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Comparison of weed control methods on infestation and crop productivity in transplant *aman* rice

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Abstract

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from June to December 2014 with a view to compare the efficacy of weeding method on the performance of transplanted *aman* rice varieties. Four transplanted *aman* rice varieties viz. Kalijira, BRRI dhan34, BRRI dhan52 and BRRI dhan64 and five different weeding treatments namely no weeding, two hand weeding at 20 & 40 days after transplanting (DAT), mechanical weeding by Japanese rice weeder at 20 and 40 DAT, soil applied pre-emergence herbicide Topstar 400 SP (Oxadiargyl 400 g/l) @ 190 ml ha^{-1} once at 3 days before transplanting and foliar applied post-emergence herbicide Manage @ 250g ha^{-1} at 6 days after transplanting were evaluated. The experiment was laid out in a split plot design assigning weed control method in the main plot and variety in the sub plot with three replications. Weed population was significantly influenced by variety and methods of weeding. The important weeds of the experimental plots were *Digitaria sanguinalis*, *Leersia hexandra*, *Paspalum scrobiculatum*, *Echinochloa crusgalli*, *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Polygonum orientale, Eclipta alba, Marsilea crenata* and *Fimbristylis miliacea*. The effect of weeding treatments on dry weight of weeds was significant. Hand weeding at 20 and 40 DAT showed the lowest dry weight of weeds followed by post-emergence herbicide Manage at 6 DAT and no weeding produced the highest dry weight of weeds. Among the weeding treatments hand weeding at 20 and 40 DAT performed the best for all the crop characters including grain yield (3.90 t ha^{-1}) followed by the post-emergence herbicide manage and no weeding showed the lowest performance (3.06 t ha^{-1}). Among the varieties, BRRI dhan34 produced the highest grain yield (4.33 t ha^{-1}) and Kalijira yielded the lowest (2.04 t ha^{-1}). The interaction between variety and weeding show that all the varieties produced higher grain yield with two hand weeding at 20 and 40 DAT than other weeding treatments. The results suggested that BRRI dhan34 might be grown with two hand weeding at 20 and 40 DAT as well as early post-emergence herbicide Manage for effective in controlling weeds and for better yield of transplant *aman* rice.

Key words: Weed control methods, transplant *aman* rice, yield

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Introduction

Bangladesh is an agro-based country. Food security of Bangladesh depends on rice agriculture. Rice (*Oryza sativa* L.) is also the staple food for more than two billion people in Asia and four hundred millions of people in Africa and Latin America (IRRI, 2010). The people in Bangladesh depend on rice as staple food and

