INFLUENCE OF PLANTING METHOD AND WEEDING ON GROWTH AND YIELD OF TRANSPLANT AMAN RICE

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CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF PLANTING METHOD AND WEEDING ON GROWTH AND YIELD OF TRANSPLANT AMAN RICE"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. SHEFAT-AL-MARUF,*** *Registration. No.***08-02973** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated: 25.02.2016
Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

Dedicated to

My

Beloved Parents

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INFLUENCE OF PLANTING METHOD AND WEEDING ON GROWTH AND YIELD OF TRANSPLANT AMAN RICE

ABSTRACT

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka from July 2013 to December 2013. The experiment consisted of two factors: Factor A: Planting method viz. Rice transplanter (P_1) and Conventional method (P_2) and Factor B: Weeding viz. No Weeding (W_0), Weeding at 20 DAT (W_1), Weeding at 35 DAT (W_2), Weeding at 50 DAT (W_3), Two Weedings at 20 DAT & 35 DAT (W_4), Two Weedings at 20 DAT & 50 DAT (W_5), Two Weedings at 35 DAT & 50 DAT (W_6) and Three Weedings at 20 DAT, 35 DAT & 50 DAT (W_7), following split-plot design with three replications. Rice transplanter required less time (91 days) for flowering whereas, conventional method required more time (103) days for flowering. The maximum number of filled grains panicle^{-1} and minimum number of unfilled grains panicle^{-1} (170.82 and 27.83 respectively) were obtained from conventional method while the minimum number of filled grains panicle^{-1} and maximum number of unfilled grains panicle^{-1} from rice transplanter (158.31 and 41.61 respectively). Higher yield (5.38 t ha^{-1}) was obtained from conventional method and lower yield (4.93 t ha^{-1}) from rice transplanter but they did not vary significantly. Higher biological yield (12.92 t ha^{-1}) was obtained from conventional method and the lower from rice transplanter (10.86 t ha^{-1}). In case of weeding, the highest grain yield was obtained from W_7 (5.48 t ha^{-1}) and lowest from W_0 (4.13 t ha^{-1}). In case of interaction between planting method and weeding, the highest grain yield obtained from P_2W_7 (5.82 t ha^{-1}) and the lowest from P_1W_0 (3.57 t ha^{-1}). There was no significant difference among the treatments except P1W0, P1W1 and P2W0 which showed significantly lower grain yield than others. As the conventional transplanting incurs more labour, using rice transplanter and weeding either at 25 DAT or 35 DAT might be suggested.

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LIST OF ACRONYMS

Acronyms	Full word
AEZ	Agro- Ecological Zone
Anon.	Anonymous
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV	Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
^0C	Degree Centigrade
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
hr	Hour(s)
IRRI	International Rice Research Institute
K_2O	Potassium Oxide
Kg	Kilogram (s)
LSD	Least Significant Difference
LAI	Leaf area Index
m	Meter
m^2	Meter squares
mm	Millimeter
MOP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
%	Percentage
P_2O_5	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
Zn	Zinc

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Rice is cultivated in 113 countries and it is the staple food of more than 50 % population of the world of which about 90 percent area exists in Asia (Das, 2012). In Asia, where 90% of rice is consumed, ensuring there is enough affordable rice for everyone, or rice security, is equivalent to food security (IRRI, 2013). Rice is the most important staple food in Asia, providing on an average 32% of total calorie uptake (Maclean *et al*., 2002). It is the grain with the second-highest worldwide production, after corn. Bangladesh is the fourth highest rice *(Oryza sativa* L.) producing country in the world (FAO, 2013).

Rice is the staple food of about 150 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Almost all of the 13 million farm families of the country grow rice. Rice is grown on about 11.56 million hectares which has remained almost stable over the past three decades. About 76.71% of the total cropped area is planted to rice in the year 2012-13. Total rice production in Bangladesh was about 10.59 million tons in the year 1971 when the country's population was only about 70.88 millions. However, the country is now producing about 34.00 million tons to feed her 149.69 million people (Mondal and Choudhury, 2014).

Thus it provides nearly 40% of national employment (48% of rural employment), about 70-76% of total calorie supply and 66% of protein intakes of an average person in the country (Ahmed, 2006). Moreover rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain, 2002).

However, there is no reason to be complacent as the population of Bangladesh is still growing by two million every year at the rate of 1.26% and the population of the country in the year 2030 will be 189.85 million. As such the country will require about 39.80 million tons of rice for the year 2030 (Mondal and Choudhury, 2014).

During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased from the present 2.74 to 3.74 t ha^{-1} (BRRI, 2011).

However, there is a little scope to increase rice area. Moreover the arable land is decreasing at the rate of 1% per annum (BBS, 2011a).

Bangladesh has three rice growing seasons among which transplant *aman* (T. *aman*) rice covers about 48.97% of total rice area and it contributes to 38.13% of the total rice production in the country (BBS, 2011b). Transplant aman covers the largest area of 5794 thousand ha with a production of 12284 thousand metric tons and average yield was about 2.12 t ha $^{-1}$ (BBS, 2012) which is much lower than that of other rice producing countries like Japan (6.8 t ha $^{-1}$), Korea (6.8 t ha $^{-1}$) and China (6.3 t ha $^{-1}$) (FAO, 2000; IRRI, 2005). The horizontal expansion of rice area in the country is not possible due to increasing population pressure. So, the only avenue left is to increase the production of rice through vertical expansion. Because of growing population, the demand for rice is expected to increase in the coming decades (Pingali *et al.*, 1997). However, to meet this demand the crop should perform to its full potential. Certain factors tend to restrict the crop's potential performance.

The mechanical transplanting of rice has been considered the most promising option, as it saves labor, ensures timely transplanting and attains optimum plant density that contributes to high productivity (Manjunatha *et al.*, 2009). Mechanical transplanting method revealed that on economic grounds, although this method is more expensive as compared with the conventional method, however, the yield benefits due to higher population stand makes it profitable to adopt (Umar *et al.*, 2001). Efficient use of resources by saving on labor (20 man-days ha-1), cost saving (Tk. 1500 ha^{-1}), water saving up to 10% , timely transplanting of seedlings of optimal age (20 days) ,ensures uniform spacing and optimum plant density (30 -35 hillsm^{-2} with 2-3 seedlingshills^{-1}, higher productivity (0.5 to 0.7 t ha^{-1}) compared to traditional methods , less transplanting shock, early vigour of seedling, better tillering and uniform maturity of crop that facilitate timely harvest and reduce harvest losses , less incidence of 'Bakanae' disease due to less root injury , promotes double no-till in rice-wheat system and in-turn longterm system sustainability ,improving soil health through eliminating puddling reduces stress, drudgery and health risks of farm laborers, generates, employment and alternate sources of income for rural youth through custom services on nursery raising and mechanical transplanting (Behera, 2000).

Among the various factors responsible for low rice production, weeds are considered to be as one of the major limiting factors due to manifold harmful effects (Kalyanasundaram *et al.*, 2006).

The infestation of weed is one of the most important constraints in the cultivation of transplant *aman* rice (Gaffer, 1983 and Mamun, 1988). So, it is often mentioned that Agriculture is a fight against weeds (Mukhopadhya and Gosh, 1981). Many investigators have reported a great loss in the yield of rice due to weed infestation from different parts of the world (Nandal and Singh, 1994). Weed depresses the normal yield of filled grains per panicle and grain weight (Smith and Shaw, 1968).

Weeds always compete with crop for resources like light, water, nutrient which are needed for crop plant to produce healthy grains (Antigua *et al.*, 1988). Competition offered by weeds is most important and it reduces the grain yield up to the extent of 32% (Singh *et al.*, 2007). In Bangladesh, weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for Transplanted (T) *Aman* rice (late summer) and 22-36% for modern *Boro* rice cultivars (winter rice) (BRRI, 2006; Mamun, 1990). Thus, it is important that they are controlled in time to avoid unproductive use of growth factors to enable the crop plant to express fully by utilizing these factors meant for them. Herbicides are effective against weed species, but most of them are specific and are effective against narrow range of weed species (Mukerjee and Singh, 2005). Therefore, appropriate and economical weed management technology is to be developed for the sustainable rice cultivation.

The transplanting of rice by rice transplanter has been practicing in some parts of Bangladesh during *aman* season. However, information exists on the potentiality of using rice transplanter and weeding are scarce. Thus a detailed study with rice transplanter and weeding with the following objectives:

- To compare the yield performance of rice transplanter and conventional method of T. *aman* rice transplanting.
- To find out the influence of weeding for optimum growth and yield of T. *aman* rice.
- To explore the interaction effect of using rice transplanter under different weed management.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The attempt has been made in this chapter to review the pertinent research information to rice cultivation in the different countries of the world especially in the context of Bangladesh. Literature on the influence of planting method and weeding on growth and yield of transplanted aman rice is particularly less available. Sufficient information is not available from the research works of the different scientists of the world in regard to the nutrient contents with their relationship patterns in support of the present piece of research conducted in the university. It is therefore, apparent find out real significant information on the two mentioned factors. Little information which is currently available relates mostly to the effect of planting method and weeding on the agronomical characters and also total yield of crops.

2.1 Effect of planting method

Hossain *et al.* (2012a) tested walking type mechanical rice transplanter in different farmers field during *aman*/2011 season to evaluate the field performance. Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method. Average yield of the machine transplanting plot and hand transplanting plot were 4.95 ton/ha and 4.85 ton/ha.

Hossain *et al.* (2012b) tested walking type mechanical rice transplanter in different farmers field during *boro*/2012 season to evaluate the field performance. Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method. In hand transplanting plot, farmer's seedling of the same variety BRRI dhan28 and BRRI dhan29 was used. Average yield of the machine transplanting plot and hand transplanting plot were 6.42 t $ha^{-1}$and 6.28 t ha^{-1}.

Kaium (2010) reported an investigate the performance of mechanical rice transplanter at the Farm Power and Machinery department field laboratory in Bangladesh Agricultural University (BAU), Mymensingh, during *Boro* and *Aman* seasons, 2010. The study revealed that the mechanical rice transplanter was found suitable in terms of technical, agronomical and financial performance over manual transplanting of rice seedlings and recommended for the farmers of Bangladesh.

Manjunatha *et al.* (2009) carried out a study on Studies on the performance of self-propelled rice transplanter and its effect on crop yield. They found that grain yield in both manual and mechanical transplanting remained on par with mean grain yield of 53.77 and 54.01 q/ha, respectively.

Das (2004) evaluated CRRI manual 4 row transplanter, 8 row VST (Yanji) self propelled rice transplanter as compared to conventional transplanting. The grain yields were 4.95 t ha $^{-1}$ for 4 row manual transplanter, 4.62 t ha $^{-1}$ for VST 8 row self propelled rice transplanter, 4.18 t ha $^{-1}$ by conventional manual transplanting.

Tripath *et al.* (2004) reported that due to rapid industrialization and migration to urban areas, the availability of labor became very scarce and with hike in the wages of labor, manual transplanting found costly leading to reduced profits to farmers. Under such circumstances a less expensive and laborsaving method of rice transplanting without yield loss is the urgent need of the hour.

Umar *et al.* (2001) reported that the evaluation of diffusion possibilities of mechanical transplanting method revealed that on economic grounds, although this method is more expensive as compared with the conventional method, however, the yield benefits due to higher population stand makes it profitable to adopt.

Islam *et al.* (2001) conducted two experiments to observe the performance of Japanese power rice transplanter at BRRI Farm Gazipur. In T. *Aman* season a test with machine and hand transplanting methods were conducted with 14 and 32 days old seedlings respectively. The machine planting was 35 times faster and produced 15% less yield compared to hand planting method.

2.2 Effect of weeding on rice

Chauhan and Johnson (2010) stated that the risks of crop yield loss due to competition from weeds in direct seeded rice was greater than in transplanted rice because the weeds and rice emerge together and farmers are not usually able to use standing water to suppress weeds at the early growth stages of rice.

Pal *et al.* (2009) opined that hand weeding on 20 and 40 DAT recorded highest grain yield of 5.08 t ha-1 in Gangetic alluvial soil because it gave very little scope to weeds to flourish and to compete with the crop preferably at the critical stage of crop weed competition.

Puniya *et al.* (2007) noticed that the highest loss of nutrients (N 42.07, P 10.00 and K 21.80 kg ha-1) occurred with unweeded control due to more density and dry weight of weeds in transplanted rice during kharif in silt loam soil of Pantnagar.

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 compared 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 60EC) during both cropping seasons.

Manish *et al.* (2006) said that *Alternanthera triandra*, *Echinochloa colona*, *Fimbristylis 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 DAT.

Walia (2006) observed that crop yield losses due to weeds mainly depend upon their intensity as well as on type of weed flora. There is a linear correlation between yield loss and population of weeds, however, above certain population limits, yield reductions becomes nearly constant due to self competition among weed plants. The greatest loss caused by the weeds resulted from their competition with crop for growth factors viz., nutrients, soil moisture, light, space, etc.

Dutta *et al.* (2005) reported that hand weeding twice at 21 and 42 DAS recorded the highest weed control efficiency and increased grain and straw yield of rice crop.

Moorthy *et al*. (2005) reported that in rainfed lowland rice, 30-60 days after sowing period was considered as critical period for crop weed competition to avoid grain yield losses. He also reported that the losses in grain yield due to weed competition for first 30, 60, and 90 days were 17.7, 11.8 and 5.0 per cent, respectively.

Bijon (2004) reported that 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.

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-1and 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 ha^{-1}), straw yield (65.35 g ha^{-1}) and harvest index (33.97%).

Bhowmick (2002) said two hand 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. They 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.

