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Performance of *Boro* rice cv. BRRI dhan28 as influenced by different plant establishment methods and weeding regimes

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ABSTRACT

At present time food safety is a precedence issues in Bangladesh and it is essential to increase the production level of rice to address this mission. The study was undertaken to evaluate the yield performance of *boro* rice cv. BRRI dhan28 under different plant establishment methods and weeding regimes. The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during December 2017 to June 2018. It was a two factor experiment that comprehended three plant establishment methods viz. sprouted seeds in line, sprouted seeds in broadcasting and transplanting of seedlings in line; five weeding regimes viz. no weeding, one hand weeding at 20 day after planting (DAP), two hand weeding at 20 and 40 DAP, three hand weeding at 20, 40 and 60 DAP, and application of herbicide (Sathi 10WP @ 185 g ha^{-1}). The experiment was set up following randomized complete block design with three replications. Yield contributing characters and yield of Boro rice were exerted significantly by plant establishment methods and the highest results were recorded in transplanting of seedlings in line method in which the number of total tiller $hill^{-1}$ (6.39), number of effective tiller $hill^{-1}$ (5.93), grains $panicle^{-1}$ (99.28), 1000 grain weight (24.16 g) and grain yield (4.19 t ha^{-1}). And the lowest results were found in sprouted seeds in broadcasting method. Considering weeding regimes, the highest number of total tillers $hill^{-1}$ (6.03), effective tillers $hill^{-1}$ (5.28), grains $panicle^{-1}$ (101.4), grain yield (4.12 t ha^{-1}) and straw yield (5.74 t ha^{-1}) were recorded with application of herbicide method. Contrariwise, no weeding showed the lowest values. In interaction effect, maximum grain yield (4.48 t ha^{-1}) was obtained in transplanting of seedlings in line method with application of herbicide and Sprouted seeds in broadcasting method with no weeding was performed the lowest grain yield (2.86 t ha^{-1}). From the overall results, the growers can be recommended to cultivate *boro* rice cv. BRRI dhan28 in transplanting of seedlings in line method with application of herbicide at different Agro-ecological zones of Bangladesh.

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Introduction

Rice (*Oryza sativa* L.*)* is the most important semi-aquatic annual grass plants under Gramineae family. About 135 million people of Bangladesh consume rice as their staple food. Bangladesh as an agro-based developing country is striving hard for its rapid development of economy. The economic development of this country is based on agriculture. The contribution of this sector in GDP is 14.32% (BBS, 2017). This sector plays significant impact on poverty alleviation, human resource development and food security. In Bangladesh, rice is main food crop and about 84.67% of cropped area is used for rice production with annual production of 34.42 million tons (BBS, 2017). However, the area and production of *Boro* rice in the country were 4.14 million hectares and 15.89 million tons 2016-2017 (BBS, 2017). For the last few years, the production in agricultural sector was startling and the most momentous role was played by rice. So, it is necessary to accept further steps to increase the production level of rice.

Direct seeded rice is the only viable option to reduce the unproductive water flows. It refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. It has been recognized as the principal method of rice establishment since 1950's in developing countries (Pandey and Velasco, 2005). Transplanting of rice seedling is the most common and elaborative plant establishment technique in irrigated situation across Bangladesh. It requires less seed and enables the crop to be planted right time in the field as nurseries raised in

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advanced. The seedlings are shown at the time of transplanting are able to compete with weeds that propagated. That's why weed infestation is generally much lower in transplanted rice compare to direct-seeded rice which increase crop yield. Mechanical power or manual labor is used to transplant rice seedling in the main field. It is troublesome and cost intensive practice because considerable amount of labor that is required to transplant (Islam *et al.,* 2016). However, compare to direct-seeded rice the growth duration of transplanted rice is somewhat longer because of the stress procured by transplantation. In *Boro* season, a large amount of seedlings are damaged due to dense fog and cold weather and the availability of seedlings become shortage. Wet seeding also helps to harvest earlier by 8-10 days than transplanted rice. It can eliminate the operations such as nursery bed preparation, care of seedling, pulling, transporting and transplanting to the main filed (Chandrapala, 2009; Sreelatha, 2011). However, in direct-seeded rice crop weed infestation becomes higher which reduce yield. So, to get maximum yield by avoiding weed infestation appropriate plant establishment method should be selected.