rice has tremendous influence on agrarian economy of the country. About 84.67% of cropped area of Bangladesh issued for rice production, with annual production of30.42 million tons from 10.4 million ha of land (BBS, 2013). Transplant *aman* rice covers 5.24 million ha (58.78% of total rice area) of land with a production of 12.89 million tons (BBS, 2013). The average yield of rice in Bangladesh is 2.92 ton ha^{-1}, which is very much low (BBS, 2013). Geographic and agronomic conditions of Bangladesh are favorable for rice cultivation. The average yield of rice is almost less than 50% of the world average. The increasing rate of population is 1.37% (BBS, 2013) and decreasing rate of agricultural land by 1% per annum (Hussain *et al*., 2006) limit the horizontal expansion of rice area. So, the only avenue left is to increase the production of rice through vertical expansion where the use of improved varieties are the most effective means to increase the yield of transplant *aman* rice. 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). Weeds grow in each of the crop field throughout the world. So, it is often said that, crop production is a fight against weeds. Where there is cultivable land, there is weed. Weeds uptake the available nutrients, compete with crops for water, light and space. Weeds are the most competitors in their early growth stages than the later and hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). In Bangladesh, weed infestation reduces the grain yield by 70-80% in *aus* rice (early summer), 30-40% for transplanted *aman* rice (autumn) and 22-36% for modern *boro* (winter) rice cultivars (Mamun, 1990). Yield losses due to weed infestation are greater than the combined losses of insect pests and diseases. To reduce the cost of rice production, it has been urgently needed to adopt alternative method of weed control viz. mechanical weed control, chemical weed control and manual weeding. Mechanical weeding and herbicides are the alternatives to hand weeding. Herbicides are effective in controlling weeds alone or in combination with hand weeding (Ahmed *et al*., 2005). Poor weed control is one of the major factors for yield reduction of rice depending on type of weed flora and their intensity (Amarjit *et al.* 1994). In Bangladesh, weeds are traditionally controlled by hand weeding. This method of weed control is very much laborious, time consuming and costly. On the other hand, herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low cost involvement in comparison to the traditional methods of hand weeding (Mian and Mamun, 1969). Moreover, in Bangladesh during *aman* season, uprooting of weeds at the critical periods is difficult due to unfavorable weather and peak labour demand. In such situation, herbicides are promising alternatives in controlling weeds (Pillai and Rao, 1974; De Datta, 1980). Now-a-days, the chemical methods of weed control are gaining popularity all over the world because of its miraculous results in crop production but most of the herbicides are very new in Bangladesh. A little information is available on the effectiveness in controlling weeds in rice, especially, in transplant *aman* rice in Bangladesh. The present study, therefore, undertaken to assess the weed control efficacy of different weed control techniques and to compare the crop productivity in transplant *aman* rice.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh-2202 during the period from June to December 2014 with a view to compare the efficacy of method of weeding on the performance of transplant *aman* rice varieties. Four transplanted *aman* rice varieties viz. Kalijira ($V_{1)}$, BRRI dhan34 ($V_{2)}$, BRRI dhan52 ($V_{3)}$ and BRRI dhan64 ($V_{)}$ and five different weeding treatments namely no weeding ($W_{1)}$, two hand weeding at 20 and 40 DAT ($W_{2)}$, mechanical weeding by Japanese rice weeder at 20 and 40 DAT (W_3), soil applied pre-emergence herbicide Topstar 400 SP (Oxadiargyl 400 g/l) @ 190 ml ha^{-1} once at 3 days before transplanting ($W_{4)}$ and foliar applied post-

emergence herbicide Manage @ 250g ha^{-1} at 6 days after transplanting (W_5)were evaluated. The experiment was laid out in split plot design assigning weed control method in the main plot and variety in the sub plot with three replications. Twenty five days old seedlings were uprooted carefully from the nursery bed and transplanted on 18 July 2014 at the rate of three seedlings per hill, maintained row and hill distance of 25 cm and 15 cm, respectively. The experimental plots were fertilized with nitrogen, phosphorus, potassium, sulphur and zinc @ 220, 100, 60, 60 and 10 kg ha^{-1} in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate respectively. Except urea, the whole amounts of other fertilizer were applied before final land preparation. Urea was top dressed in two installments at 20 and 40 DAT. Weeding was done as per the experimental treatments. Due to frequent rains during crop growth period, no irrigation was needed and excess water was drained out at the time of heavy rain. Observations were regularly made and the field looked nice with normal green plants. The crops were at full maturity harvested on 30 October 2014 (BRRI dhan64), 12 November 2014 (BRRI dhan34) and 20 November 2014 (Kalijira and BBRI dhan 52). Then the harvested crops of each plot except 5 hills $plot^{-1}$ was bundled separately, properly tagged and brought to threshing floor. The crops were then threshed and the fresh weights of grain and straw were recorded plot-wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}. The data of weed parameters were collected at 20 and 40 DAT of rice plants. Weed parameters such as weed species and total weed dry weight (g m^{-2}) were collected. Crop characters such as plant height, number of total tillers $hill^{-1}$, number of ear bearing tillers $hill^{-1}$, number of non-ear bearing tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, number of sterile spikelet $panicle^{-1}$, 1000-grain weight, grain yield, straw yield , biological yield and harvest index were recorded. Data were analyzed using the "Analysis of Variance" technique and mean differences were adjudged by Duncans' Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