Chinnusamy *et al*. (2000) reported that maintaining a weed free period up to 45 DAT was essential to augment the yield of medium duration rice.

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.

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.

Balaswamy (1999) found that hand weeding twice at 20 and 40 days after transplanting resulted in low weed numbers, followed by herbicides.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest 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 weedy 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.

Sanjoy *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.

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.

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%.

Alam *et al.*, (1996) observed that weed control efficiency was higher in two hand weeding (90.67%) than dose of Oxadiazon and Cinosulfuron treatments.

Singh and Pillai (1996) conducted an experiment by using seven short duration rice cultivars, which were grown in the wet season of 1988-1989 in Rajendranagar, Andhra Pradesh. They reported that crops were hand weeded at 20 and 40 DAS compared with unweeded controls, weed control treatments decreased weed dry weight of 65.3-68.7 %, mean grain was 1.04 t ha^{-1} without weed control and 2.17-2.25 t ha^{-1} with weed control treatments.

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*.

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

Kamalam and Bridgit (1993) reported that the average reduction in grain yield due to weed competition was 56 percent.

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} (54.4%) in transplanted rice under medium land condition.

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%.

Dexit and Shidul (1981) carried out an experiment comprising of 8 weed control treatments and stated that hand weeding twice gave the highest paddy yields of 4.51 t ha^{-1} followed by propanil + one hand weeding (3.1 t ha^{-1}).

Nizam and Zahidul (1981) observed that the highest grain yield was obtained from BR4 followed by Naizershail and BR6 in both unweeded and weeded conditions. They also found that the yield reduction caused by weeds was 0.25 t ha^{-1} in the tallest variety (Naizershail), 0.46 t ha^{-1} in the intermediate variety (BR4) and 0.68 t ha^{-1} in the shortest variety (BR6).

Ahmed and Moody (1980) observed that number of grasses and sedges was significantly higher in the unweeded plots of both the seeding methods. Broad-leaved weeds were significantly more in the weeded plots than in the unweeded plots in both the methods except when the row seeded crop was weeded three times. In case of weed weight grasses and sedges had similar trends as weed population; however, the weight of broad-leaved weeds was significantly higher in the unweeded plots than the weeded plots for both seeding methods. The total weed weight was significantly lower in the weeded plots than in unweeded plots in both of the seeding methods. There was neither difference between seeding methods nor was there any difference between plots that had been weeded twice or thrice so far as the weed weight was concerned.

BRRI (1976) reported that the increasing the frequency of hand weeding 1 to 2 times at 21 and 42 days after transplanting was found to reduce the weed density and weed dry matter and caused to double the yield.

Sethi *et al.* (1971) found that weeds grew rapidly for 30 days after sowing in unweeded up to 60 days substantially reduced weed population and increased rice dry matter production after 60 days few new grew. Weeds dry weight and rice grain yields were negatively and linearly related. In the western state of Nigeria, it is recommended that the first weeding be done 2-3 weeks later and by a third one if necessary.

Vega *et al.* (1967) reported that grain yield may be seriously reduced by weed infestation. They also found that such reduction as much as 83%. They observed that traditional rice variety Palwan had grain yield of 0.05 t ha^{-1} with poor weed control whereas good weed control resulted in 3 t ha^{-1} of rice yield.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from July 2013 to December 2013. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area had sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix III.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.4-5.6 and had organic carbon 0.82%. The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

A. Planting method (2):

1. Rice Transplanter (P_1)
2. Conventional method (P_2)

B. Weeding (8)

1. No weeding (W_0)
2. Weeding at 20 DAT (W_1)
3. Weeding at 35 DAT (W_2)
4. Weeding at 50 DAT (W_3)
5. Two weedings at 20 DAT & 35 DAT (W_4)
6. Two weedings at 20 DAT & 50 DAT (W_5)
7. Two weedings at 35 DAT & 50 DAT (W_6)
8. Three weedings at 20 DAT, 35 DAT & 50 DAT (W_7)

3.2.2 Experimental design

The experiment was laid in a split-plot design with three replications having planting method in the main plots and weeding in the sub-plots. There were 16 treatment combinations. The total numbers of unit plots were 48. The size of unit plot was 4.0 m by 3.0 m. The distances between plot to plot and replication to replication were 0.75 m and 1 m respectively. The layout of the experiment has been shown in Appendix II.

3.3 Description of Variety

BRRI dhan49 was used as studied variety. BRRI dhan49, a high yielding variety of *aman* rice was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh in 2008. The grain quality of the variety is same as Nizershail. Its duration is 7 days lower compare to BR11. The average height of the variety is 100 cm, duration 135 days and yield 5.0 t ha^{-1}.

3.4 Crop Management

3.4.1 Raising of Seedling

3.4.1.1 Seed collection

Seeds of BRRI dhan49 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh.

3.4.1.2 Seed sprouting

Healthy seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.1.3 Preparation of seedling nursery

A common procedure was followed in raising of seedlings in the seedbed for conventional method. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.4.1.4 Seed sowing

3.4.1.4.1 Seed sowing on the seedbed

Seeds were sown on the seedbed on July 15, 2013 for raising nursery seedlings.

3.4.1.4.2 Seed sowing on the tray

Seeds were sown on the tray on July 25, 2013 for raising nursery seedlings.

3.4.2 Preparation of experimental land

The experimental field was first opened on July 30, 2013 with the help of a tractor drawn disc plough, later on August 13, 2013 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor plough and subsequently leveled by laddering. All kinds of weeds and residues of previous crop were removed from the field. After the final land preparation the field layout was made on August 14, 2013 according to experimental plan. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.3 Fertilizer application

The experimental area were fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} N, P_2O_5, K_2O, S and Zn in the form of urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top-dressed in three equal installments. The first one-third urea was top-dressed after seedling recovery, second during the vegetation stage and third at 7 days before panicle initiation.

3.4.4 Uprooting and transplanting of seedlings

The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. The 30 days old nursery seedlings were uprooted carefully on August 14, 2013 and were kept in soft mud in shade. The seedlings were then transplanted with 20 cm × 20 cm spacing on the well-puddled plots. The seedlings of tray were irrigated gently at times using watering can and then shift to the transplanter at 20 days old for transplanting in the main field. The whole field of each replication marked for transplanter were transplanted first and then marked as per plot size by uprooting excess seedlings from drains.

3.4.5 Intercultural operations

3.4.5.1 Thinning and gap filling

After one week of transplantation, a minor gap filling was done as and where necessary using the seedling from the previous source as per treatment. No thinning was done for any treatment.

3.4.5.2 Application of irrigation water

Irrigation water was added to each plot according to the need. All the plots were kept irrigated maintaining 3-5 cm stagnant water throughout the entire period upto 15 days before harvesting.

3.4.5.3 Plant protection measures

3.4.5.4 General observation of the experimental field

The field was investigated time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa was observed during tillering stage that controlled properly. No bacterial and fungal disease was observed in the field. Weeding of respective plots were done as per treatment.

3.4.5.5 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan49 that was transplanted by rice transplanter and conventional method were done on 06 December 2013 and 28 November 2013 respectively. Ten pre-selected hills plot^{-1} from which different crop growth data were collected and 5 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to maintain moisture of about 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

3.4.6 Recording of data

Experimental data were recorded at different growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of hills at different dates from the inner rows leaving border rows and harvest area for grain. The followings data were recorded during the experiment.

A. Crop growth characters

i. Plant height (cm) at 25 days interval from 15 DAT and at harvest
ii. Number of tillers $hill^{-1}$ at 25 days interval from 15 DAT and at harvest
iii. Leaf area index at 25 days interval from 15 DAT
iv. Time of flowering

B. Weed data

i. Weed population $m^{-2}plot^{-1}$ at 20, 35 and 50 DAT

ii. Weed dry matter $m^{-2}plot^{-1}$ at 20, 35 and 50 DAT

C. Yield and other crop characters

i. Number of effective tillers $hill^{-1}$
ii. Number of ineffective tillers $hill^{-1}$
iii. Length of panicle (cm)
iv. Number of rachis branches $panicle^{-1}$
v. Number of filled grains $panicle^{-1}$
vi. Number of unfilled grains $panicle^{-1}$
vii. Weight of 1000-grains (g)
viii. Grain yield (t ha^{-1})
ix. Straw yield (t ha^{-1})
x. Biological yield (t ha^{-1})
xi. Harvest index (%)

3.4.7 Detailed procedures of recording data

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

A. Crop growth characters

i. Plant height (cm)

Plant height was measured at 15, 40, 65, 90 DAT and at harvest. The height of the randomly pre-selected 5 hills plot^{-1} was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading. The collected data were finally averaged.

ii. Number of tillers hill^{-1}

Number of tillers hiil^{-1} were counted at 15, 40, 65, 90 DAT and at harvest from five randomly pre-selected hills and averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

iii. Number of leaves hill^{-1}

Number of leaves hiil^{-1} were counted at 15 40, 65 and 90 DAT from five randomly pre-selected hills and finally averaged as their number hill^{-1} basis.

iv. Leaf Area Index (LAI)

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

v. Time of flowering

Time of flowering was measured when about 50% panicles of the plants within a plot emerged. The number of days for flowers was recorded.

B. Yield and other crop characters

i. Effective tillers hill^{-1} (no.)

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers 5 hill^{-1} was recorded and finally averaged for counting effective tillers number hill^{-1}.

ii. Ineffective tiller hill^{-1} (no.)

The tiller having no panicle was regarded as ineffective tillers. The number of ineffective tillers 5 hill^{-1} was recorded and finally averaged for counting ineffective tillers number hill^{-1}.

iii. Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

iv. Rachis branches panicle^{-1} (no.)

Primary branches of panicle that contains a number of spikelet termed as rachis branches. The number of total rachis branches present on ten panicles were recorded and finally averaged.

v. Filled grains panicle^{-1}(no.)

Grain was considered to be filled if any kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

vi. Unfilled grains panicle^{-1} (no.)

Unfilled grains means the absence of any kernel inside in and such grains present on each of ten panicles were counted and finally averaged.

vii. Weight of 1000-grains (g)

One thousand cleaned dried grains were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained about 12% moisture and the mean weight were expressed in gram.

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

Grain yield was determined from the central 7.2 m^2 area of each plot and expressed as t ha^{-1} on about 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

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

Straw yield was determined from the central 7.2 m^2 area of each plot. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

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

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

$$\text{Biological yield (t ha}^{-1}) = \text{Grain yield (t ha}^{-1}) + \text{Straw yield (t ha}^{-1})$$

xi. Harvest Index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Donald, 1963; Gardner et al., 1985).

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

3.4.8 Statistical Analyses

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance. (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

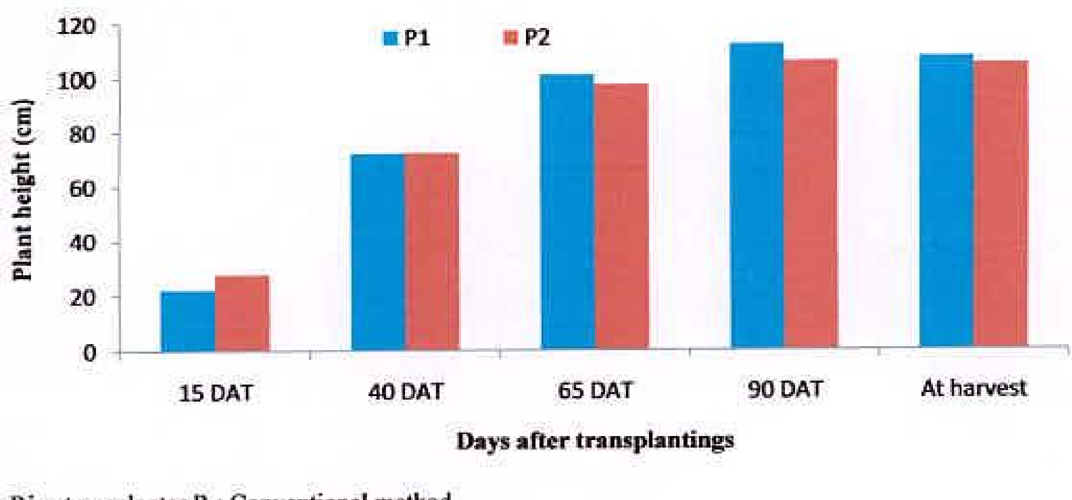
Results obtained from the present study regarding the effects of planting methods and weeding of transplant *aman* rice and their interactions on the yield and yield components have been presented, discussed and compared in this chapter. The analytical results have been presented in Tables 1 through Table 18, Figures 1 through 13 and Appendices IV through IX.

4.1 Crop growth characters

4.1.1 Plant height at different days after transplantation

4.1.1.1 Effect of planting method

The plant height of T. *aman* rice was not significantly influenced by planting method except 90 days after transplanting (DAT) (Appendix IV Figure 1). The result revealed that at 90 DAT, the rice transplanter produced taller plant (112.32 cm) and conventional method produced shorter plant (105.97cm). Munnaf *et al.* (2014) also found that mechanical transplanter produced taller plant compare to conventional method.



