treatments with different varieties.

4.4 Economic performance of different weed control treatments under different varieties

The cost of production and return of unit plot of *boro* rice varieties (Hira-6 (hybrid), BRRI dhan29 (inbred) and Sonarbangle-6 (hybrid)) converted into hectare and discussed below:

Economic performance of *boro* rice was varied for different weed control treatments and different varieties used in the present experiment. The cost of production was varied mainly for the weeding cost and for raising of seedlings under different varieties. The weeding cost was varied mainly for labourers and material required under different weed control treatments. For the inbred variety BRRI dhan29, much seeds were required for raising of seedlings as in that variety more hills m^{-2} were needed as compared to the hybrid variety Sonarbangla-6 and Hira-6. So, for the hybrid variety less seeds were required for raising of seedlings to cover the field.

In case of no weeding, there was no involvement of cost for weed control. In the treatment W_1 (one hand weeding) required 50, 50 and 56 labourers for Sonarbangla-6, Hira-6 and BRRI dhan29 respectively. In the treatment W_2 (two hand weeding), 35. 35 and 40 labourers were required for Sonarbangla-6, Hira-6 and BRRI dhan29 respectively. In case of herbicidal treatments fewer labourers were required for weeding than the treatment W_1 and W_2 but the labourer numbers were not varied according to different varieties. The weeding cost was Tk.1690.00, 1900.00, 1690.00 1762.50, 2042.50, 1762.50, 1640.00, 1850.00, 1640.00, 1440.00, 1650.00 and 1440.00 for the treatment combination of V_1W_3, V_2W_3, V_3W_3, V_1W_4, V_2W_4, V_3W_4, V_1W_5, V_2W_5, V_3W_5, V_1W_6, V_2W_6, V_3W_6 respectively (Table 14).

Table 14. Economic performance of different weed control treatments

Treatment	Cost of production (Tk./ha)			Gross return (Tk./ha)			Net profit (Tk./ha)	BCR
	Variable fixed cost	Weeding cost	Total cost	Grain	Straw	Total return		
V_1W_0	47657.00	0.00	**47657.00**	44325.00	3145.00	**47470.00**	-187.00	0.99
V_1W_1	47657.00	3500.00	**51157.00**	58562.00	4965.00	**63527.00**	12370.00	1.24
V_1W_2	47657.00	4410.00	**52067.00**	60524.00	5628.00	**66152.00**	14085.00	1.26
V_1W_3	47657.00	1690.00	**49347.00**	61462.00	5158.00	**66620.00**	17273.00	1.35
V_1W_4	47657.00	1762.50	**49419.50**	63468.00	5456.00	**68924.00**	19504.50	1.39
V_1W_5	47657.00	1640.00	**49297.00**	59874.00	4798.00	**64672.00**	15375.00	1.31
V_1W_6	47657.00	1440.00	**49097.00**	62568.00	5236.00	**67804.00**	18707.00	1.38
V_2W_0	45504.00	0.00	**45504.00**	40368.00	3126.00	**43494.00**	-2010.00	0.96
V_2W_1	45504.00	3640.00	**49144.00**	48751.00	4986.00	**53737.00**	4593.00	1.09
V_2W_2	45504.00	4760.00	**50264.00**	51268.00	5026.00	**56294.00**	7990.00	1.11
V_2W_3	45504.00	1900.00	**47404.00**	50964.00	5432.00	**56396.00**	8992.00	1.19
V_2W_4	45504.00	2042.50	**47546.50**	52624.00	5498.00	**58122.00**	10575.50	1.22
V_2W_5	45504.00	1850.00	**47354.00**	50862.00	5023.00	**55885.00**	8531.00	1.18
V_2W_6	45504.00	1650.00	**47154.00**	51562.00	5126.00	**56688.00**	9534.00	1.20
V_3W_0	47361.00	0.00	**47361.00**	43562.00	3254.00	**46816.00**	-445.00	0.99
V_3W_1	47361.00	3500.00	**50861.00**	59652.00	4856.00	**64508.00**	13647.00	1.27
V_3W_2	47361.00	4450.00	**51771.00**	61265.00	5236.00	**66501.00**	14730.00	1.28
V_3W_3	47361.00	1690.00	**49051.00**	60864.00	5026.00	**65890.00**	16839.00	1.34
V_3W_4	47361.00	1762.50	**49123.50**	65235.00	5429.00	**70664.00**	21540.50	1.44
V_3W_5	47361.00	1640.00	**49001.00**	60654.00	5236.00	**65890.00**	16889.00	1.34
V_3W_6	47361.00	1440.00	**48801.00**	62286.00	5410.00	**67696.00**	18895.00	1.38

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)

Excluding weeding cost, cost of production of *boro* rice varieties ha^{-1} was Tk. 47361.00, 47657.00 and 45504.00 for Sonarbangla-6, Hira-6 and BRRI dhan29 respectively (Table 14). Including weeding cost, the cost of production was the highest (Tk.51157.00 ha^{-1}) for the treatment V_1W_1 (One hand weeding in the hybrid variety Hira-6) and the lowest (Tk.47154.00 ha^{-1}) at V_2W_6 (Pretilachlor in BRRI dhan29) (Table 14).

4.4.1 Gross return

Gross return was influenced by different weed control treatments and varieties (Table 14). The highest gross return (Tk. 70664.00 ha^{-1}) was obtained from V_3W_4 (Ethoxysulfuran in the hybrid variety Sonarbangla-6) and the lowest gross return (Tk.43494.00 ha^{-1}) was obtained from V_2W_0 (no weeding in the inbred variety BRRI dhan29. The second highest gross return (Tk. 68924.00 ha^{-1}) was obtained from V_1W_4 (Ethoxysulfuran in the hybrid variety Hira-6).

4.4.2 Net return

Net return varied in different weed control treatments and varieties (Table 14). The highest net profit (Tk. 21540.50 ha^{-1}) was obtained from the treatment at the hybrid variety Sonarbangla-6 with Ethoxysulfuran. In the unweeded plots at all varieties no profit was achieved.

4.4.3 Benefit cost ratio (BCR)

Benefit cost ratio varied in different weed control treatments and varieties (Table 7). It was evident that the herbicidal treatment W_4 along with the hybrid variety Sonarbangla-6 gave the highest BCR than the other two varieties (Hira-6 and BRRI dhan29). Among all the treatment combinations, the hybrid variety Sonarbangla-6 along with herbicidal treatment Ethoxysulfuran at 25% higher than the recommended dose gave the highest BCR (1.44). The second highest BCR (1.39) was given by the treatment combination of V_1W_4 (Ethoxysulfuran at 25% higher than the recommended dose in the hybrid variety Hira-6) and the third highest BCR (1.38) was given by the V_3W_6 (Pretilachlor at 25% lower than the recommended dose in the hybrid variety Sonarbangla-6) and V_1W_6 (Pretilachlor at 25% lower than the recommended dose in the hybrid variety Hira-6). All the unweeding treatments at different varieties showed the negative BCR. This might be because less production due to higher weeds competition. Pretilachlor at 25% lower than the recommended dose in the hybrid variety Sonarbangla-6 was also profitable because the herbicide Pretilachlor could easily controlled the weeds more effectively in the crop field and labourers requirement were also less than the hand weeding treatment. The weeds were controlled in the soil at the initial stages of the crop and contributed to the vigorous growth that ultimately produced higher effective tillers m^{-2} and grain yield. It can be concluded from economic point of view that when labour is a limiting factor, herbicide may serve as an alternative means of weed control.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2008 to May, 2009 to investigate growth and yield of hybrid and inbred *boro* rice affected by different weed control methods. The experiment consisted of two factors; 1) Variety: V_1 = Hira-6 (hybrid), V_2 =BRRI dhan29 (inbred) and V_3 = Sonarbangla-6 (hybrid) 2) Weed control methods: W_0 =No weeding (Control), W_1= One weeding (30 DAT), W_2= Two weeding (30 DAT & 50 DAT), W_3= Sunrise 150 WG at recommended dose (100g ha^{-1}), W_4= Sunrise 150 WG at 25% higher than the recommended dose, W_5= Commit 500 EC at recommended dose (1000 ml ha^{-1}) and W_6= Commit 500 EC at 25% lower than the recommended dose. The experiment was laid out in a randomized complete block design (factorial) with three replications.