***Infested weed species in the experimental field*:** Ten weed species belonging to seven families infested the experimental field. Among the ten species of weeds four were grasses, five were broadleaved and one was sedge. Local name, scientific name, family, morphological type and life cycle of the weed in the experimental plot have been presented in Table 1. The important weeds of the experimental plots were *Digitaria sanguinalis*, *Leersia hexandra*, *Paspalum scrobiculatum*, *Echinochloa crusgalli*, *Monochoria vaginalis*, *Ludwigia hyssopifolia*, *Polygonum orientale, Eclipta alba, Marsilea crenata* and *Frimbristylis miliacea*. Rashid (2011) found that the most important weed species in T. *aman* rice at Agronomy Field of Bangladesh Agricultural University, Mymensigh were *Paspalum scrobiculatum, Echinochloa crusgalli, Digitaria sanguinalis, Leersia hexndra and Echinochloa colonum*. Rahman *et al.* (2007) conducted an experiment at the Agronomy Field, Bangladesh Agricultural University, Mymensingh during the period from July to December 2000 for an economic study of different levels of herbicide use and hand weeding method in controlling weeds in transplanted *aman* rice. Important weed species found to infest the crop were *Panicum repens*, *Cynodon dactylon*, *Marsilea crenata* and *Ludwigia prostrata*. Weed infestation in the experimental field of this study were consisted with that of Rashid (2011) and Rahman *et al.* (2007).

Conditions favorable for growing transplant *aman* rice are also favorable for the exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weed tends to increase when the weed population also increases and the intensity of this competition also increases when the nature and the weed growth are comparatively more exuberant and speedier than growth of the desired crop plants.

***Effect of variety on total dry weight of weed*:** Variety showed significant effect on total dry weight of weed at 20 and 40 DAT (Figure 1). At 20 DAT, the highest total dry weight of weed (8.43 g m^{-2}) was found in BRRI dhan52 which was statistically similar with Kalijira (8.41 g m^{-2}) and the lowest one was found in BRRI dhan34 (7.15 g m^{-2}). At 40 DAT, the highest total dry weight of weed (15.10 g m^{-2}) was found in Kalijira which was statistically similar (14.74) with BRRI dhan52 and the lowest one was found in BRRI dhan 34 (12.74 g m^{-2}).

***Effect of weeding methods on total dry weight of weed*:** Dry weight of weed was significantly influenced by different weed control practices as recorded at 20 DAT and 40 DAT (Figure 2).

Table 1. Infesting weed species found growing in the experimental plots of transplant *aman* rice

Sl. No.	Local Name	Scientific name	Family	Morphological Type	Life cycle
1.	Anguli ghash	*Digitaria sanguinalis* L.	Gramineae	Grass	Annual
2.	Arail	*Leersia hexandra* Swartz.	Gramineae	Grass	Annual
3.	Angta	*Paspalum scrobiculatum* L	Gramineae	Grass	Annual
4.	Bara-Shama	*Echinochloa crusgalli* L.	Gramineae	Grass	Annual
5.	Panikaghu	*Monochoria vaginalis* (Burn. F.) C. Presl.	Pontederiaceae	Broadleaved	Perennial
6.	Panilong	*Ludwigia hyssopifolia* (G. Don) Exell.	Onagrraceae	Broadleaved	Annual
7.	Panimorich	*Polygonum orientale*	Polygonaceae	Broadleaved	Annual
8.	Kesuti	*Eclipta alba*	Compositae	Broadleaved	Perennial
9.	Shusni shak	*Marsilea crenata*	Marsileaceae	Broadleaved	Perennial
10	Joina	*Fimbristylis miliacea* L.	Cyperaceae	Sedge	Annual