In rice cultivation weed creates serious yield reduction problems. Weed infestation is an innate phenomenon in rice field. Improperly controlled weeds compete for soil nutrition with more rapidly in growth and cause reduction of yield and grain quality. A large number of troublesome weed species are grown in rice field as the climatic condition of Bangladesh is favorable for weeds. Weed acts as a barrier for rice plants that compete for nutrients, space, water, air and light (Miah *et al.,* 1990). Mamun (1990) reported that weed growth reduced the grain yield by 68-100% for direct seeded aus rice, 22.36% for modern boro rice and 16-48% for transplanted aman rice. In rice production weeds are major biotic constraints (Yeasmin and Ye 2008) and weed management is a serious challenge for farmers and researcher as well (Anwer *et al.,* 2011). Weed management requires a large number of labors which increase the production cost. Choosing the suitable weeding regime depends on weed flora, weed dynamics, weed intensity, time of weeding and soil moisture. The cost of production of rice can be reduced by adopting of alternative methods of weed control which includes mechanical, biological and chemical weed control in combination with manual weeding. Herbicides and mechanical weeding are the alternative to hand weeding. However, herbicides are getting popularity at present time because it saves labor and regarded as cost effective. In controlling weeds numerous pre-emergence herbicides are used together with hand weeding (Ahmed *et al.,* 2003). So, the selection of the effective weeding regime plays an important role to get higher yield by reducing the weed infestation.

Choosing a suitable plant establishment method and weed management practice is an imperative for rice production in a sustainable way. Hence, the present study was undertaken to find out the yield performance of *Boro* rice cv. BRRI dhan28 under different plant establishment methods and weeding regimes.

Materials and Methods

The experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period in December 2017 to June 2018. The experiment consisted three plant establishment method *viz* Sprouted seeds in line, Sprouted seeds in broadcast, Transplanting of seedlings in line and five weeding regimes *viz.* no weeding, one hand weeding at 20 DAP, two hand weeding at 20 and 40 DAP, three hand weeding at 20, 40 and 60 DAP, and application of herbicide Pyrazosulfuron Ethyl. The experiment was laid out in randomized complete block design (RCBD) with three replications. Thus total numbers of unit plot was 45. The space between blocks and between unit plots was 1.0 m and 0.75 m. The size of the unit plot was $10m^2$ (4.0 x 2.5 m). Seeds of BRRI dhan28 were collected in the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Seeds were soaked in water for 48 hours and kept for sprouting, then sprouted seeds were sown in 30 plots for direct seeding, 15 plots of them were placed with sprouted seeds in line continuously and 15 plots of them were sprouted seeds in broadcast. Sprouted seeds were sown in 25 cm individual lines contineously and for the broadcast, sprouted seeds were randomly broadcasted on 12 December 2017. On the other hand for transplanting of seedling in line method sprouted seeds were broadcasted on prepared nursery bed in same time/date i.e. on 12 December 2017. Fourty five days old seedlings were then transplanted on 27 January 2018 with 25 cm × 15 cm spacing at two seedlings per $hill^{-1}$. Weeding was done as per experimental treatments. In case of no weeding treatment, weeds were allowed to grow in the plots in sowing to harvesting of the crop. Others intercultural operations were done for ensuring and maintaining the normal growth of the crop. Harvesting was done when 90% of grains turned yellow. The plants in one square meter area in the centre of the plot were harvested at ground level. The direct seeded mature plots were harvested on 25 May, 2018. And the transplanted plots were harvest on 5 June, 2018. The crop was then separately threshed, grain and straws were sun dried thoroughly and weights were recorded. Prior to the harvest, five hills were randomly selected in each unit plot to collect data on yield components. While it was completed to collect the data then the grains and straws in five sampling hill were added to the total grain and

straw yield. All the recorded data were compiled and tabulated with the help of computer package, MSTAT-C. The mean differences of the treatments were analyzed by the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of plant establishment method