P_1: Rice transplanter P_2: Conventional method

Figure 1. Plant height of rice as affected by planting methods (LSD $_{(0.05)}$=2.30 at 90 DAT)

4.1.1.2 Effect of weeding

Significant variation of plant height was found due to different weeding only at 40 DAT (Appendix IV and Table 1). The results revealed that at 40 DAT, the tallest plant (75.45 cm) was obtained from the W_7 which was statistically similar with the W_3 (74.88 cm), W_4 (73.88 cm) and W_0 (72.72 cm) and the shortest plant (69.77 cm) was obtained from W_2 (69.77 cm) which was statistically similar with the W_1 (70.52 cm), W_5 (70.17 cm), W_6 (71.22 cm) and W_0 (72.72 cm). At 15 DAT, the numerically maximum plant height obtained from the W_4 (26.54 cm) and minimum plant height was obtained from the W_2 (23.32 cm). At 65 DAT, the maximum plant height obtained from the W_7 (101.9 cm) and minimum height was obtained from the W_2 (98.35 cm). At 90 DAT and at harvest, the maximum height obtained from the W_7 (112.00 cm and 109.10 cm respectively) and minimum plant height was obtained from the W_2 (104.9 cm and 103.40 cm respectively). Dissimilar findings were observed by Toufiq (2003) and Attalla and Kholosy (2002).

Table 1. Effect of weeding on plant height at different growth duration

Treatments	Plant height (cm) at different DAT				
	15	40	65	90	At harvest
W_0	25.60	72.72 abcd	99.00	108.50	105.90
W_1	23.80	70.52 cd	98.80	109.80	106.10
W_2	23.32	69.77 d	98.35	104.90	103.40
W_3	25.82	74.88 ab	98.48	109.20	106.80
W_4	26.54	73.88 abc	100.20	111.20	107.50
W_5	24.10	70.17 cd	98.83	107.50	105.20
W_6	24.25	71.22 bcd	98.80	110.00	107.10
W_7	25.85	75.45 a	101.90	112.00	109.10
$LSD_{(0.05)}$	NS	3.893	NS	NS	NS
CV (%)	10.46	4.55	4.21	3.81	4.29

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.1.1.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not significantly influenced the plant height (Appendix IV and Table 2). At 15 DAT, numerically tallest plant (29.26 cm) obtained from P_2W_7 and shortest plant (21.02 cm) obtained from P_1W_6. At 40 DAT, numerically tallest plant (76.47 cm) obtained from P_2W_7 and shortest plant (68.60 cm) obtained from P_2W_2. At 65 DAT, numerically tallest plant (102.80 cm) obtained from P_1W_7 and shortest plant (95.20 cm) obtained from P_2W_2. At 90 DAT, numerically tallest plant (115.90 cm) obtained from P_1W_4 and shortest plant (100.10 cm) obtained from P_2W_2. At harvest, numerically tallest plant (109.80 cm) obtained from P_1W_4 and shortest plant (100.40 cm) obtained from P_2W_2.

Table 2. Interaction effect of planting method and weeding on plant height

Treatments	Plant height (cm) at different DAT				
	15	40	65	90	At harvest
P_1W_0	22.23	72.3	100.9	110.3	106.5
P_1W_1	21.03	69.03	100.8	113.1	105.9
P_1W_2	22.15	70.93	101.5	109.7	106.5
P_1W_3	23.39	75.7	99.57	111.9	107.5
P_1W_4	24.57	74.9	102.5	115.9	109.8
P_1W_5	21.12	68.87	100.7	110.9	106.9
P_1W_6	21.02	72.05	100.9	112.7	108.6
P_1W_7	22.44	74.43	102.8	114.2	109.4
P_2W_0	28.97	73.13	97.13	106.8	105.3
P_2W_1	26.57	72	96.77	106.5	106.3
P_2W_2	24.49	68.6	95.2	100.1	100.4
P_2W_3	28.24	74.07	97.4	106.5	106
P_2W_4	28.51	72.87	97.83	106.6	105.2
P_2W_5	27.09	71.47	96.97	104.2	103.5
P_2W_6	27.48	70.4	96.73	107.3	105.5
P_2W_7	29.26	76.47	100.9	109.8	108.7
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	10.46	4.55	4.21	3.81	4.29

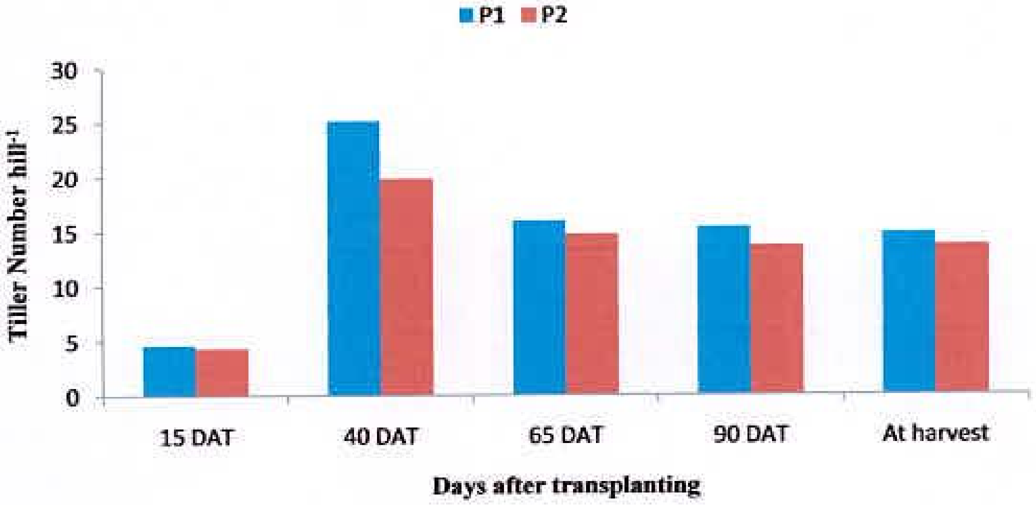
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.1.2 Number of tillers hill^{-1} at different days after transplantation

4.1.2.1 Effect of planting method

The production of total number of tillers hill^{-1} of T. *aman* rice was statistically insignificant and was not influenced by different planting methods (Appendix V and Figure 2). Numerically higher number of tillers hill^{-1} at 15, 40, 65, 90 DAT and at harvest was observed in the planting method of rice transplanter and the lower number of tillers hill^{-1} was obtained from the conventional planting method. Munnaf *et al.* (2014) also found non-significant effect of tillers hill^{-1}.



P_1: Rice transplanter P_2: Conventional method

Figure 2. Tiller number hill^{-1} of rice as affected by planting method

4.1.2.2 Effect of weeding

Significant variation of the total number of tillers hill^{-1} was found due to different weeding only at harvest (Appendix V and Table 3). The results revealed that at harvest, the highest numbers of tillers hill^{-1} (16.00 and 15.70) was obtained from the W_5 and W_1 respectively which was statistically similar with the W_4 (15.40) and W_7 (14.07) and the lowest numbers of tillers hill^{-1} (13.13) was obtained from W_0 and W_3 which was statistically similar with the W_2 (13.33), W_6 (13.50), W_4 (15.40) and W_7 (14.07). At 15 DAT, the numerically maximum numbers of tillers hill^{-1} obtained from the W_0 (4.82) and minimum numbers of tillers hill^{-1} was obtained from the W_3 (3.81). At 40 DAT, the maximum numbers of tillers hill^{-1} obtained from the W_4 (26.30) and minimum numbers of tillers hill^{-1} was obtained from the W_3 (19.07). At 65 DAT, the maximum numbers of tillers hill^{-1} obtained from the W_4 (17.60) and minimum numbers of tillers hill^{-1} was obtained from the W_0 (13.73). At 90 DAT, the maximum numbers of tillers hill^{-1} obtained from the W_1 (15.83) and minimum numbers of tillers hill^{-1} was obtained from the W_3 (12.97). Significant variation of the total number of tillers hill^{-1} found only at harvest. Similar results were also reported by BRRI (1998) and Atalla and Kholosy (2002).

Table 3. Effect of weeding on number of tillers hill^{-1} at different days after transplantation

Treatments	Tiller number hill^{-1} at different DAT				
	15	40	65	90	At harvest
W_0	4.817	20.7	13.73	13.33	13.13 c
W_1	4.633	25.77	15.17	15.83	15.70 a
W_2	5	22.7	14.7	14.37	13.33 bc
W_3	3.808	19.07	13.83	12.97	13.13 c
W_4	4.5	26.3	17.6	15.6	15.40 ab
W_5	4.533	24.93	16.87	15.67	16.00 a
W_6	4.242	19.41	15.77	13.93	13.50 bc
W_7	4.333	20.97	15.27	14.6	14.07 abc
$LSD_{(0.05)}$	NS	NS	NS	NS	2.083
CV (%)	22.89	18.06	14.16	16.53	12.33

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

NS= Not Significant

4.1.2.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced number of tillers hill^{-1} (Appendix V and Table 4). At 15 DAT, numerically maximum number of tillers hill^{-1} (5.27) obtained from P_1W_0 and minimum number of tillers hill^{-1} (3.35) obtained from P_1W_3. At 40 DAT, numerically maximum number of tillers hill^{-1} (31.07) obtained from P_1W_4 and minimum number of tillers hill^{-1} (16.93) obtained from P_2W_6. At 65 DAT, numerically maximum number of tillers hill^{-1} (18.67) obtained from P_1W_4 and minimum number of tillers hill^{-1} (12.73) obtained from P_2W_1. At 90 DAT, numerically maximum number of tillers hill^{-1} (17.73) obtained from P_1W_5 and minimum number of tillers hill^{-1} (12.73) obtained from P_1W_3. At harvest, numerically maximum number of tillers hill^{-1} (17.40) obtained from P_1W_5 and minimum number of tillers hill^{-1} (12.40) obtained from P_2W_2.

Table 4. Interaction effect of planting method and weeding on number of tillers hill^{-1} at different days after transplantation

Treatments	Tiller number hill^{-1} at different DAT				
	15	40	65	90	At harvest
P_1W_0	5.26	22.33	14.60	13.8	12.73
P_1W_1	4.46	28.93	17.60	17.53	16.87
P_1W_2	5.60	26.33	16.53	15.67	14.27
P_1W_3	3.35	18.07	13.47	12.73	13.33
P_1W_4	5.06	31.07	18.67	16.73	16.53
P_1W_5	4.86	30.00	16.87	17.73	17.40
P_1W_6	4.55	21.88	14.93	14.20	13.73
P_1W_7	3.93	22.40	15.33	14.73	13.93
P_2W_0	4.36	19.07	12.87	12.87	13.53
P_2W_1	4.80	22.6	12.73	14.13	14.53
P_2W_2	4.40	19.07	12.87	13.07	12.40
P_2W_3	4.26	20.07	14.20	13.20	12.93
P_2W_4	3.93	21.53	16.53	14.47	14.27
P_2W_5	4.20	19.87	16.87	13.60	14.60
P_2W_6	3.93	16.93	16.60	13.67	13.27
P_2W_7	4.73	19.53	15.20	14.47	14.20
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	22.89	18.06	14.16	16.53	12.33

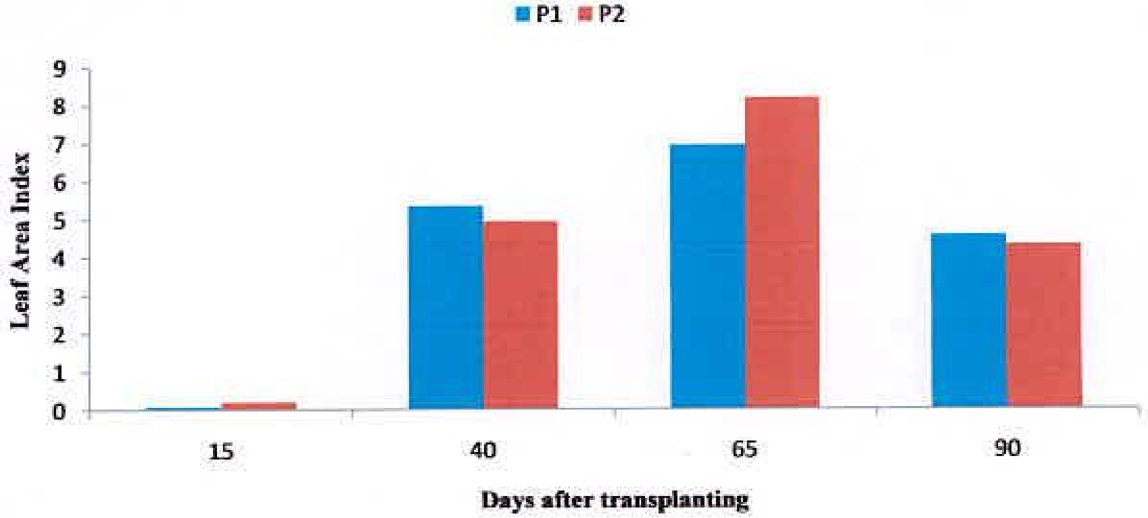
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.1.3 Leaf Area Index (LAI) at different days after transplantation

4.1.3.1 Effect of planting method

Leaf area index (LAI) was not significantly influenced by planting methods except 15 DAT (Appendix VI and Figure 3). The result revealed that at 15 DAT, the conventional method produced higher LAI (0.21) and rice transplanter produced lower LAI (0.09).



P_1: Rice transplanter P_2: Conventional method

Figure 3. Leaf Area Index of rice as affected by planting method (LSD $_{(0.05)}$=0.04 at 15 DAT)

4.1.3.2 Effect of weeding

Leaf area index (LAI) was not significantly influenced by different methods of weeding (Appendix VI and Table 5). At 15 DAT, the maximum leaf area index observed in W_7 (0.19) and minimum leaf area index (0.13) observed in W_2 and W_6. At 40 DAT, the maximum leaf area index observed in W_4 (6.16) and minimum leaf area index observed in W_3 (4.68). At 65 DAT, the maximum leaf area index observed in W_4 (9.17) and minimum leaf area index observed in W_1 (6.46). At 90 DAT, the maximum leaf area index observed in W_6 (4.86) and minimum leaf area index observed in W_2 (4.11).