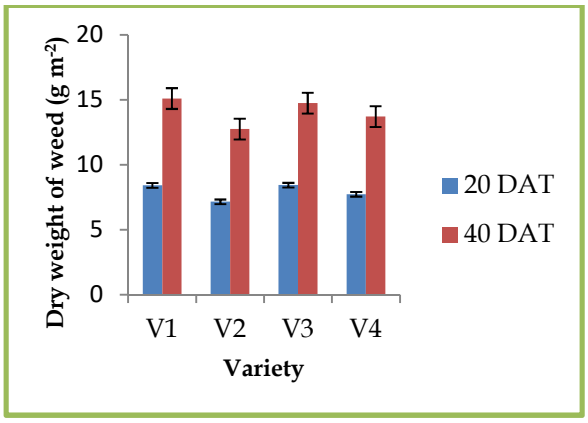

Figure 1. Effect of variety on dry weight of weed at 20 and 40 DAT in transplant *aman* rice (Bar represents standard error of means)

Here,V_1 = Kalijira,V_2 = BRRI dhan34,V_3 = BRRI dhan52,V_4 = BRRI dhan64

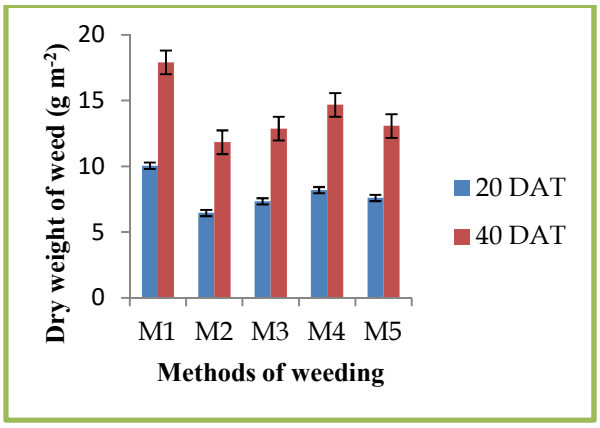

Figure 2. Effect of methods of weeding on dry weight of weed at 20 and 40 DAT in transplant *aman* rice (Bar represents standard error of means)

Here,M_1 = No weeding, M_2 = Two hand weeding at 20 and 40 DAT, M_3 = Mechanical weeding by Japanese rice weeder at 20 and 40 DAT, M_4 = Soil applied pre-emergence herbicide (Topstar® 400 SP) at 3 DAT, M_5 = Foliar applied post-emergence herbicide (Manage @ 250g ha^{-1}) at 6 DAT

At 20 DAT, the highest dry weight of weed (10.05g m^{-2}) was observed in the no weeding practice and the lowest dry weight of weed (6.46 g m^{-2}) was observed at two hand weeding practice at 20 and 40 DAT. At 40 DAT, the highest dry weight of weed (17.90 g m^{-2}) was observed in the no weeding practice and the lowest dry weight of weed (11.84 g m^{-2}) was observed at two hand weeding at 20 and 40 DAT which was statistically similar with post-emergence herbicide Manage @ 250g ha^{-1} (13.07 g m^{-2}) at 20 and 40 DAT). Singh and Kumar (1999) also reported that the maximum dry weight of weed was recorded in the unweeded control which was significantly higher compared to other weed control practices. Rekha *et al.* (2002) reported that weed density was lower in all weeding practices compared to the unweeded control plot.

***Effect of interaction between variety and method of weeding on total dry weight of weed*:** Significant variation was found on dry weight of weed due to interaction between variety and weeding methods at 20 and 40 DAT (Table 2). At 20 DAT, the highest dry weight of weed (14.62 g m^{-2}) was found in V_1M_1 (Kalijira× No weeding) treatment and the lowest (4.33 g m^{-2}) was found in V_1M_2 (Kalijira× Two hand weeding at 20 DAT). At 40 DAT, the highest dry weight of weed (27.62 g m^{-2}) was found in V_1M_1 (Kalijira × No weeding) and the lowest (6.55 g m^{-2}) was found in V_1M_2 (Kalijira× Two hand weeding at 20 and 40 DAT) which was statistically similar with V_3M_5 (BRRI dhan 52 × post-emergence herbicide Manage @ 250 g ha^{-1} at 40 DAT).