The most important weeds of the experimental plot were *Echinochloa colonum, Cyperus rotundus, Scirpus mucronatus, Spilanthes acmella*. Among the varieties, the maximum weed density (100.50 m^{-2}) was found at 35 DAT in the inbred variety BRRI dhan29 (V_2) and the lowest weed density was found in the hybrid variety Sonarbangle-6 (V_3) and then in the variety Hira-6 (V_1) in all DAT. The highest plant height (92.34 cm) was recorded in the hybrid variety (Sonarbangla-6) and the lowest height (89.09 cm) was in the inbred variety (BRRI dhan29) and the same trend of plant height for another hybrid variety (Hira-6) over inbred variety was obtained at 20, 45 and 70 DAT. At 20, 45, 70 and 95 DAT, the maximum tiller number $hill^{-1}$ was observed in the hybrid variety (Sonarbangla-6 and Hira-6) and the minimum number of tiller was obtained from the inbred variety (BRRI dhan29). At 45 and 70 DAT, the highest leaf area index (4.69, 5.65 and 4.36, 5.63 respectively) was found in the hybrid variety (Hira-6 and Sonarbangla-6 respectively) and the lowest leaf area index (4.10 and 5.40, respectively) was found in the inbred variety (BRRI dhan29). Weed control treatments showed significant variations in LAI throughout the growing periods. The total dry weight of plant was significantly influenced by variety at 70 DAT and 95 DAT but was similar at 20 and 45 DAT. The growth rate CGR and RGR of rice crop was significantly influenced by variety at 20-45, 45-70 and 70-95 DAT. The hybrid variety Sonarbangla-6 (V_3) produced the highest plant height (99.29 cm) compared to the other hybrid variety Hira-6 (V_1) (92.16 cm) and the inbred variety BRRI dhan29 (V_2) (91.76 cm). The hybrid variety Sonarbangla-6 produced maximum number of total and effective tillers hill^{-1} and the minimum was obtained from the inbred variety BRRI dhan29. The maximum (25.02 cm) and minimum (24.34 cm) panicle length was obtained from Sonarbangla-6 and BRRI dhan29 respectively. The maximum number of grains panicle^{-1} (174.50) was obtained from the hybrid variety Sonarbangla-6 and the minimum number of grains panicle^{-1} (169.00) was obtained from the inbred variety BRRI dhan29. The highest weight of 1000-grains (25.74 g) was obtained from the hybrid variety Sonarbangla-6 and the lowest weight of 1000-grains (24.29 g) was obtained from the inbred variety BRRI dhan29. The significantly highest grain yield (6.51 t ha^{-1}) was obtained from the hybrid variety Sonarbangla-6 compared to the yield of other hybrid variety Hira-6 (6.28 t ha^{-1}) and inbred variety BRRI dhan29 (5.47 t ha^{-1}). The higher straw yield (11.55 t ha^{-1}) was obtained from inbred variety BRRI dhan29 compared to the yield of other hybrid variety Hira-6 (10.93 t ha^{-1}) and Sonarbangla-6 (10.26 t ha^{-1}).

The weed density (number m^{-2}) was decreased in all other treatments at 42 DAT and 49 DAT due to the crop weed competition and weed mortality. Relatively lowest weed density (number m^{-2}) was found in the herbicidal treatment W_4 (Post emergence herbicide) than all other treatments. The lowest plant height was observed at every sampling period in no weeding treatment. Tillers hill^{-1} increased gradually upto 45 DAT and then decreased in the all weed control treatments except W_2 and W_6 at 70 DAT due to mortality of ineffective tillers at later stages. The lowest TDM throughout the growing period was observed in unweeded treatment. Unweeded treatment showed the lowest CGR and RGR throughout the growing period. Among the weed management W_4 the herbicidal treatment gave the maximum plant height (95.97 cm) and the lowest (93.64 cm) produced in no weeding treatment. Among the weed control treatments, the highest number of total tillers hill^{-1} (18.72) was observed by W_4 treatment and the W_0 treatment gave the lowest number of total tillers hill^{-1} (10.79). The maximum panicle length was obtained from W_4 treatment (25.41 cm) while the minimum panicle length was obtained from W_0 treatment (24.16 cm). The total number of grains panicle^{-1} was highest in W_4 treatment (193.50) while the lowest number of grains panicle^{-1} was observed in the W_0 treatment (129.80). The thousand grain weight was highest in W_4 treatment (27.88 g) and the thousand grains weight was lowest (24.25 g) in the unweeded plot. The highest grain yield (8.88 t ha^{-1}) was obtained from W_4 treatment and the lowest grain yield (3.04 t ha^{-1}) was obtained from W_0 treatment. The highest straw yield (14.19 t ha^{-1}) was obtained from the treatment W_4 and the lowest straw yield (4.20 t ha^{-1}) was obtained from the unweeded treatment.

Unweeded treatment resulted the highest weed density in all varieties throughout the growing season. In most of the cases the unweeded plot with all varieties obtained the lowest plant height over day's upto 95 DAT. The hybrid variety (Sonarbangla-6) in each weed control treatment had the highest total tillers hill^{-1} at each sampling period and it reached maximum at 45 DAT and afterwards it declined with the advancement of crop growth duration. On the contrary, the inbred variety (BRRI dhan29) (V_2) in combination with all weeding treatments produced the lowest number of tillers hill^{-1} at each period. Unweeded treatment in combination with all varieties produced the lowest LAI. All the weed control treatments gave higher TDM over time at the hybrid variety and gave lower TDM at inbred variety. The interaction of weed control treatments and variety significantly influenced the CGR and RGR throughout the growing period. Overall treatment combinations, V_3W_4 gave the highest plant height (103.35 cm). The highest number of total tillers hill^{-1} produced by the interaction between the hybrid varieties Sonarbangla-6 (V_3) along with the herbicidal weed management (W_4). The maximum length of panicle (25.11cm) was obtained in V_3W_4 treatment combination and the minimum length of panicle (22.74 cm) was obtained in V_1W_0 treatment combination. Treatment combination V_3W_4 produced the highest grains panicle^{-1} (197.10) the W_4 in hybrid and inbred varieties produced comparatively higher number of total grains panicle^{-1} compared to other weed control treatments. The lowest grains panicle^{-1} was obtained from the unweeded treatment with the three varieties. The highest thousand grain weight was observed in the treatment combination of V_3W_4 (29.58 g) and the lowest was observed in the treatment combination of V_2W_0 (22.08 g). The highest grain yield (9.50 t ha^{-1}) was obtained from the treatment combination of V_3W_4 which was statistically superior to the other treatments. The highest straw yield (15.19 t ha^{-1}) was obtained from the interaction between the inbred variety BRRI dhan29 and Sunrise 150 WG at the recommended dose and the lowest straw yield (5.03 t ha^{-1}) was observed from the interaction between the inbred variety BRRI dhan29 and unweeded treatment.

The herbicidal treatment W_4 along with the hybrid variety Sonarbangla-6 gave the highest BCR than the other two varieties (Hira-6 and BRRI dhan29). Among all the treatment combinations, the hybrid variety Sonarbangla-6 along with herbicidal treatment Ethoxysulfuran at 25% higher than the recommended dose gave the highest BCR (1.44). The second highest BCR (1.39) was given by the treatment combination of V_1W_4 and all the unweeding treatments at different varieties showed the negative BCR.