Table 5. Effect of weeding on Leaf Area Index (LAI) at different days after transplantation

Treatments	Leaf area index at different DAT			
	15	40	65	90
W_0	0.15	5.23	6.74	4.31
W_1	0.14	5.72	6.46	4.34
W_2	0.13	5.00	6.66	4.11
W_3	0.14	4.68	7.25	4.41
W_4	0.16	6.16	9.17	4.54
W_5	0.15	5.39	8.60	4.31
W_6	0.13	4.92	7.17	4.85
W_7	0.18	4.78	8.34	4.51
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	46.21	25.80	22.65	23.01

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.1.3.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced leaf area index (Appendix VI and Table 6). At 15 DAT, numerically maximum leaf area index (0.30) obtained from P_2W_7 and minimum leaf area index (0.06) obtained from P_1W_5. At 40 DAT, numerically maximum leaf area index (6.77) obtained from P_1W_4 and minimum leaf area index (4.09) obtained from P_2W_2. At 65 DAT, numerically maximum leaf area index (10.34) obtained from P_2W_4 and minimum leaf area index (5.98) obtained from P_1W_1. At 90 DAT, numerically maximum leaf area index (5.35) obtained from P_1W_6 and minimum leaf area index (3.65) obtained from P_2W_1.

Table 6. Interaction effect of planting method and weeding on Leaf Area Index (LAI) at different days after transplantation

Treatments	Leaf area index at different DAT			
	15	40	65	90
P_1W_0	0.08	5.83	6.90	4.04
P_1W_1	0.08	5.94	5.98	5.03
P_1W_2	0.10	5.92	6.98	4.13
P_1W_3	0.08	4.45	6.75	4.61
P_1W_4	0.13	6.77	8.01	4.32
P_1W_5	0.06	5.58	7.01	4.52
P_1W_6	0.09	5.60	6.24	5.35
P_1W_7	0.07	4.21	7.58	4.45
P_2W_0	0.22	4.63	6.58	4.58
P_2W_1	0.21	5.50	6.93	3.65
P_2W_2	0.15	4.09	6.35	4.09
P_2W_3	0.21	4.91	7.76	4.22
P_2W_4	0.20	5.55	10.34	4.77
P_2W_5	0.24	5.19	10.19	4.103
P_2W_6	0.17	4.25	8.11	4.36
P_2W_7	0.30	5.35	9.103	4.57
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	46.21	25.80	22.65	23.01

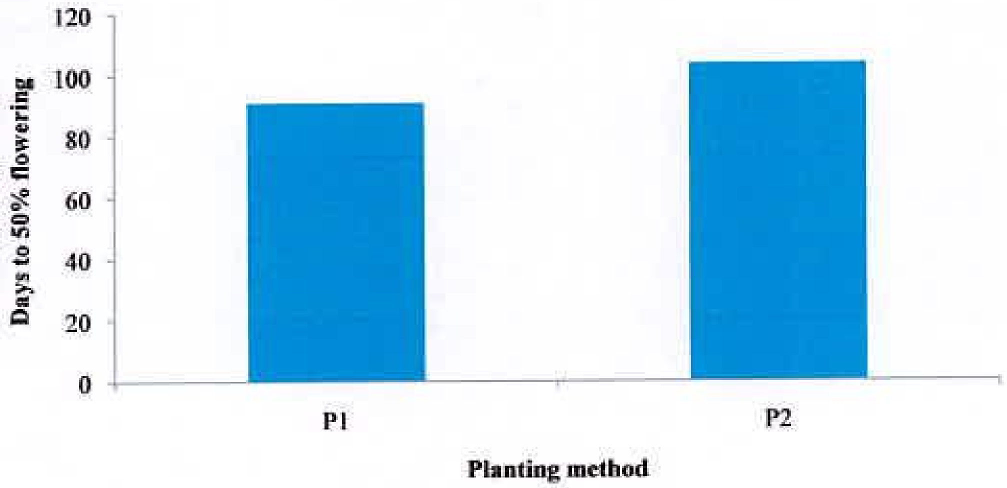
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.1.4 Days to flowering

4.1.4.1 Effect of planting method

Days to 50% flowering significantly varied among the planting method, where conventional method needed longer time for 50% flowering (103.58 days) compared to the rice transplanter (90.92 days) (Appendix VI and Figure 4).



P_1: Rice transplanter P_2: Conventional method

Figure 4. Days to flowering of rice as affected by planting methods (LSD $_{(0.05)}$ = 2.33)

4.1.4.2 Effect of weeding

Effect of weeding on days to 50% flowering was not statistically significantly influenced (Appendix IX and Table 7). Numerically longest time to take 50% flowering was in W_4 (98.17 days) compared to the W_0 and W_3 (96.33 days).

Table 7. Effect of weeding on Days to 50% flowering

Treatments	Days to 50% flowering
W_0	96.33
W_1	97.67
W_2	97.33
W_3	96.33
W_4	98.17
W_5	97.50
W_6	97.00
W_7	97.67
LSD $_{(0.05)}$	NS
CV (%)	1.32

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

4.1.4.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding on days to 50% flowering was not significantly influenced (Appendix IX and Table 8). Numerically longest time to take 50% flowering was in P_2W_4 (104.30 days) compared to the P_1W_3 (89.67 days).

Table 8. Interaction effect of planting method and weeding on Days to 50% flowering

Treatments	Days to 50% flowering
P_1W_0	90.00
P_1W_1	91.33
P_1W_2	90.67
P_1W_3	89.67
P_1W_4	92.00
P_1W_5	92.00
P_1W_6	90.00
P_1W_7	91.67
P_2W_0	102.70
P_2W_1	104.00
P_2W_2	104.00
P_2W_3	103.00
P_2W_4	104.30
P_2W_5	103.00
P_2W_6	104.00
P_2W_7	103.70
$LSD_{(0.05)}$	NS
CV (%)	1.32

P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

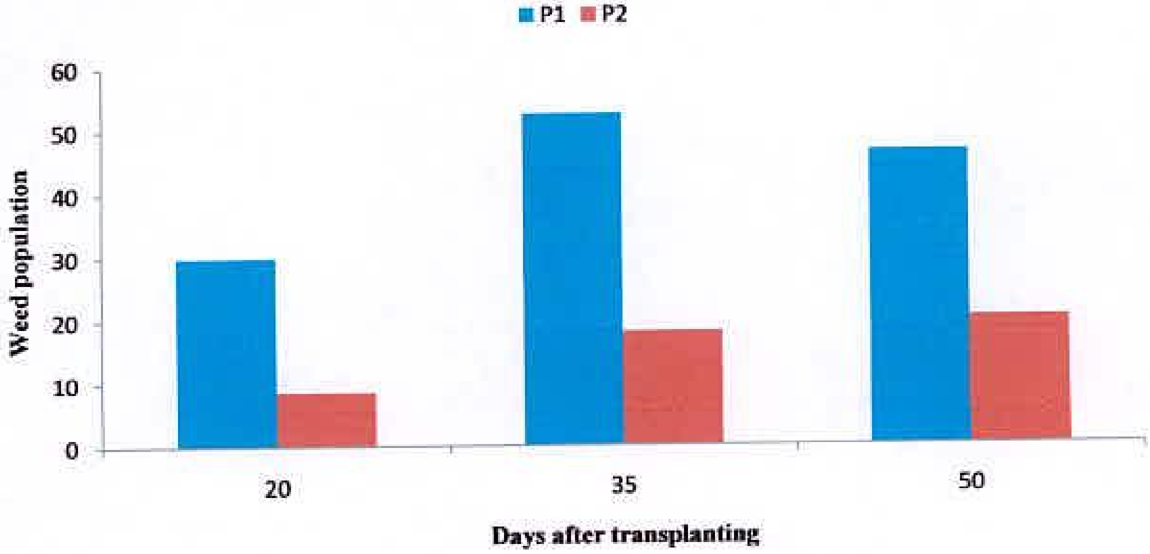
NS= Not Significant

4.2 Weed data

4.2.1 Weed population

4.2.1.1 Effect of planting method

Weed population was significantly differed between planting methods (Appendix VII and Figure 5). The result revealed that at 20 DAT, 35 DAT and 50 DAT, number of weeds m^{-2} was higher (29.92, 52.58 and 46.50 respectively) in the method that was transplanted by rice transplanter and lower number of weeds m^{-2} (8.63, 18.08 and 20.17 respectively) was found in conventional transplanting method.



P_1: Rice transplanter P_2: Conventional method

Figure 5. Weed population of rice as affected by planting method (LSD $_{(0.05)}$ = 1.08, 2.94, 0.65 at 20 DAT, 35 DAT and 50 DAT respectively)

4.2.1.2 Effect of weeding

Weed population was significantly influenced by different weeding treatment at 20 DAT, 35 DAT and 50 DAT (Appendix VII and Table 9). The results revealed that at 20 DAT, the highest number of weeds m^{-2} found in W_5 (32.00) and lowest number of weeds observed in W_4 (11.67) and it was similar with W_7 (12.50). At 35 DAT, the highest number of weeds m^{-2} found in W_0 (68.33) and it was similar with W_6 (64.33) and lowest number of weeds observed in W_7 (6.00). At 50 DAT, the highest number of weeds m^{-2} found in W_0 (138.30) and lowest number of weeds observed in W_7 (5.17). Similar findings were also reported by Trivedi *et al.* (1986), Rekha *et al.* (2002) and Bijon (2004).

Table 9. Effect of weeding on weed population in rice

Treatments	Weed population m^{-2} at different DAT		
	20	35	50
W_0	15.67 cd	68.33 a	138.30 a
W_1	18.33 c	21.50 d	15.17 cd
W_2	22.83 b	41.33 b	13.00 e
W_3	17.67 c	40.50 b	49.50 b
W_4	11.67 e	26.17 c	13.33 de
W_5	32.00 a	14.50 e	15.17 cd
W_6	23.50 b	64.33 a	17.00 c
W_7	12.50 de	6.000 f	5.167 f
$LSD_{(0.05)}$	3.28	4.35	2.11
CV (%)	14.40	10.42	5.36

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

4.2.1.3 Interaction effect of planting method and weeding

Weed population was significantly influenced by interaction effect of planting method and weeding at 20 DAT, 35 DAT and 50 DAT (Appendix VII and Table 10). The results revealed that at 20 DAT, the highest number of weeds m^{-2} found in P_1W_5 (50.33) and lowest number of weeds observed in P_2W_4 (2.33) and it was similar with P_2W_0 (4.00) and P_2W_7 (5.00). At 35 DAT, the highest number of weeds m^{-2} found in W_0 (120.00) and lowest number of weeds observed in P_1W_7 (4.00) and it was similar with P_2W_5 (7.67), P_2W_7 (8.00), P_2W_1 (9.33), P_2W_4 (12.33) and P_2W_2 (13.67). At 50 DAT, the highest number of weeds m^{-2} found in P_1W_0 (200.70) and lowest number of weeds observed in P_2W_7 (2.33) and it was similar with P_1W_4 (4.00).

Table 10. Interaction effect of planting method and weeding on weed population in rice

Treatments	Weed population m^{-2} at different DAT		
	20	35	50
P_1W_0	27.33 c	120.00 a	200.70 a
P_1W_1	23.67 cd	33.67 e	21.33 d
P_1W_2	35.67 b	69.00 b	14.67 ef
P_1W_3	28.00 c	64.67 bc	92.67 b
P_1W_4	21.00 d	40.00 d	4.00 jk
P_1W_5	50.33 a	21.33 f	14.00 fg
P_1W_6	33.33 b	68.00 b	16.67 ef
P_1W_7	20.00 d	4.00 i	8.00 i
P_2W_0	4.00 gh	16.67 fg	76.00 c
P_2W_1	13.00 e	9.33 hi	9.00 hi
P_2W_2	10.00 ef	13.67 gh	11.33 gh
P_2W_3	7.33 fg	16.33 fg	6.33 ij
P_2W_4	2.33 h	12.33 gh	22.67 d
P_2W_5	13.67 e	7.667 hi	16.33 ef
P_2W_6	13.67 e	60.67 c	17.33 e
P_2W_7	5.00 gh	8.00 hi	2.33 k
$LSD_{(0.05)}$	4.64	6.16	2.98
CV (%)	14.40	10.42	5.36

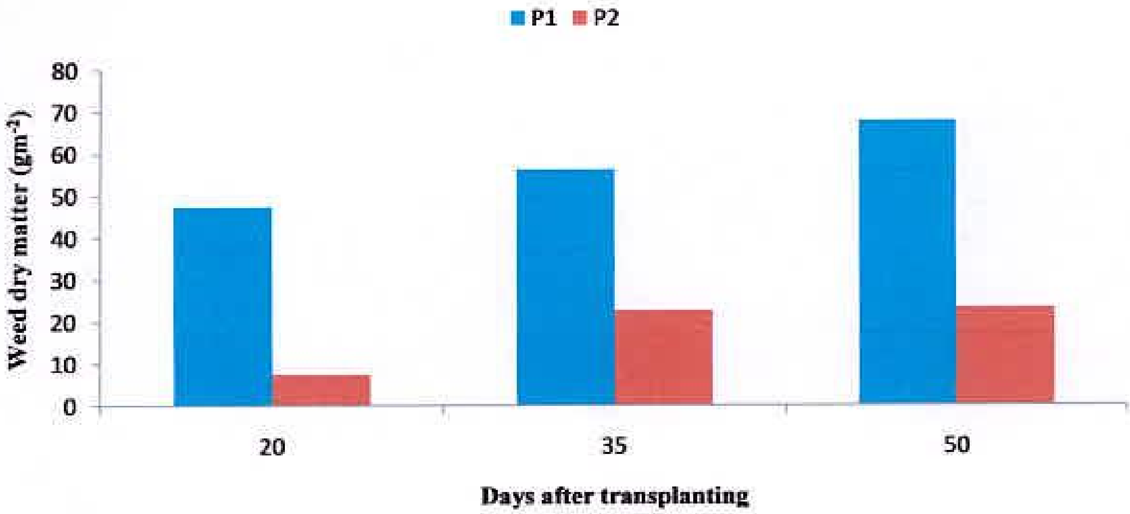
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.2.2 Weed dry matter

4.2.2.1 Effect of planting method

Weed dry matter was significantly different between planting methods (Appendix VIII and Figure 6). The result revealed that at 20 DAT, 35 DAT and 50 DAT, weed dry matter m^{-2} was higher (47.36g, 56.21g and 67.90g respectively) in the method that was transplanted by rice transplanter and lower number of weeds m^{-2} (7.43g, 22.61g and 23.30g respectively) was found in conventional transplanting method.