***Effect of variety on crop characters*:** Plant height, number of total tillers $hill^{-1}$, number of ear bearing tillers $hill^{-1}$, number grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were significantly influenced by variety (Table 3). The highest number of tillers $hill^{-1}$ (11.18) was observed in BRRI dhan34 and the lowest number of tillers $hill^{-1}$ (8.07) was observed in Kalijira. Tiller number is a varietal character and it is the genetic constituent of the variety, therefore, plant height was different between the four varieties. The highest number of ear bearing tillers $hill^{-1}$ (10.12) was found in BRRI dhan34 and the lowest number of ear bearing tillers $hill^{-1}$ (6.86) was obtained in Kalijira.

Table 2. Combined effect of variety and methods of weeding on dry weight of weed at 20 and 40 DAT

Treatment combination	Dry weight of weed (gm m^{-2})	
	20 DAT	40 DAT
M_1V_1	14.62^{a}	27.62^{a}
M_1V_2	5.36^{j}	9.94^{ij}
M_1V_3	13.51^{b}	22.35^{b}
M_1V_4	6.71^{fgh}	11.68^{fghi}
M_2V_1	4.33^{k}	6.55^{k}
M_2V_2	8.33^{d}	14.49^{def}
M_2V_3	6.21^{hi}	13.48^{defg}
M_2V_4	6.98^{ef}	12.85^{defghi}
M_3V_1	5.90^{ij}	10.33^{hij}
M_3V_2	8.25^{d}	14.84^{de}
M_3V_3	8.33^{d}	14.19^{defg}
M_3V_4	6.89^{efg}	12.10^{efghi}
M_4V_1	6.11^{hi}	11.90^{efghi}
M_4V_2	7.50^{e}	13.19^{defgh}
M_4V_3	8.39^{d}	15.17^{d}
M_4V_4	10.74^{c}	18.44^{c}
M_5V_1	11.08^{c}	19.09^{c}
M_5V_2	6.29^{ghi}	11.24^{ghij}
M_5V_3	5.70^{ij}	8.52^{jk}
M_5V_4	7.33^{ef}	13.42^{defg}
Sx	0.21	0.90
Level of significance	**	**
CV (%)	4.53	11.02

Here, M_1 = No weeding,M_2 = Physical method by hand, two times at 20 and 40 DAT, M_3 = Mechanical method by Japanese rice weeder, two times at 20 and 40 DAT, M_4 = Chemical method through soil applied herbicide once at 3 days before transplanting, M_5 = Chemical method through foliar applied herbicide once at 6 days after transplanting, V_1 = Kalijira, V_2 = BRRI dhan34, V_3 = BRRI dhan52, V_4 = BRRI dhan64, ** =Significant at 1% level of probability, NS = Not significant, CV= Coefficient of variation, DAT= Days after transplanting

The probable reason of difference among the varieties in producing the number of effective tillers $hill^{-1}$ is the

genetic make up of the varieties. The present result is in agreement with that of Chowdhury *et al.* (1993), who stated that ear bearing tillers hill^{-1} varied with varieties. In case of number of grains panicle^{-1} the highest number of filled grains panicle^{-1} (123.20) was observed in BRRI dhan34 and the lowest one (83.80) was found in Kalijira. Variable number of grains panicle^{-1} among the varieties was observed by Kamal *et al*. (1988). Varietal variations regarding the number of grains panicle^{-1} might be due to their variation in genetic constituents. The highest grain yield (4.33 t ha^{-1}) was produced by BRRI dhan34 while the lowest yield (2.04 t ha^{-1}) was obtained from Kalijira. The highest grain yield from BRRI dhan34 was mainly due to the higher number of grains panicle^{-1} (122.2) and other yield attributes. Differences in number of grain yield due to varieties were also reported by Yoshida (1994) and Siddeque *et al*. (2002). Varietal variations regarding grain yield might be due to their variation in genetic constituents.