In conclusion, this study suggest that different weed control methods greatly affected the weed control efficacy, crop characters, yield contributing characters and grain yield of *boro* rice. Among the weed control treatments, application of Sunrise 150 WP 25% higher than the recommended dose (125 gha^{-1}) increased 22.63% higher grain yield than the application of Commit 500EC (Pre-emergence) 25% lower than the recommended dose (750 $mlha^{-1}$) and increased 34.9% grain yield than two weeding due to higher number of panicles $hill^{-1}$ and grains $panicle^{-1}$. But the weed control cost was the minimum for chemical weeding (herbicide) than hand weeding. Application of Sunrise 150 WP (Post Emergence) 25% higher than the recommended dose was also an effective weed control method which was more economic and effective than other treatments.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

2. Another experiment may be carried out with different variety.

3. Another experiment may be carried out with different weed management and their combination.

REFERENCE

Agazzani, C., Campagana, G. and Rapparini, G. (1999). Weed control in dry sown rice. *Informatore Agrario*. **55** (22): 85-87.

Ahmed, G. J. U., Mamun, A. A., Hossain, S. M. A., Siddique, S. B. and Mirdha, A. J. (1997). Effect of Bosagran and raking combined with hand weeding to control weeds in aus rice . *Bangladesh Agron. J.* **7** (1&2): 31-32.

Ahmed, G. J. U., Mridha, A. J., Bhuiyan, M. K. A., Riches, C. R. and Mortimer, M. (2003). Effect of different weed management systems on weed control, plant growth and grain yield of lowland rice. In: Proceedings of Nineteenth Asian Pacific Weed Sci. Soc. Conf. 17-21 March, 2003. Philippines. No. **1**: 84-92.

Ahmed, G. J.U., Hossain, S. T., Rahman M. B. and Kabir M. S. (1999). Chemical weed control in wet seeded rice. Brighton Crop Protec. Conf. Weeds Proc. Intl. Conf. Brighton, UK. pp. 243-248.

Ahmed, M.H., Islam, M.A. (1983). Relative efficiency and economics of different cultural methods and herbicides for weed control in transplanted aus rice. *Bangladesh J. Agril. Sci.* **23**(1): 67-73.

Akbar, A. (2004) Effect of establishment methods and weed management practices on some growth attributes of rice. *Rice Sci*. **13** (2): 131-140.

Alam, M. S., Islam, M. N., Zaman, A. K. M., Biswas, B. K. and Saha, M. K. (1996). Relative efficiency and economics of different cultural methods and herbicides for weed control in transplanted aus rice. *Bangladesh J. Agril. Sci.* **23**(1): 67-73.

Ali, A., Karim, M.A., Hassan, G., Ali, A., Ali, S.S. and Majid, A. (1993). Rice grain quality as influenced by split application of nitrogenous fertilizer. Intl. Rice Res. Newsl. **17**(3): 7.

Amarjit, D., Angiras, N. N. and Rana, S. S. (1994). Integrated weed management in direct seeded puddled sprouted rice. *Indian J. Agron.* **43** (4): 644-649.

Amin, M. R., Hamid, A., Choudhury, R. U., Raquibullah, S. M. and Asaduzzaman M. (2006). Nitrogen Fertilizer Effect on Tillering, Dry Matter Production and Yield of Traditional Varieties of Rice. *Int. J. Sustain. Crop Prod.* **1**(1): 17-20.

Angiras, N. N. and Rana, S. S. (1998). Integrated weed management in direct seeded puddled sprouted rice. *Indian J. Agron.* **43** (4): 644-649.

Anonymous. (1970). Rice Production Manual (Revised Edition). International Rice Research Institute, Los Banos, Philipines.

Anonymous. (1992). Encarta Reference Library 2005. 1993-2004 Microsoft Corporation.

Anonymous. (1998). Adaption and adoption USG technology for resource poor farmers in the tidal submergence area. Annual Internal Review Report for 2003-2004. Bangladesh Rice Res. Inst. Gazipur. p. 4.

Anonymous. (2003). Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 7-8.

Ashraf, M. M., Awan, T. H., Manzoor, Z., Ahmad, M. and Safdar, M. E. (2006). Screening of herbicides for weed management in transplanted rice. *J. Animal Plant Sci.* **16** (3/4): 89-92.

Attalla, S. I. and and Kholosy. A. S. (2002). Effect of weed control treatment on transplanted rice. Bull. Fac. Agric. Cairo Univ. 53(4): 525-530.

Ayub, M., Sharma, M. S. and Nazir M. S. (1987). The yield and yield component of fine rice as influenced by different spacing. Pakistan J. Sci. Ind. Res., 30(7): 523-525.

Babiker, F.S.H. (1986). The effect of zinc sulphate levels on rice growth and productivity. *Alexandria J. Agril. Res.* **31**(2): 480-481.

Balaswamy, K. (1999). Effect of urea and herbicides on weed composition and density in transplanted rice. *J. Res.* ANGRAU. **27** (3): 5 -11.

Baloch, M. S., Awan, 1. U., Gul H. and Khakwani, A. A. (2006). Effect of establishment methods and weed management practices on some growth attributes of rice. *Rice Sci*. **13** (2): 131-140.

Bari, M. N., Mamun, A. A. and Anwar, S. M. S. (1995). Weed infestation in transplanted aman rice as affected by land topography and time of transplanting. *Bangladesh J. Agril. Sci*. **22** (2): 227-235.

BBS (Bangladesh Bureau of Statistics). (2008). Statistical Year Book of Bangladesh Bureau of Statistics. Min. Plan. Govt. People's Repub. Bangladesh. p. 456.

Belz, R. G. (2007). Allelopathy in crop-weed interactions - an update. Pest Management Sci. **63** (4): 308-326.

Bhattacharya, S. P., Gash, R. P., Brahmachari, K., Pal, T. K. and Kumar, T. K. K. (1996). Efficiency of some new generation herbicides in controlling weed of transplanted born paddy. Etwiron. Exot **14** (2): 657-661.

Bhowmick, M. K. (2002). Optimization of Pretilachlor dose for weed management in transplanted rice. *Annals Plant Protec. Sci.* **10** (1): 131 - 133.

Bhowmick, M. K. (2002). Optimization of Pretilachlor dose for weed management in transplanted rice. *Annals Plant Protec. Sci.* **10** (1): 131 - 133.

Bijon, K. M. (2004). Effect of variety and weed control on weed seed bank, weed dynamics and the performance of transplanted aman rice. M. S. Thesis. Dept. Apron., Bangabandu Sheikh Mujibar Rahman Agril. Univ., Salna, Gazipur. ,Bangladesh.

BINA (Bangladesh Institute of Nuclear Agriculture). (1993). Annual Report (1992-93). Bangladesh Inst. Nucl. Agric. P. O. Box No. 4. Mymensingh. pp. 143-147.

Biswas, J. C., Satter, S. A. and Siddlque, S. B. (1991). Evaluation of herbicides in direct seeded rice. *Bangladesh Rice J.* **2** (1-2): 40-46.

Brar, L. S., Walia, U. and Dhaliwal, B. K. (1997), Time of application of herbicides against Echinochloa crus-galli in transplanted rice. *J. Res. Punjab. Agril. Univ.* **34** (2): 131-135.

BRRI (Bangladesh Rice Research Institue). (1995). Adhunik Dhaner Chash (in bengali). Pub no.5. Bangladesh Rice Res. Inst., Joydebpur, Gazipur. pp. 12, 20-21, 23.

BRRI (Bangladesh Rice Research Institule). (1998). Anual Report for 1995.