P_1: Rice transplanter P_2: Conventional method

Figure 6. Weed dry matter of rice as affected by planting method (LSD $_{(0.05)}$ = 1.63, 1.93, 1.49 at 20 DAT, 35 DAT and 50 DAT respectively)

4.2.2.2 Effect of weeding

Weed dry matter was significantly influenced by weeding treatment (Appendix VIII and Table 11). The result revealed that at 20 DAT, the highest dry weight of weeds m^{-2} observed in W_5 (53.86 g m^{-2}) and the lowest dry weight of weeds observed in W_4 (10.08 g m^{-2}) and W_7 (10.70 g m^{-2}). At 35 DAT, the highest dry weight observed in W_0 (94.19 g m^{-2}) and the lowest dry weight of weeds observed in W_7 (6.46 g m^{-2}). At 50 DAT, the highest dry weight observed in W_0 (151.10 g m^{-2}) and the lowest dry weight of weeds observed in W_7 (3.63 g m^{-2}).

Table 11. Effect of weeding on weed dry matter in rice

Treatments	Weed dry matter m^{-2} at different DAT		
	20	35	50
W_0	21.03 d	94.19 a	151.10 a
W_1	27.69 c	16.05 e	37.43 c
W_2	37.43 b	40.57 c	18.75 f
W_3	27.35 c	43.43 c	81.65 b
W_4	10.08 e	32.53 d	19.61 f
W_5	53.86 a	13.56 e	28.19 d
W_6	30.97 c	68.49 b	24.43 e
W_7	10.70 e	6.457 f	3.62 g
LSD $_{(0.05)}$	3.65	4.42	2.68
CV (%)	11.27	9.48	4.98

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

4.2.2.3 Interaction effect of planting method and weeding

Weed dry matter was significantly influenced by the interaction effect of planting method and weeding (Appendix VIII and Table 12). The result revealed that at 20 DAT, the highest dry weight of weeds m^{-2} observed in P_1W_5 (99.79 g m^{-2}) and the lowest dry weight of weeds m^{-2} observed in P_2W_4 (2.47 g m^{-2}) and it was similar with P_2W_7 (3.14 g m^{-2}), P_2W_2 (3.46 g m^{-2}) and P_2W_0 (5.97 g m^{-2}). At 35 DAT, the highest dry weight m^{-2} observed in P_1W_0 (174.60 g m^{-2}) and the lowest dry weight of weeds m^{-2} observed in P_2W_5 (5.61 g m^{-2}), P_1W_7 (6.09 g m^{-2}), P_2W_7 (6.82 g m^{-2}) and P_2W_1 (6.95 g m^{-2}) and it was similar with P_2W_4 (8.89 g m^{-2}). At 50 DAT, the highest dry weight m^{-2} observed in P_1W_0 (206.20 g m^{-2}) and the lowest dry weight of weeds observed in P_2W_7 (1.22 g m^{-2}).

Table 12. Interaction effect of planting method and weeding on weed dry matter

Treatments	Weed dry matter m^{-2} at different DAT		
	20	35	50
P_1W_0	36.08 d	174.60 a	206.20a
P_1W_1	45.95 c	25.16 ef	60.10 d
P_1W_2	71.39 b	52.98 d	16.80 i
P_1W_3	40.33 d	60.26 c	155.40 b
P_1W_4	17.69 ef	56.16 cd	26.66 g
P_1W_5	99.79 a	21.51 f	40.91 e
P_1W_6	49.34 c	52.97 d	31.14 f
P_1W_7	18.26 e	6.09 h	6.03 k
P_2W_0	5.97 i-k	13.83 g	96.07 c
P_2W_1	9.43 g-i	6.95 h	14.77 ij
P_2W_2	3.46 jk	28.16 e	20.70 h
P_2W_3	14.38 e-g	26.61 ef	7.87 k
P_2W_4	2.46 k	8.89 gh	12.56 j
P_2W_5	7.93 h-j	5.61 h	15.48 ij
P_2W_6	12.61 f-h	84.01 b	17.73 hi
P_2W_7	3.14 jk	6.81 h	1.21 l
$LSD_{(0.05)}$	5.16	6.25	3.79
CV (%)	11.27	9.48	4.98

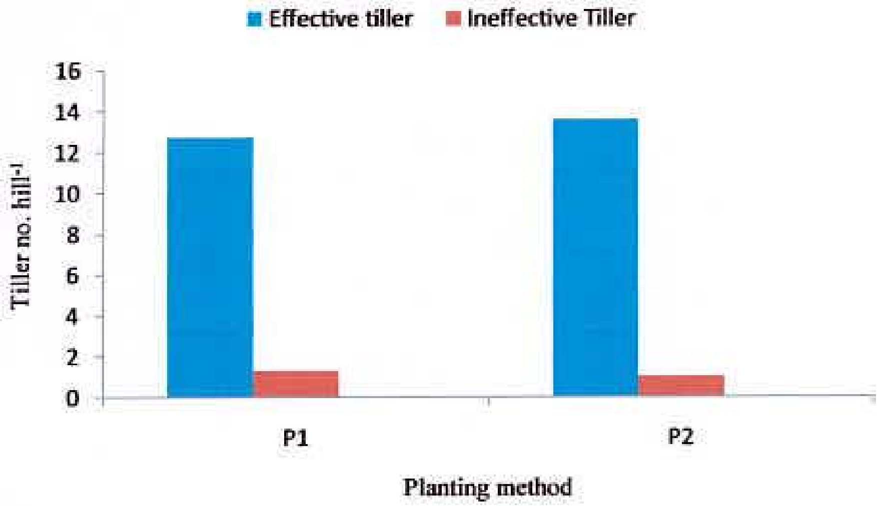
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

4.3 Yield and other crop characters

4.3.1 Number of effective tillers hill^{-1}

4.3.1.1 Effect of planting method

The number of effective tillers hill^{-1} was not significantly influenced by planting method (Appendix IX and Figure 7). Numerically the higher number of effective tillers hill^{-1} (13.60) was obtained from rice transplanter and the lower number of effective tillers hill^{-1} (12.72) observed in conventional planting method. So rice transplanter produced higher number of effective tillers hill^{-1} compared to the conventional method. Similar results were also reported by Manjunatha *et al.* (2009) and Munnaf *et al.* (2014).



P_1: Rice transplanter P_2: Conventional method

Figure 7. Effective tillers hill^{-1} and ineffective tillers hill^{-1} of rice as affected by planting method

4.3.1.2 Effect of weeding

The number of effective tillers hill^{-1} was not significantly influenced by weeding (Appendix 9 and Table 13). The numerically maximum number of effective tillers hill^{-1} (14.80) was observed in W_5 and the minimum number of effective tillers hill^{-1} (12.7) observed in W_3.

Table 13. Effect of weeding on number of effective and ineffective tillers hill^{-1} of rice

Treatments	Effective tillers (no. hill^{-1})	Ineffective tillers (no. hill^{-1})
W_0	12.23	0.9
W_1	14.53	1.167
W_2	12.43	1.133
W_3	12.07	1.067
W_4	13.97	1.433
W_5	14.8	1.2
W_6	12.4	1.1
W_7	12.87	1.2
$LSD_{(0.05)}$	NS	NS
CV (%)	13.82	56.96

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

4.3.1.3 Interaction effect of planting method and weeding

The number of effective tillers hill^{-1} was not statistically significantly influenced by planting method and weeding (Appendix IX and Table 14). The maximum number of effective tillers hill^{-1} (15.80) was observed in P_1W_1 and the minimum number of effective tillers hill^{-1} (11.47) observed in P_1W_0.

Table 14 . Interaction effect of planting method and weeding on number of effective and ineffective tillers hill^{-1} of rice

Treatments	Effective tillers (no. hill^{-1})	Ineffective tillers (no. hill^{-1})
P_1W_0	11.47	1.26
P_1W_1	15.80	1.06
P_1W_2	13.27	1.33
P_1W_3	12.20	1.13
P_1W_4	15.60	0.93
P_1W_5	15.73	1.66
P_1W_6	12.67	1.06
P_1W_7	12.07	1.86
P_2W_0	13.00	0.53
P_2W_1	13.27	1.26
P_2W_2	11.60	0.93
P_2W_3	11.93	1.00
P_2W_4	12.33	1.93
P_2W_5	13.87	0.73
P_2W_6	12.13	1.13
P_2W_7	13.67	0.53
$LSD_{(0.05)}$	NS	NS
CV (%)	13.82	56.96

P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

NS= Not Significant

4.3.2 Number of ineffective tillers hill^{-1}

4.3.2.1 Effect of planting method

The number of ineffective tillers hill^{-1} was not significantly influenced by planting method (Appendix IX and Figure 7). Numerically the higher number of ineffective tillers hill^{-1} (1.29) was obtained from rice transplanter and the lower number of ineffective tillers hill^{-1} (1.01) observed in conventional planting method. Similar results were also reported by Manjunatha *et al.* (2009) and Munnaf *et al.* (2014).

4.3.2.2 Effect of weeding

The number of ineffective tillers $hill^{-1}$ was not significantly influenced by weeding (Appendix IX and Table 14). The maximum number of ineffective tillers $hill^{-1}$ (1.43) was observed in W_4 and the minimum number of ineffective tillers $hill^{-1}$ (0.90) observed in W_0.

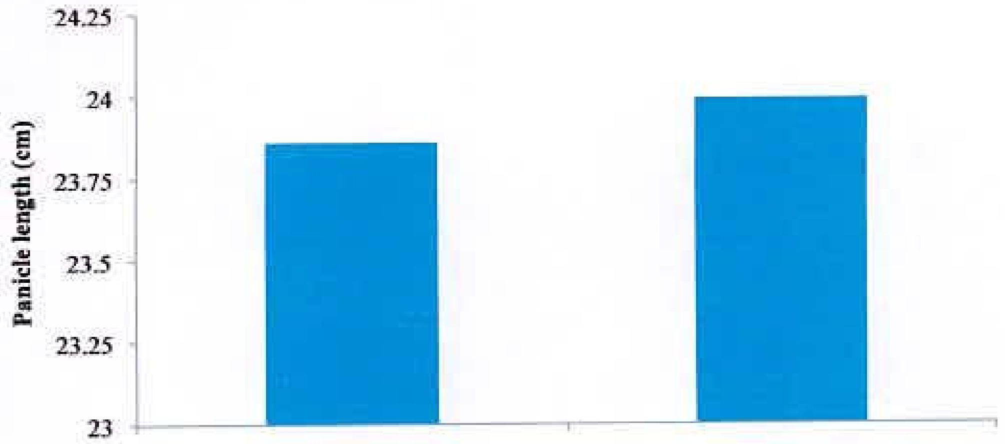
4.3.2.3 Interaction effect of planting method and weeding

The number of ineffective tillers $hill^{-1}$ was not statistically significantly influenced by planting method and weeding (Appendix IV and Table 14). The maximum number of ineffective tillers $hill^{-1}$ (1.93) was observed in P_2W_4 and the minimum number of ineffective tillers $hill^{-1}$ (0.53) observed in P_2W_0 and P_2W_7.

4.3.3 Panicle length

4.3.3.1 Effect of planting method

The length of panicle was not significantly influenced by planting method (Appendix IX and Figure 8). Numerically the higher length of panicle (23.99cm) was obtained from conventional planting method and the lower length of panicle (23.86cm) observed in rice transplanter method.



P_1: Rice transplanter P_2: Conventional method

Figure 8. Panicle length of rice as affected by planting method

4.3.3.2 Effect of weeding

The length of panicle was not significantly influenced by weeding (Appendix IX and Table 15). Numerically the maximum length of panicle (24.26cm) observed in W_7 and the minimum length of panicle (23.58cm) observed in W_0 (no weeding) treatment.

Table 15. Effect of weeding on different crop characters

Treatments	Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)
W_0	23.58	10.92	167.70	29.92	18.30 c
W_1	23.73	11.02	160.20	32.83	19.25 a-c
W_2	23.94	11.20	170.40	30.32	20.30 a
W_3	23.74	10.83	160.10	33.60	19.81 ab
W_4	24.19	11.18	159.70	35.80	18.83 b
W_5	24.14	11.33	162.10	38.50	19.85 ab
W_6	23.84	10.83	163.40	39.42	18.81 bc
W_7	24.26	11.35	173.10	37.38	19.97 a
LSD $_{(0.05)}$	NS	NS	NS	NS	1.06
CV (%)	2.42	4.15	10.76	29.14	4.64

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT

NS= Not Significant

4.3.3.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced the panicle length (Appendix IX and Table 16). Numerically the maximum length of panicle (24.83cm) observed in P_1W_7 and the minimum length of panicle (23.27cm) observed in P_2W_0.