Plant establishment methods affected significantly to yield contributing characters and yield of *Boro* rice cv. BRRI dhan28 (Table 1). Tallest plant (85.26 cm) was obtained in transplanting of seedling in line method and shortest plant (76.62 cm) was recorded in sprouted seeds in broadcasting method. Maximum spacing and more availability of nutrients ensure highest growth in transplanted rice crop. Chandrapala (2009) and Mahapatra *et al*. (1985) found the similar results. They reported that maximum spacing and more availability of nutrients ensure highest growth in transplanted rice crop. The optimum spacing ensures the plant lower competition and can absorb more nutrients for growth. The highest number of total tiller hill^{-1} (6.39) was obtained in transplanting of seedlings in line method and the lowest tiller hill^{-1} (4.58) was found in sprouted seeds in broadcasting method. Direct seeded rice faced more stress to get soil moisture than that of transplanted rice (Biswas and Salokhe 2005). The highest number of effective tillers hill^{-1} (5.93) was found in transplanting of seedlings in line method and lowest number of effective tillers hill^{-1} (3.74) was found with sprouted seeds in broadcasting method. It may be the fact that transplanting method provides enough nutrients, lights and air which helped in producing maximum effective tillers hill^{-1}. Mridha *et al.* (1991) reported the similar findings. Panicle length, grains panicle^{-1} and sterile grains panicle^{-1} not affected significantly. Numerically the long panicle (21.62 cm) was obtained in transplanting of seedlings in line method and short panicle (21.20 cm) was obtained in sprouted seeds in broadcasting method. Goel and Verma (2000) found longest panicle length in the transplanted puddle rice than direct seeded rice. Transplanting of seedling in line method showed highest number of grains panicle^{-1} (99.28) and lowest grains panicle^{-1} (96.97) was in sprouted seeds in broadcasting method. Reddy and Ghosh (1987) were reported the same observations who stated that transplanting method produced highest number of grains panicle^{-1}. The highest weight of 1000 grain (24.16 g) was observed in transplanting of seedlings in line method and the lowest weight of 1000-grain (23.23 g) was observed in sprouted seeds in broadcast method. Xiang *et al.* (1999) found higher 1000-grains weight in transplanting seedlings than broadcasting of sprouted seeds. It was found that the highest grain yield (4.19 t ha^{-1}) and straw yield (6.19 t ha^{-1}) were obtained in transplanting of seedling in line method and the lowest grain yield (3.33 t ha^{-1}) and straw yield (4.15 t ha^{-1}) were obtained in sprouted seeds in broadcasting method (Figure 1 & 2). In early stage, direct seeded rice suffered from inadequate moisture that`s why it produce lower grain and straw. Transplanted rice provide higher yield because it gets benefits of puddling condition and the rhizosphere environment provide higher nutrient uptake which resulted greater source of accumulation and translocation of photosynthesis. Roy *et al.* (1990) and Chowdhury *et al.* (1993) reported same observations and stated that yield depends on some contributing characters. Highest harvest index (44.51 %) was produced by sprouted seeds in broadcasting method and lowest harvest index (40.36%) was found in transplanting of seedlings in line method. Sarkar *et al.* (2003) reported highest harvest index in direct seeded crops than the nursery seedlings.

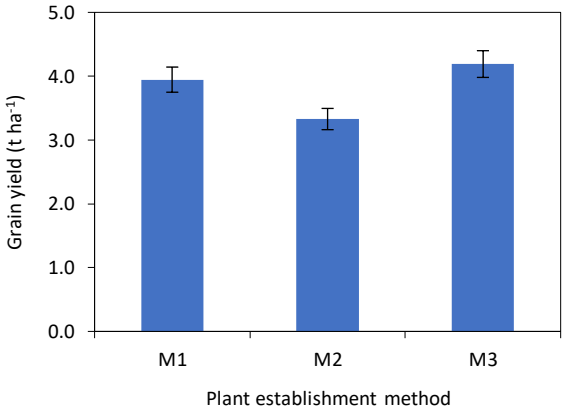


Figure 1. Effect of plant establishment methods on grain yield of *boro* rice cv. BRRI dhan28 (Bar represents standard errors of means). Here, M_1= Sprouted seeds in line, M_2= Sprouted seeds in broadcasting, M_3= Transplanting of seedlings in line