BRRI (Bangladesh Rice Research Institute). (1979). Annual report for 1975-76. Bangladesh Rice Res. Inst., Jodebpur, Gazipur, Bangladesh. pp. 3-5.

BRRI (Bangladesh Rice Research Institute). (1991). Annual Report for 1988. Bangladesh Rice Res. Inst., Joydebpur, Gazipur. pp. 8-15.

BRRI (Bangladesh Rice Research Institute). (1994). Annual Report for 1993. Bangladesh Rice Res. Inst., Jodebpur, Gazipur. pp. 8-9.

BRRI (Bangladesh Rice Research Institute). (1997). Bangladesh Rice Research Institute serving the nation. Gazipur 1701, Bangladesh. p. 14.

BRRI (Bangladesh Rice Research Institute). (2000). Annual Report for 1999-2000. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 63-67.

Burhan, H. D., Sozzi and Zosehke. (1989). Set-off for weed control in rice. Practical. experience for Indonesia. Proc. 12th Asian Pacific Weed Sci. Soc. Conf. 1989. Taipei, Tainwan. No. 1:127-131.

Carbonell, P. U. and Moody, K. (1983). Weed control practices in irrigated and rainfed rice farms in Nueva, Ecija, Philippines. *Philippines Agric*. **66**: 458-469.

Chandra, B. V., Mahedvappa, M., Krishnamurthy, A. H. and Bhaskar, V. (1992). Performance of IRRI rice hybrids in Mandya, Karnataka, India. *Intl. Rice Res. Newsl.* **17** (2): 6.

Chandra, D. and Mama, G. B. (1990). Weed management in transplanted rice grown under shallow submerged condition. *Indian J. Agron.* **27** (4): 465-467.

Chandra, S. and Pandey, J. (2001). Effect of rice culture, nitrogen and weed control on nitrogen competition between scented rice and weeds. *Indian J. Agron.* **46** (1): 23-25.

Chandra, S. and Solanki, O. S. (2003). Herbicidal effect on yield attributing characters of rice in direct seeded puddled rice. *Agril. Sei. Digest Karmal.* **23**(1):75-76.

Chandra, S., Tiwari, A. N. and Singh, R. (1998), Efficiency of herbicides in direct seeded puddled rice. *Agril. Sci. Digest Karnal*. **18** (2): 71-72.

Chowdhury, H. A. H., Talukder, N. M., Chowdhury, A. K. and Hossain, M. Z. (1995). Effect of Ronstar on weed management, yield and nutrient uptake by rice. *Bangladesh J. Agril. Sci*. **22** (1): 93-98.

Chowdhury, M. T. U., Sarker, A. U., Sarker, M. A. R. and Kashem, M. A. (1993). Effect of variety and number of seedlings hill^{-1} on the yield and its components on late transplanted *aman* rice. *Bangladesh J. Agril. Sci*. **20**(2): 311-316.

Chowdhury, S. A., Majid, M. A., Huque, K. S., Islam, M. and Rahman, M. M. (1995). Effect of variety on yield and nutritive value of rice straw. *Asian-Australasian J. Ani. Sci.* **8**(4): 329-335.

Costa, D. J. and Hoque, M. N. (1986). Superimposed variety trial on T. *aman* [Transplanted rice in Bangladesh]. Proc. Central Review Workshop, On-Farm Research Div. Jul. 5-10. BARI., Joydebpur, Bangladesh. pp. 25-26.

Damodaran, H. (2001). Breakthrough in hybrid rice technology-Jaldi Dhan provides success to IARI efforts. Daily Business Line. http://www.hinduonnet.com/businessline/2001/11/03/stories/070367za.htm.

Devaraju, K. M., Gowda, H. and Raju, B. M. (1998). Nitrogen response of Karnataka Rice Hybrid 2. *Int.Rice Res. Notes*. **23**(2): 43.

Dhiman M., Singh,R. P. and Singh, R. K. (2006). Studies on weed management in transplanted rice (*Oryza sativa* L.). *Res. Crops*. **7** (3): 630-632.

Elliot, P. C., Navarez, D. C. and Moody, K. (1984). Yield of rainfed transplanted rice as affected by cultivar, fertilizer level and weeding regime. Rice Farming Systems Program. Intl. Rice Res. Inst., Los Banos, Philippines. pp. 1-6.

FAO (Food and Agriculture Organization). (1998). Production Yearbook for 1998. FAO, UN. Rome, Italy. p.118.

FAO (Food and Agriculture Organization) Database(2004).

Gardner, Y. P. 1985 Gill, P.S. and Shahi, H.N. (1985). Effect of Nitrogen levels in relation of age of seedlings and time of transplanting oil growth yield and milling characteristics of rice. *Indian J. Agric. Sei.* **57**(9): 6310-614.

Gill, P. P., Hari, O.M., Katyal, S.K. and Dhiman, S.D. (1992). Response of two rice hybrids to graded levels of nitrogen. *Indian J. Agric. Sci*. **70**: 140-142.

Gnanasambandan, S. and Murthy, P. B. (2001). Effect of tillage practices and pre-emergence herbicides application for weed control in wet seeded rice. *Madras Agril. J*. **88** (10-12): 590-593.

Gogoi, A. K. (1998). Weed control in late transplanted tow land rice. *Indian, J. Agron.* **43** (2): 298-301.

Gogoi, A. K., Rajkhowa, D. J. and Kandali, R. (2000). Effect of varieties and weed control practices on rice productivity and weed growth. *Indian J. Agron.* **45** (3): 580-585.

Guilani, A. A., Siadat, S. A. and Fathi, G. (2003). Effect of plant density and seedling age on yield and yield components in 3 rice cultivars in Khusestan growth conditions. *Iranian J. Agric. Sci.* **34**(2): 427-438.

Haque, M. E. (1993). Rostar as weedicide in transplanted aman rice M.S. Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymenshngh, pp. 29-31.

Hossain, M. (2000). Auto-ecology of Echinochloa crus-galli and its control in direct seeded aus rice. M. S. Thesis. Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 57-62.

Hossain, S. M. A and Alam, A. B. M. N. (1991). Productivity of cropping pattern of participating farmers. **In:** Fact searching and Intervention in two FSRDP Sites, Activities. 1980-1990. Farming system Research and Development Programme, BAU, Mymensingh, Bangladesh. pp. 41-44.

Hunt, R. (1978). Plant growth analysis. The institute of Biology's studies in Biology No. 96. Edward Arnold (Publishers) Limited, London, UK.

Hutson, Y. P. and Roberts, P. K. (1987). Relative efficacy of herbicides in transplanted rice. *Indian J. Weed Sci*. **35** (3-4): 257-258.

Idris, M. and Matin, M. A. (1990). Response of four exotic strains of *aman* rice to urea. *Bangladesh J. Agric. Assoc. China*. **118**: 48-61.

IRRI (International Rice Research Institute). 1985. International Rice Res. Inst., Los Bonos, laguna, Philipines. pp.224-231.

Islam, S. (1995). Effect of variety and fertilization on yield and nutrient uptake in transplant *aman* rice. M.S. thesis. Dep. Agron. Bangladesh Agril. Univ. Mymensingh. pp. 26, 29.

Islam, M. S., and Haq, K. A, (1987). Development of a low cost weeder for low land paddy. *Bangladesh J. Agric.* **12** (4): 255-262.

Islam, T., Bhowmick, M. K., Ghosh, R. K. and Sounda, G. (2001). Effect of Pretilachlor on weed control and yield of transplanted rice. *Environ. Ecol.* **19** (2): 265-268.

Isley, P. (1960). Effect of Pretilachlor on weeds in direct seeded puddled rice. *Indian J. Weed Sci*. **2** (1): 28-30.

Jena, S. N., Tripathy, S., Sarangi, S. K. and Biswal, S. (2002). Integrated weed management in direct seeded rainfed lowland rice. *Indian J. Weed. Sci.* **34** (1-2): 32-35.