Table 16. Interaction effect of planting method and weeding on different crop characters

Treatments	Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)
P_1W_0	23.89	10.97	162.0	39.33	18.16 g
P_1W_1	23.40	10.80	150.1	32.03	18.68 d-g
P_1W_2	23.97	10.93	158.6	35.73	19.94 a-c
P_1W_3	23.65	10.43	156.5	38.23	19.98 a-c
P_1W_4	23.74	11.10	147.8	43.10	19.05 c-g
P_1W_5	23.97	11.07	164.4	44.57	19.37 b-f
P_1W_6	23.45	10.90	155.8	48.53	19.06 c-g
P_1W_7	24.83	11.57	171.5	51.30	19.86 a-d
P_2W_0	23.27	10.87	173.4	20.50	18.44 fg
P_2W_1	24.05	11.23	170.3	33.63	19.81 a-e
P_2W_2	23.92	11.47	182.2	24.90	20.65 a
P_2W_3	23.84	11.23	163.6	28.97	19.63 a-f
P_2W_4	24.64	11.27	171.5	28.50	18.61 e-g
P_2W_5	24.32	11.60	159.8	32.43	20.34 ab
P_2W_6	24.23	10.77	171.1	30.30	18.55 fg
P_2W_7	23.68	11.13	174.7	23.47	20.07 a-c
$LSD_{(0.05)}$	NS	NS	NS	NS	1.19
CV (%)	2.42	4.15	10.76	29.14	4.64

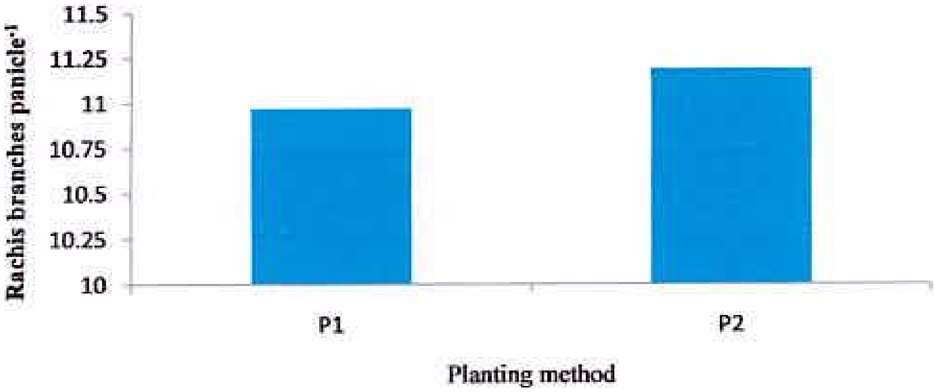
P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT ;

NS= Not Significant

4.3.4 Rachis branches panicle^{-1}

4.3.4.1 Effect of planting method

The number of rachis branches panicle^{-1} was not significantly influenced by planting method (Appendix IX and Figure 9). Numerically the higher number of rachis branches panicle^{-1} (11.19) was obtained from conventional planting method and the lower number of rachis branches panicle^{-1} (10.97) observed in rice transplanter method.



P_1: Rice transplanter P_2: Conventional method

Figure 9. Rachis branches panicle^{-1} of rice as affected by planting method

4.3.4.2 Effect of weeding

The number of rachis branches panicle^{-1} was not significantly influenced by weeding. (Appendix IX and Table 15). Numerically the maximum number of rachis branches panicle^{-1}(11.35) observed in W_7 and the minimum number of rachis branches panicle^{-1} (10.83) observed in $W_3$and W_6.

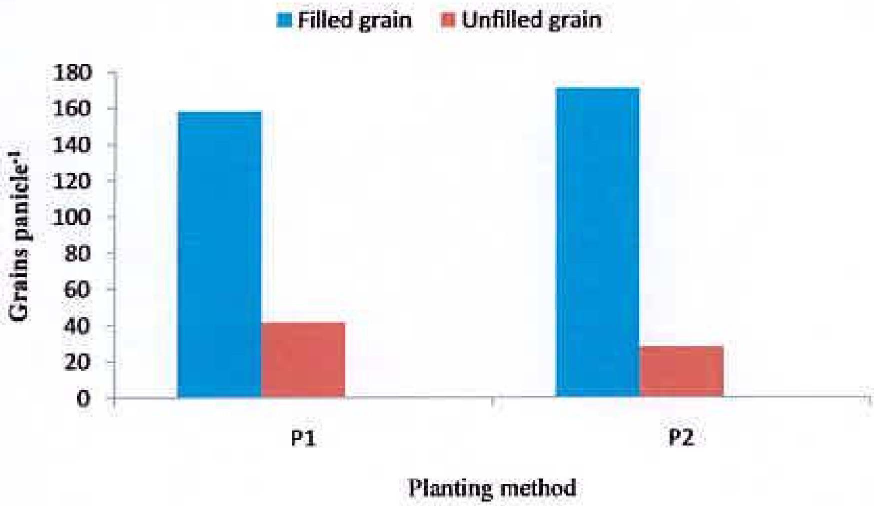
4.3.4.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced the rachis branches panicle^{-1} (Appendix IX and Table 16). Numerically the maximum number of rachis branches panicle^{-1} (11.57) observed in P_1W_7 and the minimum number of rachis branches panicle^{-1} (10.43) observed in P_1W_3.

4.3.5 Filled grains panicle^{-1}

4.3.5.1 Effect of planting method

The number of filled grains panicle^{-1} was not significantly influenced by planting method (Appendix IX and Figure 10). Numerically the higher number of filled grains panicle^{-1} (170.82) was obtained from conventional planting method and the lower number of filled grains panicle^{-1} (158.31) observed in rice transplanter method.



P_1: Rice transplanter P_2: Conventional method

Figure 10. Filled grains panicle^{-1} and unfilled grains panicle^{-1} of rice as affected by planting method

4.3.5.2 Effect of weeding

The number of filled grains panicle^{-1} was not significantly influenced by weeding (Appendix IX and Table 15). Numerically the maximum number of filled grains panicle^{-1} (173.10) observed in W_7 and the minimum number of filled grains panicle^{-1} (159.70) observed in W_4. So increasing number of weedings increased the filled 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.

4.3.5.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced the filled grains panicle^{-1} (Appendix IX and Table 16). Numerically the maximum number of filled grains panicle^{-1} (182.20) observed in P_2W_7 and the minimum number of filled grains panicle^{-1} (147.80) observed in P_1W_4.

4.3.6 Unfilled grains panicle^{-1}

4.3.6.1 Effect of planting method

The number of unfilled grains panicle^{-1} was not significantly influenced by planting method (Appendix IX and Figure 10). Numerically the higher number of unfilled grains panicle^{-1}(41.60) was obtained from rice transplanter method and the lower number of unfilled grains panicle^{-1} (27.84) observed in conventional planting method.

4.3.6.2 Effect of weeding

The number of unfilled grains panicle^{-1} was not significantly influenced by weeding (Appendix IX and Table 15). Numerically the maximum number of unfilled grains panicle^{-1} (39.82) observed in W_6 and the minimum number of unfilled grains panicle^{-1} (29.92) observed in W_0.

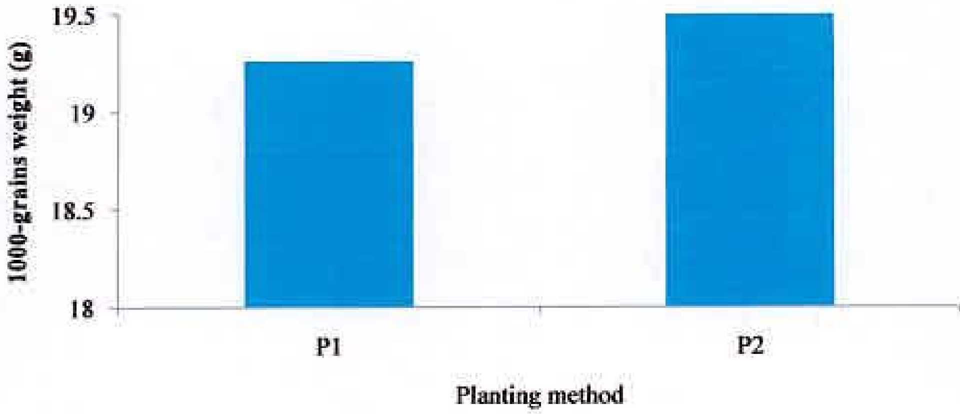
4.3.6.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was not statistically significantly influenced the unfilled grains panicle^{-1} (Appendix IX and Table 16). Numerically the maximum number of unfilled grains panicle^{-1} (50.30) observed in P_1W_7 and the minimum number of unfilled grains panicle^{-1} (20.50) observed in P_2W_0.

4.3.7 Weight of 1000-grains

4.3.7.1 Effect of planting method

The weight of 1000-grains was not significantly influenced by planting method (Appendix IX and Figure 11). Numerically the maximum weight of 1000-grains (19.51 g) was obtained from conventional planting method and the minimum weight of 1000-grains (19.26 g) observed in rice transplanter method. Similar results were also reported by Munnaf *et al* (2014).



P_1: Rice transplanter P_2: Conventional method

Figure 11. 1000-grains weight of rice as affected by planting method

4.3.7.2 Effect of weeding

The weight of 1000-grains was significantly influenced by weeding (Appendix IX and Table 15). The highest weight of 1000-grains (20.30 g) was obtained from W_2 and it was statistically similar with W_7 (19.97 g), W_5 (19.85 g), W_3 (19.81 g) and W_1 (19.25 g) and the lowest weight of 1000-grains (18.30 g) observed in W_0 and it was statistically similar with W_6 (18.81 g) and W_1 (19.25 g). Similar finding were observed by Yuan *et al.* (1991).

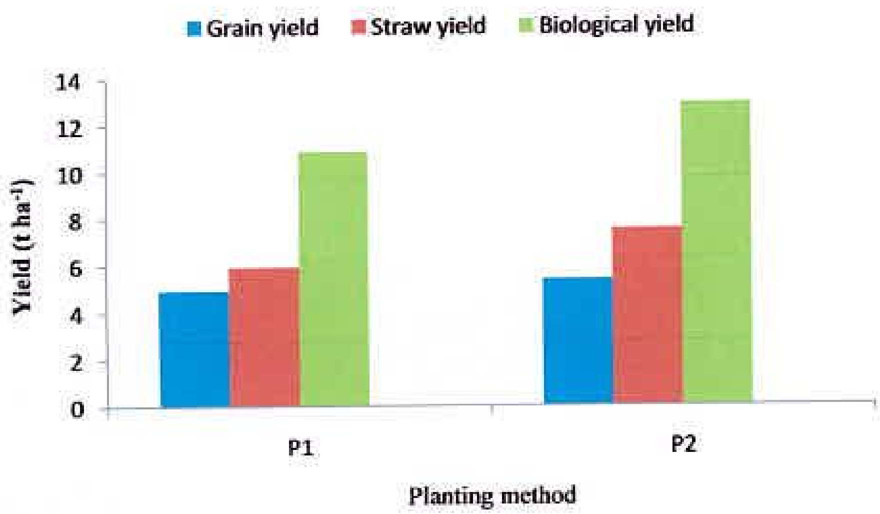
4.3.7.3 Interaction effect of planting method and weeding

Interaction effect of planting method and weeding was significantly influenced the weight of 1000-grains (Appendix IX and Table 16). The highest weight of 1000-grains (20.65 g) observed in P_2W_2 and it was statistically similar with P_2W_5 (20.34 g), P_2W_7 (20.07 g), P_1W_3 (19.98 g), P_1W_2 (19.94 g), P_1W_7 (19.86 g) and P_2W_1 (19.81 g) and the lowest weight of 1000-grains (18.16 g) observed in P_1W_0 and it was statistically similar with P_2W_0 (18.44 g), P_2W_6 (18.55 g), P_2W_4 (18.61 g), P_1W_1 (18.68 g), P_1W_4 (19.05 g) and P_1W_6 (19.06 g).

4.3.8 Grain yield

4.3.8.1 Effect of planting method

Grain yield was not significantly influenced by the planting method (Appendix X and Figure 12). Numerically the higher grain yield (5.38 t ha^{-1}) was obtained from the conventional planting method and lower (4.93 t ha^{-1}) from the rice transplanter method. Similar results were also reported by Hossain *et al* (2012a), Hossain *et al* (2012a), Manjunatha *et al.* (2009) and Munnaf *et al* (2014).



P_1: Rice transplanter P_2: Conventional method

Figure 12. Grain yield, Straw yield and Biological yield of rice as affected by planting method (LSD $_{(0.05)}$ = 0.94 for Biological yield)

4.3.8.2 Effect of weeding

Grain yield was significantly influenced by the weeding (Appendix X and Table 17). The highest grain yield (5.48 t ha^{-1}) observed in W_7 and it was statistically similar with W_2 (5.44 t ha^{-1}), W_3 (5.33 t ha^{-1}), W_5 (5.32 t ha^{-1}), W_6 (5.26 t ha^{-1}), W_4 (5.23 t ha^{-1}) and W_1 (5.04 t ha^{-1}) and lowest grain yield (4.13 t ha^{-1}) observed in W_0. All other treatments gave higher yield compared with no weeding. Similar findings were also reported by Polthanee *et al.* (1996), Thomas *et al.* (1997), Sanjoy *et al.* (1999), Gogoi *et al.* (2000) and Atalla and Kholosy (2002).