Table 3. Effect of variety on yield and yield contributing characters of transplant *aman* rice

Variety	Plant height (cm)	Total number of tillers hill^{-1}	No. of ear bearing tillers hill^{-1}	No. of grains panicle^{-1}	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
V_1	134.5^a	8.07^d	6.86^d	83.80^d	2.04^d	5.01^d
V_2	121.7^b	11.18^a	10.12^a	123.2^a	4.33^a	6.47^a
V_3	114.6^c	9.79^c	8.66^c	92.80^c	4.05^b	6.26^b
V_4	92.64^d	10.35^b	9.26^b	115.2^b	3.80^c	6.12^c
Sx	0.974	0.084	0.088	0.891	0.03	0.01
Level of significance	**	**	**	**	**	**
CV (%)	3.26	3.32	3.93	3.33	3.38	0.84

Here, V_1 = Kalijira, V_2 = BRRI dhan34, V_3 = BRRI dhan52, V_4 = BRRI dhan64, ** =Significant at 1% level of probability, CV= Coefficient of variation

***Effect of weeding methods on crop characters*:** Weeding method had significant effect on yield and yield contributing characters (Table 4). The highest number of tillers hill^{-1} (10.86) was observed in two times hand weeding at 20 and 40 DAT treatment and the lowest one (8.88) was found in no weeding treatment. In no weeding treatment weed crop competition was higher and weed suppressed the rice plant growth ultimately tiller number was reduced. De Datta (1990) observed that effective weed management increased number of effective tillers hill^{-1} due to more availability of water, nutrients and light. Similar results were supported by Singh *et al.* (1999). The highest number of ear bearing tillers hill^{-1} (9.85) was produced by two hand weeding at 20 and 40 DAT treatment and the lowest number of ear bearing tillers hill^{-1} (7.60) was produced by no weeding treatment. The highest number of grains panicle^{-1} (108.3) was produced by two hand weeding at 20 and DAT, while the lowest number of grains panicle^{-1} (98.75) was produced by no weeding treatment. It indicated that weed free condition encouraged the number of filled grains panicle^{-1} and negative effect of weeds on plant growth resulted in decreased number of filled grains panicle^{-1}. De Datta (1990) observed that effective weed management increased number of filled grains panicle due to more availability of water, nutrients and light. Similar results were supported by Singh *et al.* (1999).

The highest grain yield (3.90 t ha^{-1}) was produced by two hand weeding at 20 and 40 DAT, while the lowest grain yield (3.06 t ha^{-1}) was produced by no weeding treatment. Mechanical weeding by Japanese rice weeder at 20 and 40 DAT and pre-emergence herbicide Topstar 400 SP (Oxadiargyl 400 g/l) @ 190 ml ha^{-1} was applied at 3 days before transplanting were statistically identical and the second highest yield (3.74) was obtained from post-emergence herbicide Manage @ 250g ha^{-1} at 6 DAT.

Table 4. Effect of methods of weeding on yield and yield contributing characters of transplant *aman* rice

Methods of weeding	Plant height (cm)	Total number of tillers hill^{-1}	No. of ear bearing tillers hill^{-1}	No. of grains panicle^{-1}	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
M_1	118.4^{a}	8.88^{e}	7.60^{e}	98.75^{d}	3.06^{d}	5.74^{e}
M_2	116.6^{a}	10.86^{a}	9.85^{a}	108.3^{a}	3.90^{a}	6.16^{a}
M_3	114.8^{ab}	9.39^{d}	8.22^{d}	102.1^{c}	3.47^{c}	5.90^{d}
M_4	111.5^{b}	9.85^{c}	8.73^{c}	103.8^{bc}	3.59^{c}	5.97^{c}
M_5	118.0^{a}	10.23^{b}	9.18^{b}	105.8^{ab}	3.74^{b}	6.05^{b}
Sx	1.11	0.09	0.099	0.917	0.04	0.02
Level of significance	**	**	**	**	**	**
CV (%)	3.26	3.32	3.93	3.33	3.38	0.84