Julfiquar, A. W., Haque, M. M., Haque, A. K. G. M. E. and Rashid, M. A. (1998). Current status of Hybrid Rice Research and Future Program in Bangladesh. Proc. Workshop on Use and Development of Hybrid Rice in Bangladesh, held at BARC, 18-19, May, 1998.

Kalhirvelan, P. and Vaiyapuri. V. (2003). Relative efficacy of herbicides in transplanted rice. *Indian J. Weed Sci*. **35** (3-4): 257-258.

Kalyanasundaram, D., Kumar, S. R.V. and Kumar, K. P. S. (2006). Studies on integrated weed management in direct-seeded lowland rice (*Oryza sativa* L.). *Res.Crops*. 7 (3): 627-629.

Kamal, A. M. A., Azam, M. A. and Islam, M. A. (1988). Effect of cultivar and NPK combinations on the yield contributing characters of rice. *Bangladesh J. Agril. Sci.* **15**(1): 105-110.

Kamalam, J. and Bridgit, T. K. (1993). Effect of chemical and integrated weed management in upland rice. *J. Tropic. Agric*. **31**: 77-80.

Kathiresan, G. and Veerabadran, V. (1991). Effect of integrated weed management on nutrient uptake in semi dry rice and associated weeds. *Mysore J. Agril. Sci.* **25**: 414-417.

Khan, M. A. H., Jensen, H. E. and Jensen, S. E. (1981). Barley crop development, yield and light energy utilization under field condition. *Cereal Res. Comm.***9**(2): 191-195.

Kulmi, G. S. (1990). Cultural and chemical weed control in transplanted rice (*Oryza sativa*). *Crop Res. Hisar*. **3** (2): 151-154.

Liu, X. (1995). II-you 92: a new hybrid rice for late season. *Chinese Rice Res. Newsl.* **3**(2): 12.

Madhu, M., Najappa, H. V. and Naik, H. R. (1996). Economics of weed control treatment in puddled seeded rice. Crop Res. Hisar. **12** (2): 133-137.

Mahajan, G., Boparai, B. S., Bra, L. S. and Sardana, V. (2003). Effect of Pretilachlor on weeds in direct seeded puddled rice. *Indian J. Weed Sci*. **35** (1-2): 128-130.

Mahbub, A. M. M., Hossain , M. and Janaich, A. (2001). Hyrid rice adoption in Bangladesh. A socioeconomic assessment of farmers experience: Research Monograph, Series no. 18. Social Sciences Division, 2001. Los Banos, Philippines. p.38.

Mamun, A. A. (1990). Weeds and their control: A Review of Weed Research in Bangladesh. JSARD, Japan Intl. Co-operation Agency. Dhaka, Bangladesh. pp. 45-72.

Mamun, A. A., Karim, S. M. R., Begum, M., Uddin, M. I. and Rahman, M. A. (1993), Weed survey in different crops under three Agroecological Zones of Bangladesh. BAURES Prog. **8**:41-51.

Mandal, M. A. H., Rahman M. A. and Gaffer, M. A. (1995). Field efficiency of Rilof H and Rifit herbicides for weed control in transplanted rice. *Bangladesh J. Agril. Sci*. 20: 7-12.

Manish C., Khajanji, S. N., Sawi, R.M. and Dewangan, Y. K. (2006). Effect of halosulfuron- methyl on weed control in direct seeded drilled rice under puddled condition of Chhattisgarh plains. Plant Archives. **6** (2): 685-687.

Mercado, P.P. (1979). Effect of halosulfuron- methyl on weed control in direct seeded drilled rice under puddled condition of Chhattisgarh plains. Plant Archives. **2** (2): 68-72.

Miah, M. H., Karim, M. A., Rahman, M. S. and Islam, M. S. (1990). Performance of Nizersail mutants under different row spacing. *Bangladesh J. Train. Dev.* **3**(2): 31-34.

Mian, M. H. and Mamun, R. (1969). Proc. Int. Seminar on Photoperiod Sensitive Transplant Rice, October 1977. Bangladesh Rice Res. Inst. BRRI. BRRI Pub. No. 34. pp. 130-132.

Mian, M. N H. and Bhuiya. M. R. (1977) Effect of Pretilachlor on weeds in direct seeded puddled rice. *Indian J. Weed Sci*. **15** (1-2): 28-33.

Molla, M. A. H. (2001). Influence of seedling age and number of seedlings on yield attributes and yield of hybrid rice in the wet season. *Int. Rice. Res. Notes.* **26**(2): 73-74.

Moorthy, B. T. S. and Das, F. C. (1992). Performance evaluation of tow manuallly operated weeders in upland rice. *Orissa J. Agril. Res*. **5** (1-2): 36-41.

Moorthy, B. T. S., Saha, S. and Saha, S. (2002). Evaluation of pre and post emergence herbicides for their effects on weeds and upland direct seeded rice. *Indian J Weed Sci.* 34 (3-4): 97-200.

Moorthy, B. T. S., Sanjay, S. and Sanjoy, S. (1999). Relative efficacy of different herbicides for weed control in direct seeded rice on puddled soil. *Indian J. Weed Sci*. 31: 3-4, 210-213.

Nair, A. K., Pramic, S. C., Ravisankar, N. and Dinesh, R. (2002). Effect of varieties and weed control practices on productivity of rice and weed growth in lowland of the South Andamans. Indian J. Agril. Sci. **72** (8): 477-479.

Nandal, D. P., Hari, O.M. and Om, H. (1998). Weed control in direct seeded puddled rice. *Indian J. Weed Sci*. **30** (1-2): 18-20.

Navarez, D. E., Estano, D. B. and Moody, K. (1982). Preliminary evaluation of farmers weed control practices in Cagayan in Philippines. *Philippines J. Weed Sci*. **8** (2): 49-55.

Nematzadeh, G. A., Arefi, H. A., Amani, R and Mani (1997). Release of a new variety of rice, namely "Nemat" with superiority in yield and quality. *Iranian J. Agric. Sci.* **28**(4): 79-86.

Nurujjman, M. 2001. Effect of plant spacing and herbicides on the weed control and yield of transplanted aman rice (cv. BR22). M. S. Thesis. Dept. Agron., Bangladesh Agril. Univ., Mymensingh, Bangladesh.

Om, H., Dhiman, S. D., Nandal, D. P. and Verma, S. L. (1998). Effect of method nursery raising and nitrogen on growth and yield of hybrid rice (*Oryza sativa*). *Indian J. Agron*. **43**(1): 68-70.

Otsuka, H., Nemoto, M. and Masuda, S. (2006). The floristic composition of paddy fields and their levees under different weed management techniques. *J. Weed Sci. Tech.* **51** (4): 229-23) 8.

Panwar, K., Madhu, M., Najappa, H. V. and Naik, H. R. (1992). Economics of weed control treatment in puddled seeded rice. Crop Res. Hisar. **12** (2): 133-137.

Patel J. R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa*). *Indian J. Agron.* **45**(1): 103-106.

Patil, S. J., Natarayan, S. P. and Pattanshetti, H. V. (1986). Herbicides for weed control in transplanted rice. *Intl. Rice Res. Newl.* **11**(2): 28.

Polthanee, A., Ta-Oun, M., Panchapan, S., Lasirkul, M., Pramojchani, P., Yamazaki, K., Nakano, M., and Ushikubo, A. (1996). Effective weed management on growth and yield of rainfed direct seeded rice. *Kaen-Kaset Khon Kaen Agril. J. Thailand.* **24**(2): 76-80.

Prasad, K. and Rafey, A. (1995). Effect of integrated weed management on weed growth, nutrient uptake, economics and energetics in rainfed upland rice (Oryza sativa). *Indian J. Agri. Sci*. **65** (4): 260-264.