Table 17. Effect of weeding on yield and other crop characters of rice

Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
W_0	4.13 b	6.49	10.62	39.05 c
W_1	5.04 a	6.89	11.94	42.79 a-c
W_2	5.44 a	6.73	12.17	44.63 ab
W_3	5.33 a	6.99	12.32	43.50 a-c
W_4	5.23 a	7.43	12.67	41.39 bc
W_5	5.32 a	6.20	11.53	46.71 a
W_6	5.26 a	6.66	11.93	44.14 ab
W_7	5.48 a	6.46	11.95	46.66 a
$LSD_{(0.05)}$	0.61	NS	NS	9.08
CV (%)	10.13	13.71	9.40	8.68

W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT;

NS= Not Significant

4.3.8.3 Interaction effect of planting method and weeding

Grain yield was significantly influenced by the interaction effect of planting method and weeding (Appendix X and Table 18). The highest grain yield (5.82 $t\ ha^{-1}$) observed in P_2W_7 and it was statistically similar with P_2W_2 (5.78 $t\ ha^{-1}$), P_2W_3 (5.73 $t\ ha^{-1}$), P_2W_6 (5.53 $t\ ha^{-1}$), P_2W_5 (5.50 $t\ ha^{-1}$), P_2W_1 (5.29 $t\ ha^{-1}$), P_1W_4 (5.24 $t\ ha^{-1}$), P_2W_4 (5.22 $t\ ha^{-1}$), P_1W_5 (5.15 $t\ ha^{-1}$), P_1W_7 (5.15 $t\ ha^{-1}$), P_1W_2 (5.09 $t\ ha^{-1}$), P_2W_6 (4.99 $t\ ha^{-1}$) and the lowest grain yield (3.57 $t\ ha^{-1}$) observed in P_1W_0.

Table 18. Interaction effect of planting method and weeding on yield and other crop characters of rice

Treatmenrs	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
P_1W_0	3.57 d	5.40	8.97 f	39.89 c
P_1W_1	4.80 c	6.09	10.89 de	44.74 a-c
P_1W_2	5.09 a-c	6.42	11.52 b-e	44.15 a-c
P_1W_3	4.94 bc	6.25	11.19 c-e	44.38 a-c
P_1W_4	5.24 a-c	7.02	12.26 a-d	42.78 a-c
P_1W_5	5.15 a-c	5.15	10.30 ef	50.18 a
P_1W_6	5.53 a-c	5.95	11.48 b-e	47.97 ab
P_1W_7	5.15 a-c	5.12	10.27 ef	50.07 a
P_2W_0	4.69 c	7.58	12.27 a-d	38.21 c
P_2W_1	5.29 a-c	7.69	12.99 a-c	40.83 c
P_2W_2	5.78 ab	7.04	12.82 a-c	45.10 a-c
P_2W_3	5.73 ab	7.73	13.46 a	42.62 bc
P_2W_4	5.22 a-c	7.85	13.08 ab	39.99 c
P_2W_5	5.50 a-c	7.26	12.76 a-d	43.34 a-c
P_2W_6	4.99 a-c	7.38	12.38 a-d	40.30 c
P_2W_7	5.82 a	7.81	13.63 a	43.26 a-c
$LSD_{(0.05)}$	0.87	NS	1.87	7.44
CV (%)	10.13	13.71	9.40	9.08

P_1: Rice transplanter P_2: Conventional method ; W_0= No Weeding, W_1= Weeding at 20 DAT, W_2= Weeding at 35 DAT, W_3= Weeding at 50 DAT, W_4= Two Weedings at 20 DAT & 35 DAT, W_5= Two Weedings at 20 DAT & 50 DAT, W_6= Two Weedings at 35 DAT & 50 DAT, W_7= Three Weedings at 20 DAT, 35 DAT & 50 DAT ;

NS= Not Significant

4.3.9 Straw yield

4.3.9.1 Effect of planting method

Straw yield was not significantly influenced by the planting method (Appendix X and Figure 12). Numerically the higher straw yield (7.55 t ha^{-1}) was obtained from the conventional planting method and lower (5.93 t ha^{-1}) from the rice transplanter method.

4.3.9.2 Effect of weeding

Straw yield was not significantly influenced by weeding (Appendix X and Table 17). Numerically the maximum straw yield (7.44 t ha^{-1}) observed in W_4 and minimum straw yield (6.21 t ha^{-1}) observed in W_5. Dissimilar observations were found by Islam (1995) and Toufiq (2003).

4.3.9.3 Interaction effect of planting method and weeding

Straw yield was not significantly influenced by the interaction effect of planting method and weeding (Appendix X and Table 18). Numerically the maximum straw yield (7.85 t ha^{-1}) observed in P_2W_4 and minimum straw yield (5.12 t ha^{-1}) observed in P_1W_7.

4.3.10 Biological yield

4.3.10.1 Effect of planting method

Biological yield was significantly influenced by planting method (Appendix X and Figure 12). The result revealed that higher biological yield (12.92 t ha^{-1}) obtained from the conventional transplanting method and lower biological yield (10.86 t ha^{-1}) observed in rice transplanter method.

4.3.10.2 Effect of weeding

Biological yield was not significantly influenced by weeding (Appendix X and Table 17). Numerically the maximum biological yield (12.67 t ha^{-1}) observed in W_4 and minimum biological yield (10.62 t ha^{-1}) observed in W_0.

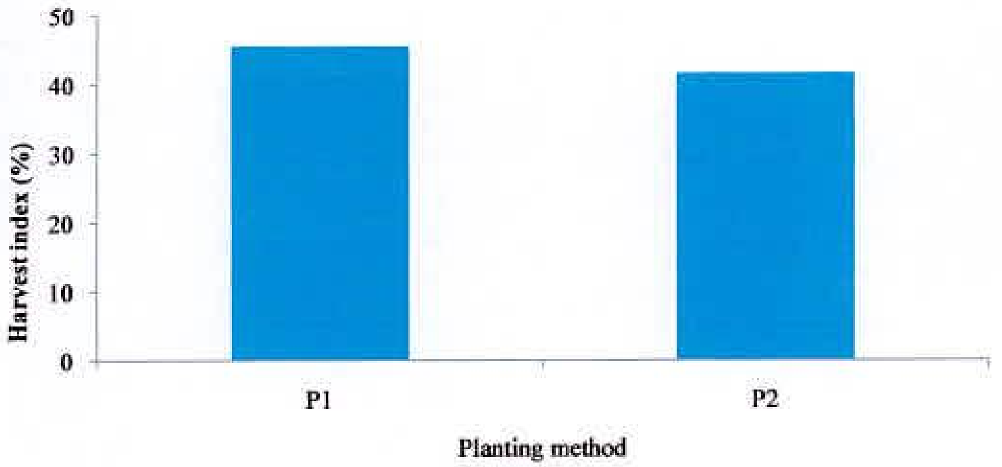
4.3.10.3 Interaction effect of planting method and weeding

Biological yield was significantly influenced by the interaction effect of planting method and weeding (Appendix X and Table 18). The highest biological yield (13.63 t ha^{-1}) observed in P_2W_7 and it was statistically similar with P_2W_3 (13.46 t ha^{-1}), P_2W_4 (13.08 t ha^{-1}), P_2W_1 (12.99 t ha^{-1}), P_2W_2 (12.82 t ha^{-1}), P_2W_5 (12.76 t ha^{-1}), P_2W_6 (12.38 t ha^{-1}), P_2W_0 (12.27 t ha^{-1}) and P_1W_4 (12.26 t ha^{-1}) and the lowest biological yield (8.97 t ha^{-1}) observed in P_1W_0 and it was statistically similar with P_1W_7 (10.27 t ha^{-1}) and P_1W_5 (10.30 t ha^{-1}).

4.3.11 Harvest index (%)

4.3.11.1 Effect of planting method

Harvest index was not significantly influenced by the planting method (Appendix X and Table 13). Numerically higher harvest index (45.52 %) was obtained from the rice transplanter method and lower (41.69%) from the conventional transplanting method. Similar results also observed by Munnaf *et al.* (2014).



P_1: Rice transplanter P_2: Conventional method

Figure 13. Harvest Index of rice as affected by planting method

4.3.11.2 Effect of weeding

Harvest index was significantly influenced by the weeding (Appendix X and Table 17). The highest harvest index (46.71%) observed in W_5 and it was statistically similar with W_7 (46.66 %), W_2 (44.63 %), W_6 (44.14 %), W_3 (43.50 %) and W_1 (42.79 %) and the lowest harvest index (39.07 %) observed in W_0 and it was statistically similar with W_4 (41.39 %), W_1 (42.79 %) and W_3 (43.50 %).

4.3.11.3 Interaction effect of planting method and weeding

Harvest index was significantly influenced by the interaction effect of planting method and weeding (Appendix X and Table 18). The highest harvest index (50.18 %) observed in P_1W_5 and it was statistically similar with P_1W_7 (50.07 %), P_1W_6 (47.97 %), P_2W_2 (45.10 %), P_1W_1 (44.74 %), P_1W_3 (44.38 %), P_1W_2 (44.15 %), P_2W_5 (43.34 %), P_2W_7 (43.26 %) and P_1W_4 (42.78 %) and the lowest harvest index (38.21 %) observed in P_2W_0 and it was statistically similar with P_1W_0 (39.89 %), P_2W_4 (39.99 %), P_2W_1 (40.13 %) and P_2W_6 (40.30 %).

Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from July 2013 to December 2013 to study the influence of planting method and weeding on growth and yield of T. *aman* rice in *aman* season under the Modhupur Tract (AEZ-28). The experiment was comprised of two sets of treatments viz. A. Planting method: (Rice transplanter and Conventional method) and B. Weeding: (No Weeding (W_0), Weeding at 20 DAT (W_1), Weeding at 35 DAT (W_2), Weeding at 50 DAT (W_3), Two Weedings at 20 DAT & 35 DAT (W_4), Two Weedings at 20 DAT & 50 DAT (W_5), Two Weedings at 35 DAT & 50 DAT (W_6) and Three Weedings at 20 DAT, 35 DAT & 50 DAT (W_7)). The experiment was laid out in split-plot design with three replications having variety in the main plots and weeding in the sub plots.

The data on crop growth characters (plant height, number of tillers hill^{-1}, leaf area index (LAI), days to 50% flowering) were recorded in the field and yield as well as other crop characters (number of effective and ineffective tillers hill^{-1}, panicle length, rachis branches panicle^{-1}, number of total grains panicle^{-1}, number of filled and unfilled grains panicle^{-1}, 1000 grains weight, grain and straw yield, biological yield and harvest index) were recorded after harvest and analysed using the MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

The planting method showed significant effect on all the agronomic parameters except total number of tillers hill^{-1}, number of leaves hill^{-1}, effective and ineffective tillers hill-1 grain and straw yield. It revealed that rice transplanter showed significantly taller plant at 90 DAT. The leaf area index (LAI) was not significantly influenced except 15 DAT. Conventional method needed longer time for flowering (103.58 days) as compared to rice transplanter (90.91 days). The higher (23.99 cm) and lower (23.86 cm) panicle length was obtained from conventional method and rice transplanter respectively. The higher number of rachis branches panicle^{-1} (11.19) was observed in conventional method and the lower number of branches panicle^{-1} (10.97) was observed in rice transplanter. The higher number of filled grains and unfilled grains panicle^{-1} (170.82 and 41.60 respectively) were obtained from the conventional method and rice transplanter respectively and the lower number of filled grains and unfilled grains panicle^{-1} (158.31 and 27.83) were obtained from the rice transplanter and conventional method respectively. The higher weight of 1000-grain (19.57 g) was obtained from the conventional method and the lower weight of 1000-grain (19.33 g) was obtained from the rice transplanter.

The weeding showed significant effect on all the agronomic parameters except leaf area index, days to flowering, effective and ineffective tillers hill^{-1} and straw yield. At 40 DAT, the highest plant height observed in W_7 (75.45 cm) and lowest plant height observed in W_2 (69.77), though there was no significant difference in respect of plant height among the weeding at other DAT. At harvest, the highest tillers hill^{-1} observed in W_5 (16.00) and lowest tillers hill^{-1} observed in W_0 (13.13), though there was no significant difference in respect of number of tillers hill^{-1} among the weeding at other DAT. The highest number of weeds found in W_0 (138.30) and lowest number of weeds observed in W_7 (5.17) at 50 DAT. The highest dry weight of weeds observed in W_0 (151.10 g) and the lowest dry weight of weeds observed in W_7 (3.63 g) at 50 DAT, The highest grain yield (5.48 t ha^{-1}) observed in W_7 and lowest grain yield (4.13 t ha^{-1}) observed in W_0.

Interaction effect of planting method and weeding was not significantly influenced except weed population and weed dry matter, 1000-grain weight, grain yield, biological yield and harvest index. The highest number of weeds found in P_1W_0 (200.70) and lowest number of weeds observed in P_2W_7 (2.33) at 50 DAT. The highest dry weight observed in P_1W_0 (206.20 g) and the lowest dry weight of weeds observed in P_2W_7 (1.22 g) at 50 DAT. The highest grain yield (5.82 t ha^{-1}) observed in P_2W_7 and the lowest grain yield (3.57 t ha^{-1}) observed in P_1W_0.

Based on the results of the present study, the following conclusions may be drawn-

- Both rice transplanter and conventional method gave similar yield.
- No weeding reduced the grain yield of transplanted rice.
- No weeding in conventional method as well as no weeding & single weeding at 20 DAT or 50 DAT using rice transplanter reduced the grain yield of rice.

However, to reach a specific conclusion and recommendation the experiments with rice transplanter need to be repeated with more varieties and in different agro-ecological zones.