Here, M_1 = No weeding, M_2 = Two hand weeding at 20 and 40 DAT, M_3 = Mechanical weeding by Japanese rice weeder at 20 and 40 DAT, M_4 = Soil applied pre-emergence herbicide (Topstar® 400 SP) at 3 DAT, M_5 = Foliar applied post-emergence herbicide (Manage @ 250g ha^{-1}) at 6 DAT, ** =Significant at 1% level of probability, CV= Coefficient of variation

***Interaction effects of variety and weeding methods on crop characters at harvest*:** Yield and yield contributing characters were significantly affected by the interaction between variety and weeding method (Table 5). The highest number of total tillers hill^{-1} (12.20) was produced by BRRI dhan34 in two hand weeding at 20 and 40 DAT treatment which was statistically similar with BRRI dhn34 in post-emergence herbicide Manage @ 250 g ha^{-1} at 6 DAT treatment, while the lowest number of total tillers hill^{-1} (6.80) was produced by Kalijira in no weeding treatment. Weed suppressed the rice plant growth ultimately tiller number was reduced. The highest number of ear bearing tillers hill^{-1} (11.26) was produced by BRRI dhan34 in two hand weeding at 20 and 40 DAT treatment and the lowest number of ear bearing tillers hill^{-1} (5.47) was produced by Kalijira variety in no weeding treatment. Results of the study proved that no weeding treatment did not encourage the rice plant to produce more number of effective tillers hill^{-1}. Similar research findings were also reported by Chowdhury *et al.* (1993) and Islam (2003). The highest grain yield (4.83 t ha^{-1}) was found in BRRI dhan34 by two hand weeding at 20 and 40 DAT, while the lowest grain yield (1.74 t ha^{-1}) was produced by Kalijira in no weeding treatment. The lowest grain yield in the no weeding practices might be due to the poor performances of yield contributing characters like number of tillers hill^{-1} and grains panicle^{-1}. Because severe weed infestation occurred in the plots due to competition for moisture, nutrients between weed and rice plants. Similar results were also observed by Gogoi *et al*. (2000) and Islam *et al.* (2001). The weeds compete with the crop for nutrient, water, air, sunlight and space. The increased yield was contributed in hand weeding treatment by highest number of effective tiller

hill^{-1}, highest number of grains panicle^{-1} over no weeding treatment. These might be due to the fact that the weeding kept the rice field weed free and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth

Table 5. Combined effect of variety and methods of weeding on yield and yield contributing characters of transplant *aman* rice