Radford, P. J. (1967). Growth analysis formulae. Their use and abuse. Crop Sci. 7: 171-175.

Rafey, A., Khan, P. A. and Srivastava, V. C. (1989). Effect of Nitrogen on growth, yield and nutrient uptake of upland rice. *Indian J. Agron.* **34** (2): 133-135.

Rahman, M. M. (2001). Effect of seedling age and spacing on the productivity of hybrid rice sonarbangla-1. M. S. Thesis, Dept. Agron., BAU, Mymensingh.

Rajendra P., Shaarma, S. N., Surendra, S. and Zaman, F. U. (1998). Productivity of hybrid rice pusa HR3 under late planting conditions. *Ann. Agril. Res.* **19**(1): 92-93.

Rajendran, R. and Kempuchetty, N. (1998). Efficiency of herbicides in direct seeded puddled rice. *Agril. Sci. Digest. Karnal*. **18** (2): 71-72.

Rajkhowa, D. J., Gogoi, A. K. and Kandali, R. (2001). Effect of weed control and nutrient management practices in rice. *Indian J. Weed Sci*. **33** (1&2): 41-55.

Raju, A., Pandian, B. J., Thukkaiyannan, P. and Thavaprakash, N. (2003). Effect of weed management practices on the yield attributes and yield of wet seeded rice. *Acta. Agron. Hungarica*. **51** (4): 461-464.

Rangaraju, G. (2002). Weed flora and weed dynamics of pre-monsoon dry seeded rainfed rice as influenced by herbicide and it's time of application. *Indian J. Weed Sci*. **34** (1-2):123-125.

Ranjit, J. D., Suwanketnikom, R. (2005). Response of weeds and yield of dry direct seeded rice to tillage and weed management. *Natural Sci*. **39** (2): 165-173.

Razzaque, A. H. M., Enamul, M. and Gaffer, M. A. (1998). Performance of Ronstar as a herbicide in transplanted amen rice. *Bangladesh J. Sci. Ind. Res.* **33** (4): 503-507.

Rekha, K. B., Razu, M. S. and Reddy, M. D. (2002). Effect of herbicides in transplanted rice. *Indian J. Weed Sci.* 34(1-2): 123-125.

Roy, B. C. (1999). Nitrogen Fertilizer Management and its Effects on Growth and Yield of Rice Varieties in Bangladesh. PhD Dissertation. Verlag Grauer, Stuttgart, Germany. p. 50.

Samanta, S. C., Gaffer, M. A., Kashem, M. A., Sultan, A. and Ahmed, S. (1995). Ronstar for weed control in transplanted aman rice culture. *Bangladesh J. Sci. Ind. Res*. **30** (2-3): 225-233.

Samar S., Ladha, J. K., Gupta, R.K., Lav, B., Rao, A. N., Sivaprasad, B. and Singh, P. P. (2007). Evaluation of mulching, intercropping with Sesbania and herbicide use for weed management in dry-seeded rice (*Oryza sativa* L.). *Crop Protec*. **26** (4): 518-524.

Sanjoy, S., Morthy, B. T. S. and Jha. K. P. (1999). Influence of different production factors on the performance of rainfed upland rice. *Indian J. Agril. Sci.* **69** (6): 449-450.

Savithri, K. E., Chidandra, M. R. and Tomy, P. J. (1994). Efficiency of pre-emergence herbicides in transplanted rice. *J. Trop. Agril*. **32**: 27-29.

Sawant, A. C., Throat, S. T., Khadse, R. R. and Bhosalef, R. J. (1986). Response of early rice varieties to nitrogen levels and spacing in coastal Maharashtra. *J. Maharashtrta Agril. Univ*. **11**(2): 182-184.

Shamsuddin, A. M., Islam, M. A. and Hossain, A. (1988). Comparative study on the yield and agronomic characters of nine cultivars of *aus* rice. *Bangladesh J. Agril. Sci.* **15**(1): 121-124.

Sharma, A. and Gogoi, A. K. (1995). Mechanical weed control in upland rice. *World Weed*. **2** (2): 137-143.

Sharma, S. K. and Bhunia, S. R. (1999). Weed management in transplanted rice under Ghaggar floodplains of northwest Rajasthan. *Indian J. Agron.* **44** (3): 543-547.

Singh, 0. P. and Bhan, V. M. (1992). Effect of herbicides and water submergence levels on control of weeds in transplanted rice. *Indian J. Weed Sci*. **24** (4): 226-230.

Singh, C. M., Moody, K. and Cho, S. C. (1985). Weed control through inter-row cultivation in upland rice. *Sarhad J Agric*. **16** (3): 35-40.

Singh, G. and Singh, O.P. (1994). Herbicidal control of weed in transplanted rice in rainfed low land condition. *Indian, J. Agron*. **39**(3): 463-465.

Singh, G., Singh, R. K., Singh, V. P., Nayak, R. and Singh, R. S. (1999). Weed management in transplanted rice (Oryza saliva) under rainfed lowland situation. *Indian J. Agron.* **44** (4): 728-732.

Singh, R. S. (2005). Study of Beushening in controlling weeds under rainfed lowland rice in Chotanagpur Region. J. *Applied Biolology*. **15** (1): 22-24.

Singh, S. and Gangwer, B. (1989). Comparative studies on production potentials in traditional tall and improved rice cultivars. *J. Andaman Sci. Assoc*. **5**(1): 81-82.

Singh, S. P. and Kumar, R. M. (1999). Efficacy of single and sequential application of herbicides on weed control in transplanted rice. *Indian J. Weed Sci.* **31** (3-4): 222-224.

Singh, V. P., Govindra S., Singh, R. K., Singh, S. P., Kumar, A., Sharma, G., Singh, M. K., Mortimer, M, and Johnson, D. E. (2005). Effect of weed management and crop establishment methods on weed dynamics and grain yield of rice. *Indian J. Weed Sci.* **37** (3/4): 189-192.

Son, Y., Park, S. T., Kim, S. Y., Lee, H. W. and Kim, S. C. (1998). Effects plant density on the yield and yield components of low-tillering large panicle type rice. *RDA J. Crop Sci. I.* **40**: 2.

Subramanian, E., Martin, G. J. and Balasubramanian, R. (2006). Effect of integrated weed-management practices on growth and yield of wet-seeded rice (Oryza sativa) and their residual effect on succeeding pulse crop. *Indian J. Agron.* **51** (2): 93-96.

Suprithatno, B. and Sutaryo, B. (1992). Yield performance of some new rice hybrids varieties in Indonesia. *Int. Rice Res. Newsl.* **17**(3): 12.

Swain, P., Annie, P. and Rao, K. S. (2006). Evaluation of rice (*Oryza sativa*) hybrids in terms of growth and physiological parameters and their relationship with yield under transplanted condition. *Indian J. Agric. Sci.* **76**(8): 496-499.

Takeda, T., Oka, M. and Agata, W. (1983). Characteristics of dry matter and grains production of rice cultivars in warmer part of Japan. I. Comparison of dry matter production between old and new types of rice. Japanese J. Crop Sci. **52**(3): 299-306.

Thomas, C. G., Abraham, C. T. and Sreedevi, P. (1997). Weed flora and their relative dominance in semi dry rice culture. *J. Tropic. Agric*. **35**: 51-53.

Toufiq, A. (2003). Integrated weed management in transplanted aman rice cv. BRRI dhan37. M. S. Thesis Dept. Agron., Bangladesh Agril. Univ., Mymensingh, Bangladesh.

Trivedi, K. K., Tiwari, J. P. and Bisen, C. R. (1 986). Integrated weed control in upland drilled rice. *Pesticides*. **20** (11): 29-33.