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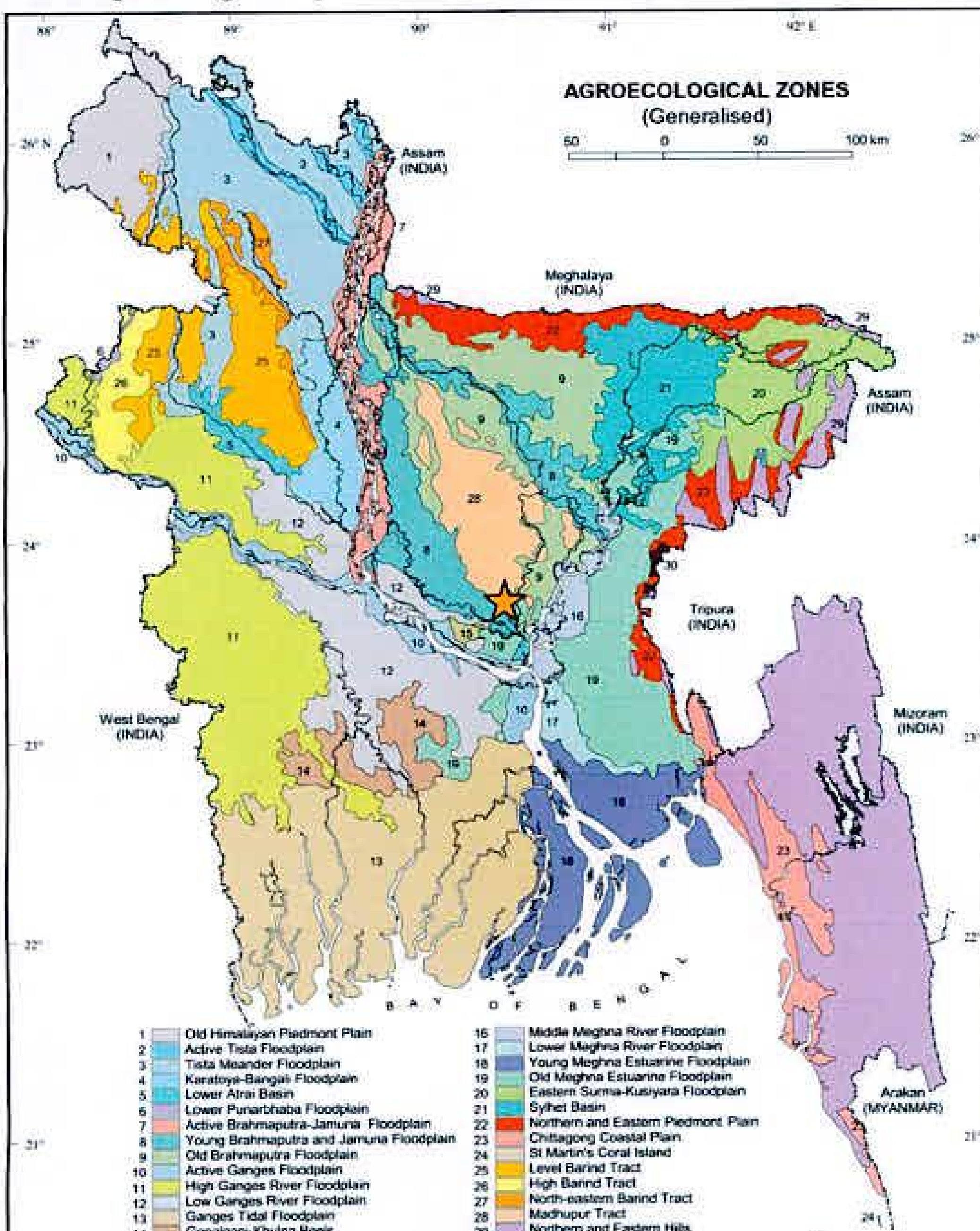
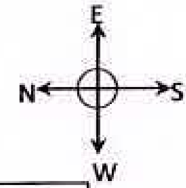
Appendices

APPENDICES

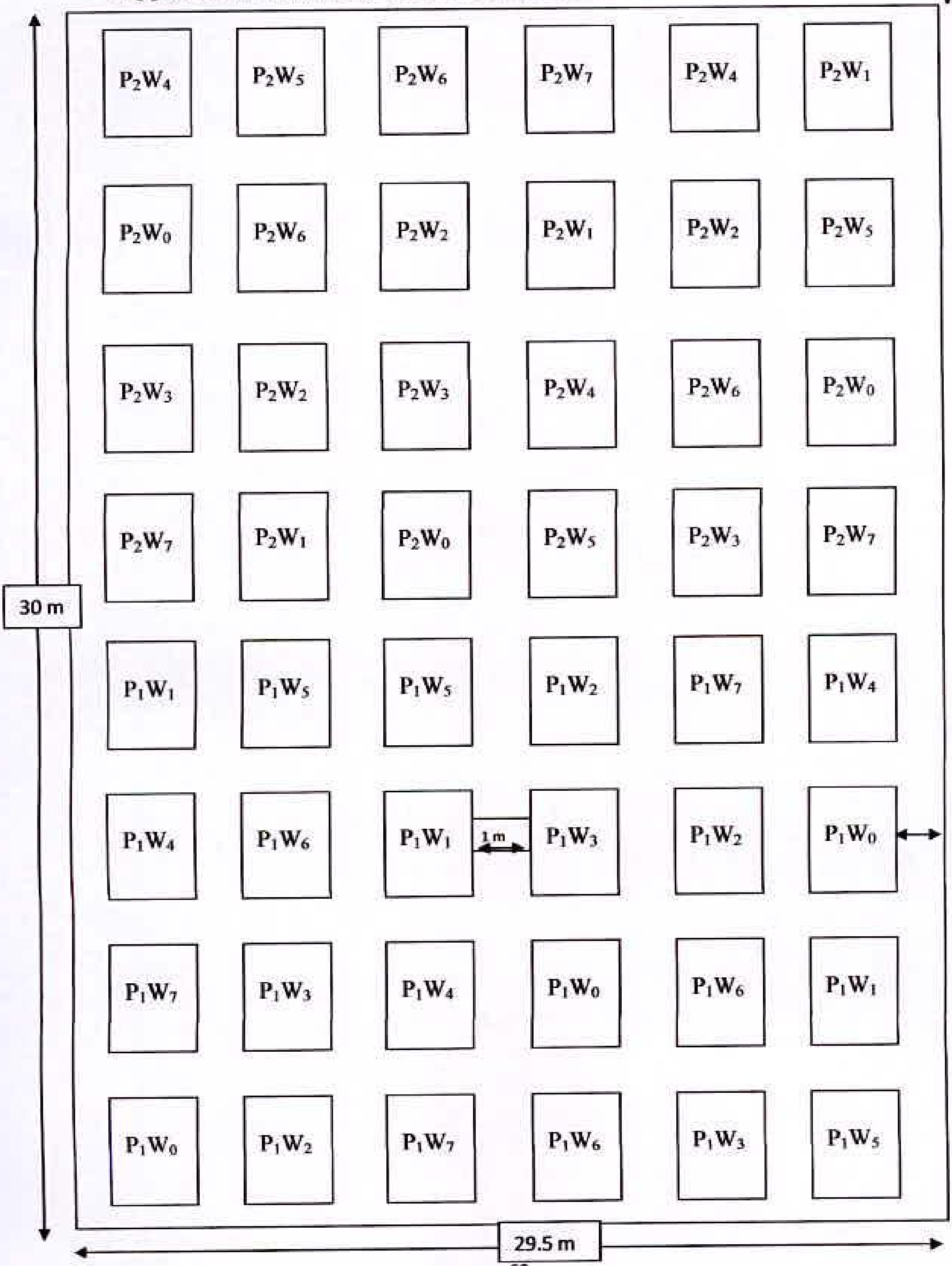
Appendix I. Map showing the experimental sites under study



★ **The experimental site under study**



Appendix II : Layout of experimental field



Appendix III: Weather data, 2013, Dhaka

Month	Average RH (%)	Average Temperature (°C)		Total Rainfall (mm)	Average Sunshine hours
		Min.	Max.		
June	83	26.5	34.2	619	4.8
July	81	25.2	31.8	761	4.3
August	80	26.7	33.5	514	4.7
September	79	24.4	31	183	3.6
October	78	22.8	31.3	341	4.9
November	73	18.9	28.6	107	5.8
December	69	16.6	23.2	0	5.6

Source : Bangladesh Meteorological Department (Climatic Divission), Agargaon, Dhaka-1207

Appendix IV. Mean square values for plant height at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values for plant height at different days after transplanting				
		15	40	65	90	At harvest
Replication	2	7.633	197.050	256.801	204.731	102.427
Planting method	1	340.960^{NS}	0.115^{NS}	177.101^{NS}	483.870*	76.003^{NS}
Error (a)	2	37.273	29.711	10.493	15.953	17.861
Weeding	7	8.299^{NS}	29.637*	8.426^{NS}	29.664^{NS}	16.674^{NS}
Planting method × weeding	7	3.667^{NS}	7.561^{NS}	2.896^{NS}	7.192^{NS}	6.998^{NS}
Error (b)	28	6.784	10.834	17.455	17.287	20.849

* Significant at 0.05 level of probability; ^{NS} Non-significant

Appendix V. Mean square values for tiller numbers hill^{-1} at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values for tiller numbers hill^{-1} at different days after transplanting				
		15	40	65	90	At harvest
Replication	2	0.133	123.210	8.123	13.353	3.391
Planting method	1	1.141^{NS}	336.282^{NS}	19.253^{NS}	35.021^{NS}	15.413^{NS}
Error (a)	2	1.766	29.730	12.253	5.726	3.716
Weeding	7	0.806^{NS}	49.720^{NS}	11.067^{NS}	7.199^{NS}	8.922*
Planting method × weeding	7	1.112^{NS}	23.504^{NS}	7.539^{NS}	3.994^{NS}	2.726^{NS}
Error (b)	28	1.054	16.484	4.783	5.772	3.101

* Significant at 0.05 level of probability; ^{NS} Non-significant

Appendix VI. Mean square values for leaf area index at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		15	40	65	90
Replication	2	0.006	2.634	0.904	0.571
Planting method	1	0.186*	4.386 NS	18.365 NS	0.824 NS
Error (a)	2	0.005	16.253	1.250	3.924
Weeding	7	0.002 NS	1.515 NS	6.172 NS	0.290 NS
Planting method × weeding	7	0.005 NS	1.505 NS	2.459 NS	0.673 NS
Error (b)	28	0.005	1.827	2.926	1.038

* Significant at 0.05 level of probability; NS Non-significant

Appendix VII. Mean square values for weed population at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting		
		20	35	50
Replication	2	1.646	6.396	8.771
Planting method	1	5440.021**	14283.00**	8321.333**
Error (a)	2	3.521	26.063	1.271
Weeding	7	268.045**	3053.619**	11845.714**
Planting method × weeding	7	90.449**	1750.619**	3856.571**
Error (b)	28	7.702	13.563	3.188

**Significant at 0.01 level of probability

Appendix VIII. Mean square values for weed dry matter at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting		
		20	35	50
Replication	2	6.796	22.372	5.473
Planting method	1	19132.459**	13540.848**	23874.380**
Error (a)	2	8.013	11.287	0.734
Weeding	7	1228.478**	5323.889**	14063.627**
Planting method × weeding	7	1075.646**	4748.8161**	4520.215**
Error (b)	28	9.525	13.971	5.160

**Significant at 0.01 level of probability

Appendix IX. Mean square values for crop growth characters, yield and other crop characters

Sources of variation	Degrees of freedom	Mean square values							
		Duration of flowering (Days)	Effective tillers m^{-2} (no.)	Ineffective tillers m^{-2} (no.)	Panicle length (cm)	Rachis branches $panicle^{-1}$	Filled grains $panicle^{-1}$ (no.)	Unfilled grains panicle-1 (no.)	1000-grains weight (g)
Replication	2	2.250	4.007	0.107	0.795	0.426	149.823	37.126	0.103
Planting method	1	1925.333^{**}	9.187^{NS}	0.963^{NS}	0.204^{NS}	0.607^{NS}	1877.501^{NS}	2274.253^{NS}	0.755^{NS}
Error (a)	2	3.083	3.062	0.566	0.591	0.190	892.458	185.776	0.849
Weeding	7	2.571^{NS}	7.262^{NS}	0.135^{NS}	0.363^{NS}	0.270^{NS}	160.786^{NS}	78.756^{NS}	2.921^{*}
Planting method × weeding	7	1.286^{NS}	4.820^{NS}	0.807^{NS}	0.773^{NS}	0.265^{NS}	155.524^{NS}	109.681^{NS}	0.624^{*}
Error (b)	28	1.643	3.311	0.429	0.336	0.212	313.744	102.383	0.809

* Significant at 0.05 level of probability; ^{NS} Non-significant

Appendix X. Mean square values for yield and other crop characters

Sources of variation	Degrees of freedom	Mean square values			
		Grain yield (t/ ha)	Straw yield (t/ha)	Biolo-gical yield (t/ha)	Harvest index (%)
Replication	2	0.134	0.667	0.216	20.499
Planting method	1	2.389^{NS}	31.331^{NS}	51.026*	175.835^{NS}
Error (a)	2	0.452	2.469	1.734	63.852
Weeding	7	1.140*	0.857^{NS}	2.248^{NS}	40.002*
Planting method × weeding	7	0.400*	0.723^{NS}	1.481*	14.190*
Error (b)	28	0.273	0.853	1.249	15.678

* Significant at 0.05 level of probability; ^{NS} Non-significant