Treatment combination	Plant height (cm)	Total number of tillers hill^{-1}	No. of ear bearing tillers hill^{-1}	No. of non-ear bearing tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelet panicle^{-1}	1000 grain weight (gm)	Grain Yield (tha^{-1})	Straw Yield (tha^{-1})	Biological Yield (tha^{-1})	Harvest Index (%)
M_1V_1	136.70	6.80l	5.47m	1.33	23.80	82.00	22.00b	11.86	1.74m	4.74n	6.49	26.87
M_1V_2	124.50	10.10f	8.94fg	1.19	23.49	119.7	21.33bc	13.07	3.76g	6.25ef	10.01	37.53
M_1V_3	118.90	8.80i	7.56jk	1.24	24.32	88.33	23.67a	23.81	3.53h	6.08h	9.61	36.76
M_1V_4	93.33	9.80fg	8.57gh	1.23	22.05	105.0	19.00efg	21.41	3.27i	5.87j	9.14	35.74
M_2V_1	137.80	9.00hi	7.91ij	1.08	24.53	87.67	20.33cde	11.78	2.28j	5.21k	7.49	30.44
M_2V_2	122.00	12.20a	11.26a	0.94	23.34	125.3	21.00bcd	12.66	4.83a	6.66a	11.49	42.05
M_2V_3	113.80	10.80de	9.75de	1.05	24.25	99.67	24.33a	23.67	4.45bc	6.44b	10.89	40.89
M_2V_4	92.95	11.40bc	10.5bc	0.97	21.98	120.3	18.00g	20.82	4.04ef	6.34cd	10.39	38.93
M_3V_1	133.80	7.87k	6.60l	1.27	24.46	82.00	21.67b	11.45	1.96l	4.94m	6.90	28.42
M_3V_2	120.10	10.27ef	9.14fg	1.12	24.65	121.3	19.00fg	13.34	4.15def	6.42bc	10.57	39.24
M_3V_3	113.50	9.40gh	8.23hi	1.17	24.33	90.00	24.33a	23.74	3.99ef	6.24efg	10.23	39.02
M_3V_4	91.95	10.00f	8.86fg	1.14	22.05	115.0	18.00g	21.13	3.77g	5.98i	9.75	38.65
M_4V_1	125.50	8.18jk	6.96kl	1.22	24.65	83.00	19.00fg	11.51	2.01kl	5.07l	7.08	28.44
M_4V_2	118.90	11.27cd	10.2cd	1.07	25.36	124.3	21.33bc	13.13	4.34cd	6.42bc	10.76	40.33
M_4V_3	109.50	9.87fg	8.76fgh	1.10	23.41	91.67	23.67a	23.00	4.07ef	6.24efg	10.31	39.48
M_4V_4	92.18	10.07f	8.98fg	1.09	22.28	116.3	18.67fg	20.47	3.93fg	6.17g	10.10	38.94
M_5V_1	138.70	8.47ij	7.31k	1.16	23.19	84.33	20.00def	11.47	2.18jk	5.10l	7.27	29.92
M_5V_2	123.00	12.00ab	11.05ab	0.95	23.85	125.3	19.00fg	13.07	4.58b	6.60a	11.18	40.98
M_5V_3	117.50	10.07f	9.00fg	1.07	23.53	94.33	24.00a	23.81	4.21de	6.31de	10.52	40.03
M_5V_4	92.77	10.40ef	9.39ef	1.01	22.27	119.3	19.00efg	20.74	4.00ef	6.21fg	10.21	39.18
Sx	2.17	0.189	0.197	0.036	0.569	1.99	0.415	0.574	0.07	0.03	0.211	0.54
Level of significance	NS	*	*	NS	NS	NS	**	NS	*	*	NS	NS
CV (%)	3.26	3.32	3.93	5.53	4.18	3.33	3.44	5.75	3.38	0.84	3.84	2.55

Here, M_1 = No weeding; M_2 = Two hand weeding at 20 and 40 DAT; M_3 = Mechanical weeding by Japanese rice weeder at 20 and 40 DAT; M_4 = Soil applied pre-emergence herbicide (Topstar® 400 SP) at 3 DAT, M_5 = Foliar applied post-emergence herbicide (Manage @ 250g ha^{-1}) at 6 DAT, V_1 = Kalijira, V_2 = BRRI dhan34, V_3 = BRRI dhan52, V_4 = BRRI dhan64, * =Significant at 5% level of probability, NS = Not significant, CV= Coefficient of variation

Conclusion

From this study, it can be concluded that all weeding treatments showed their superiority over no weeding in the production of grain and straw yield. Among the weeding treatments, hand weeding at 20 and 40 DAT showed the best performance of all the crop characters including yield. So, for the control of weeds in effective manner and in order to get highest grain yield in transplanted *aman* rice, hand weeding at 20 and 40 DAT might be followed. In case of labor scarcity, post-emergence herbicide Manage @ 250 g ha^{-1} at 6 DAT might also be followed to get highest grain yield in transplant *aman* rice.

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