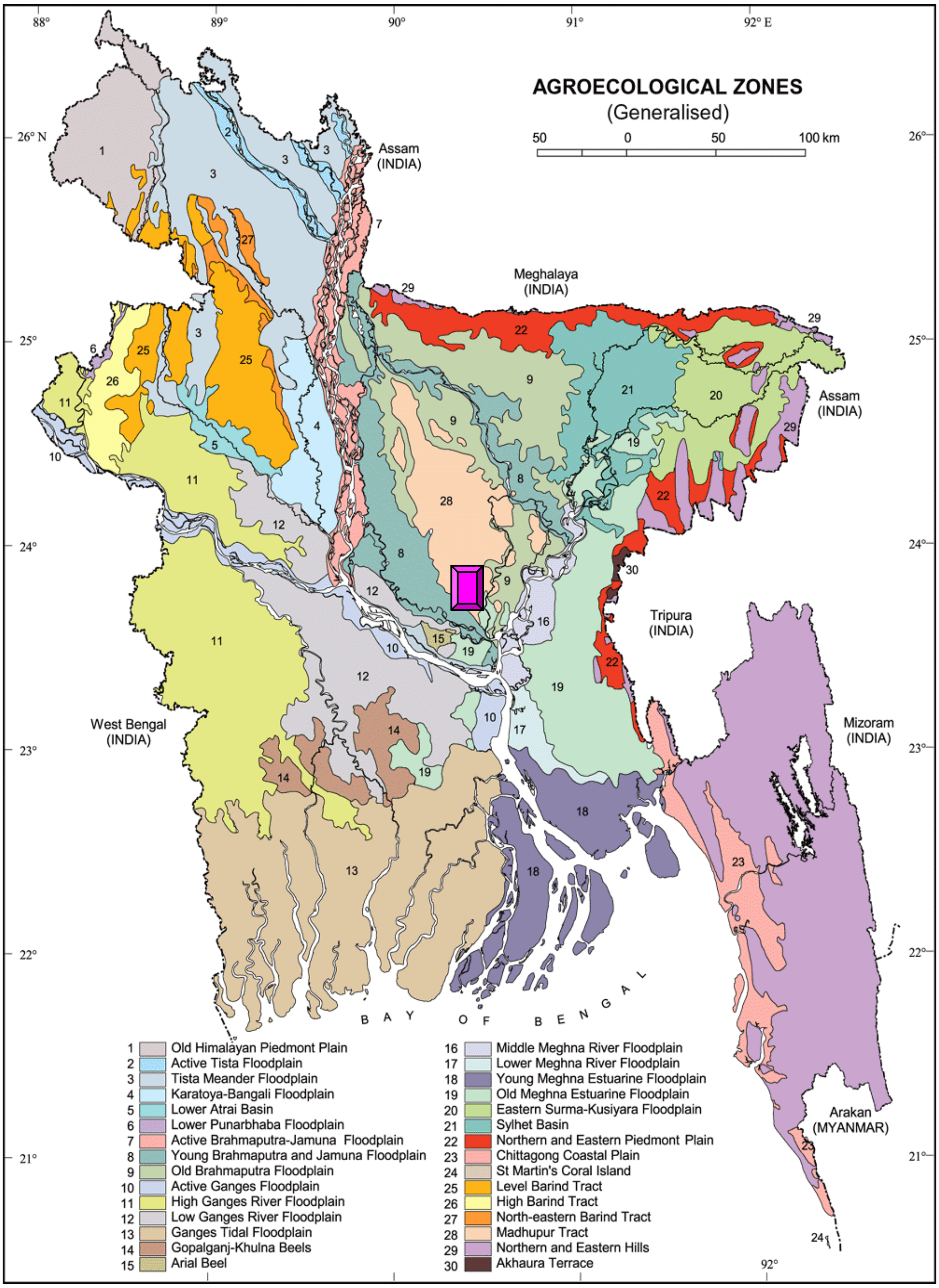
Venkataraman, N. S. and Gopalan, M. (1995). Current status of weed problems in rice production in Tamil Nadu, India. In. Papaws, H. R. and Heong, K. L. (ed.) Weed Management in Rice Production. *Intl. Rice. Res. Inst., Los. Banos. Laguna, Philippines*. pp. 113-126.

Wang, J. L., Xu, Z. J. and Yi, X. Z. (2006). Effects of seedling quantity and row spacing on the yields and yield components of hybrid and conventional rice in northern China. *Chinese J. Rice Sci.* **20**(6): 631-637.

Yoshida, S. (1981). Climatic influence on yield and yield components of lowland rice in the tropics. Climate and Rice. Los Banos, Philippines. pp. 471- 494.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of experimental field soil analyzed in Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix III. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from December 2008 to May, 2009

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11
April, 2009	33.2	21.1	61	88
May, 2009	27.0	19.2	63	54

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix IV. Analysis of variance (Mean squares) for weed density as influenced by variety and weed management in boro rice at different DAT

Sources of variation	Degrees of freedom	Mean square						
		Weed density (no. m^{-2})						
		7 DAT	**14DAT**	**21 DAT**	**28 DAT**	**35 DAT**	**42 DAT**	**49 DAT**
Replication	2	55.619	9.000	33.583	71.583	252.778	223.504	83.012
Variety (A)	2	51.571*	116.249**	51.571	256.321**	323.361**	734.397**	1134.250**
Weeding (B)	6	103.143**	5553.387**	8744.060**	10638.726**	10414.193**	9023.361**	7663.655**
Interaction (A×B)	12	87.571**	158.104**	146.738**	253.530**	329.532**	318.647**	296.333**
Error	40	12.269	9.429	41.646	28.883	37.844	57.654	45.512

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix V. Analysis of variance (Mean squares) for plant height and total number of tillers hill^{-1} as influenced by variety and weed management in boro rice at different DAT

Sources of variation	Degrees of freedom	Mean square							
		Plant height (cm)				Total number of tillers hill^{-1}			
		20 DAT	45 DAT	70 DAT	95 DAT	20 DAT	45 DAT	70 DAT	95DAT
Replication	2	16.275	25.668	28.939	127.327	0.458	0.023	14.450	5.653
Variety (A)	2	16.170*	1.433	15.669	58.937	0.366*	15.672**	33.489**	7.102*
Weeding (B)	6	9.326	31.112*	52.597	64.594*	0.231*	51.177**	73.354**	26.716**
Interaction (A×B)	12	3.134	3.207	19.342	13.828	0.086	5.927**	7.359**	3.467*
Error	40	4.515	9.689	40.878	20.801	0.088	0.800	1.362	1.374

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix VI. Analysis of variance (Mean squares) for LAI and total dry matter (g hill^{-1}) as influenced by variety and weed management in boro rice at different DAT

Sources of variation	Degrees of freedom	Mean square							
		LAI				**Total dry matter (g hill^{-1})**			
		20 DAT	45 DAT	70 DAT	95 DAT	20 DAT	45 DAT	70 DAT	95 DAT
Replication	2	1.833	2.079	0.327	0.407	0.150	42.943	96.825	300.968
Variety (A)	2	0.884**	0.772**	0.414**	0.620	0.305	5.201	10.991	292.749**
Weeding (B)	6	0.444**	1.639**	0.973**	0.968	0.891**	18.152**	35.860**	363.899**
Interaction (A×B)	12	0.036	0.028	0.014	0.037	0.481**	0.314	1.764	17.161
Error	40	0.117	0.075	0.017	0.436	0.165	2.362	6.825	16.568

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix VII. Analysis of variance (Mean squares) for crop growth rate (CGR) and relative growth rate(RGR) as influenced by variety and weed management in boro rice at different DAT

Sources of variation	Degrees of freedom	Mean square					
		CGR (g hill^{-1} day^{-1})			**RGR (mg hill^{-1} day^{-1})**		
		20-45 DAT	**45-70 DAT**	**70-95 DAT**	**20-45 DAT**	**45-70 DAT**	**70-95 DAT**
Replication	2	0.048	0.048	0.000	42.857	18.697	19.048
Variety (A)	2	0.011	0.004	0.577**	54.171**	1.018	53.186**
Weeding (B)	6	0.025**	0.013*	0.255**	57.480**	5.181*	3.375
Interaction (A×B)	12	0.001	0.002	0.027*	38.585**	0.741	2.390
Error	40	0.005	0.005	0.011	10.357	1.630	1.648

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix VIII. Analysis of variance (Mean squares) for yield and yield contributing characters as influenced by variety and weed management in boro rice

Sources of variation	Degrees of freedom	Plant height (cm)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Ineffective tillers hill^{-1} (No.)	Total grains panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)
Replication	2	45.094	19.048	10.778	0.153	1384.302	2123.365	45.762
Variety (A)	2	376.382**	26.217**	14.313**	4.347**	184.324	236.190	25.594**
Weeding (B)	6	11.543	60.137**	84.379**	2.405**	4745.617**	6728.443**	173.663**
Interaction (A×B)	12	15.413	5.060**	5.083**	0.228*	54.214	60.549	5.792
Error	40	12.538	1.548	0.728	0.095	208.552	240.983	4.195

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix VIII. Contd.

Sources of variation	Degrees of freedom	Panicle length (cm)	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t ha^{-1})	Harvest Index (%)
Replication	2	1.362	29.798	10.714	0.656	15.345	14.627
Variety (A)	2	17.881**	12.346*	6.265**	8.825**	29.642**	6.778*
Weeding (B)	6	17.124**	62.072**	30.344**	81.344**	208.567**	59.106**
Interaction (A×B)	12	1.358*	6.396	0.037	2.329	2.161*	3.591*
Error	40	0.665	3.260	0.714	1.325	1.009	1.403

Note: ** = Significant at 1% level of probability and * = Significant at 5% level of probability

Appendix IX. Production cost as influenced by variety and weed management in boro rice

A. Wages and price of different items used in the experiment

No.	Item of expenditure	Rate (Tk.)
A.	Labour: 1. Human labour (man-day of 8 hours)	70.00
	2. Animal labour (animal-day of 8 hours of a pair of bullock)	60.00
	3. mechanical labour (tractor-day of 8 hours)	1740.00
B.	Rice seed varieties: 1. BRRI dhan29 per kg	35.00
	2. Sonarbangla-6 per kg	240.00
	3. Hira-6 per kg	260.00
C.	Fertilizer: 1. Urea per kg	6.00
	2. TSP per kg	13.00
	3. MP per kg	10.00
	4. Gypsum per kg	4.00
	5. Zinc sulphate per kg	40.00
D.	Irrigation (One irrigation per hectare)	650.00
E.	Pesticide: 1.Herbicide	
	• Sunrise 150 WG per 100 g	850.00
	• Commit 500 EC per 100 ml	80.00
	2. Insecticide	
	• Malathion per 100 ml	60.00
F.	Value of land (One hectare)	150000.00
G.	Interest on inputs and value of land per year	12.50%
H.	Miscellaneous overhead cost	5%

B. Operation wise break up of labour required per hectare of boro rice (excluding weeding cost)

Sl. No.	Operation	Man-day for Hira-6	Man-day for BRRI dhan29	Man-day for Sonarbangla-6	Animal-day	Tractor-day
1.	Land preparation	35.00	35.00	35.00	20.00	0.5
2.	Fertilizer application	3.00	3.00	3.00	-	-
3.	Seedling transplanting	35.00	40.00	32.00	-	-
4.	Weeding	variable	variable	variable	-	-
5.	Irrigation	10	10	10	-	-
6.	Plant protection (spraying insecticide)	1	1	1	-	-
7.	Harvesting	30.00	28.00	25.00	-	-
8.	Carrying	15.00	15.00	15.00	-	-
9.	Threshing	15.00	20.00	15.00	-	-
10.	Cleaning, drying, weight and bagging	14.00	14.00	14.00	-	-
Total labour		158.00	166.00	150.00	20.00	0.5
Total cost of labour		11060.00	11620.00	10500.00	1200.00	870.00

C. Cost of production per hectare of boro rice excluding weeding cost

Sl. No.	Head of cost of production	Cost (Tk.)	Cost (Tk.)	Cost (Tk)
		Hira-6	BRRI dhan29	Sonarbangla-6
1.	Input cost			
	A. Immaterial cost	12342.00	13458.00	12422.00
	B. Material cost			
	• Seedling (for 1 ha)	13098.00	9655.00	12729.00
	• Fertilizer			
	1.Urea 270 kg	1620.00	1620.00	1620.00
	2. TSP 150 kg	1950.00	1950.00	1950.00
	3. MP 120 kg	1200.00	1200.00	1200.00
	4. Gypsum 100 kg	400.00	400.00	400.00
	5. Zinc sulphate 10 kg	400.00	400.00	400.00
	• Irrigation (10 times)	6500.00	6500.00	6500.00
	• Insecticide (Malathion)	1500.00	1500.00	1500.00
	Total input cost (Immaterial cost + Material cost)	39010.00	36683.00	38721.00
2.	Overhead cost			
	• Interest on input cost @ 12.5% for 5 months	1047.00	1076.00	1025.00
	• Interest on value of land @ 12.5% for 5 months	6550.00	6550.00	6550.00
	• Miscellaneous overhead cost @ 5% of input cost	1050.00	1195.00	1065.00
	Total overhead cost	8647.00	8821.00	8640.00
Total cost of production(excluding weeding cost)		47657.00	45504.00	47361.00

D. Total cost of production

Treatment	Immaterial cost		Material cost		Total cost
	Number-man day^{-1}	Cost (Tk)	Amount	Cost (Tk)	Cost (Tk)
V_1W_0	0.00	0.00	0.00	0.00	0.00
V_1W_1	50.00	3500.00	0.00	0.00	3500.00
V_1W_2	63.00	4410.00	0.00	0.00	4410.00
V_1W_3	12.00	840.00	100 g	850.00	1690.00
V_1W_4	10.00	700.00	125 g	1062.50	1762.50
V_1W_5	12.00	840.00	1000 ml	800.00	1640.00
V_1W_6	12.00	840.00	750 ml	600.00	1440.00
V_2W_0	0.00	0.00	0.00	0.00	0.00
V_2W_1	52.00	3640.00	0.00	0.00	3640.00
V_2W_2	68.00	4760.00	0.00	0.00	4760.00
V_2W_3	15.00	1050.00	100 g	850.00	1900.00
V_2W_4	14.00	980.00	125 g	1062.50	2042.50
V_2W_5	15.00	1050.00	1000 ml	800.00	1850.00
V_2W_6	15.00	1050.00	750 ml	600.00	1650.00
V_3W_0	0.00	0.00	0.00	0.00	0.00
V_3W_1	50.00	3500.00	0.00	0.00	3500.00
V_3W_2	63.00	4410.00	0.00	0.00	4410.00
V_3W_3	12.00	840.00	100 g	850.00	1690.00
V_3W_4	10.00	700.00	125 g	1062.50	1762.50
V_3W_5	12.00	840.00	1000 ml	800.00	1640.00
V_3W_6	12.00	840.00	750 ml	600.00	1440.00

Here, V_1 = Hira-6, V_2 = BRRI dhan29, V_3 = Sonarbangla-6 and W_0 = No weeding, W_1 = One weeding (30 DAT), W_2 = Two weeding (30 DAT & 50 DAT), W_3 = Ethoxysulfuran (recommended dose), W_4 = Ethoxysulfuran (25% higher than the recommended dose), W_5 = Pretilachlor (recommended dose), W_6 = Pretilachlor (25% lower than the recommended dose)