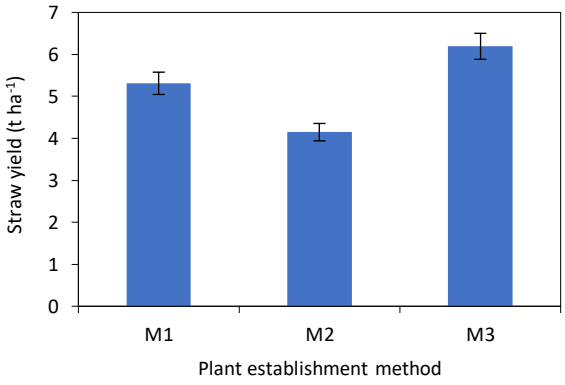


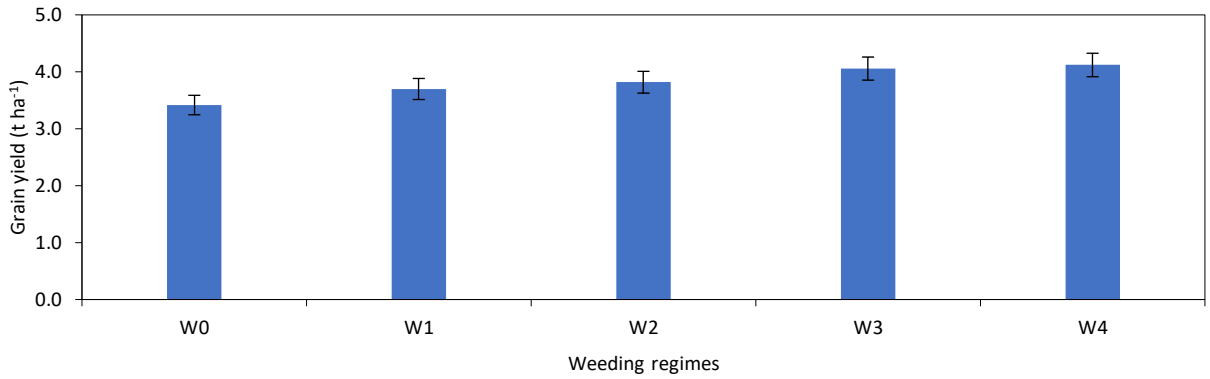
Figure 2. Effect of plant establishment methods on straw yield of *boro* rice cv. BRRI dhan28 (Bar represents standard errors of means). Here, M_1= Sprouted seeds in line, M_2= Sprouted seeds in broadcasting, M_3= Transplanting of seedlings in line

Effect of weeding

Yield components and yield of *Boro* rice cv. BRRI dhan28 were significantly affected by weeding regimes (Table 2). The tall plant (81.77 cm) was obtained in application of herbicide and the short plant height (79.33 cm) was obtained in no weeding. The highest number of total tillers hill^{-1} (6.03) was obtained in application of herbicide which was at par with three hand weeding and no weeding showed the lowest number of total tillers hill^{-1} (4.38). Competition between rice plants and weeds for nutrients and water was lowest in case of application of herbicide compared to no weeding. It may be the fact that favored rice plants to produce more tillers reported by Walia *et al.* (2009). The highest number of effective tillers hill^{-1} (5.28) was obtained in application of herbicide and the lowest number of effective tillers hill^{-1} (3.83) was recorded in no weeding. Lowest competition between rice plants and weeds in case of herbicide application might have resulted in highest number of effective tillers hill^{-1}. Smith (1981) was supported this results. The short panicle (21.14 cm) was obtained in no weeding. Weeds always compete with plants and make difficulties to uptake nutrients. Without proper growth photosynthesis hampered so that tillering process hampered. These results are in conformity with the findings of Sharma *et al.,* (1994). The highest number of grains panicle^{-1} (101.4) was recorded in application of herbicide treated plots which were similar with all weeding regime plots except no weeding plots which produced lowest number of grains panicle^{-1} (90.84). Less competition among rice plants and weeds might have encouraged the distribution of assimilates towards grains resulting in highest number of grains panicle^{-1}. This observation was similar to Mukhupadhyay and Ghosh (1981). The highest weight of 1000-grain (23.69 g) was obtained in application of herbicide and the lowest weight of 1000-grain (23.51g) was obtained in no weeding. The results are in conformity with the findings of Rekha *et al.* (2002) and Shan *et al*. (2012). The highest grain yield (4.12 t ha^{-1}) and straw yield (5.76 t ha^{-1}) were found in application of herbicide method. On the contrary, the lowest grain yield (3.42 t ha^{-1}) and straw yield (4.51 t ha^{-1}) were obtained in no weeding (Figure 3 & 4). Grain yield increases due to the contribution of number of effective tillers, number of spikelet's panicle^{-1} and individual grain weight. And Straw yield decreased with the increase in weed infestation. Bhat *et al*. (2011) reported similar results. The highest harvest index (43.12%) was obtained in no weeding and the lowest harvest index (42.06%) was found in application of herbicide.

Interaction effect between plant establishment method and weeding regimes

The interaction effect of plant establishment method and weeding exposed significant influence on yield components and yield of *Boro* rice cv. BRRI dhan28 (Table 3). Transplanting of seedling in line method with application of herbicide (M3W4) produced the tallest plant (87.20 cm) which was statistically similar with transplanted of seedling in line sowing with all weeding regime and the shortest plant (72.33cm) was obtained in sprouted seeds in broadcasting method with no weeding (M2W0). Lowest crop- weed competition ensures favorable environment for crop growth. These results are in accordance with the findings of Ahmed *et al.* (2012). Total tillers hill^{-1} (7.70) was the highest in transplanting of seedling in line method with application of herbicide (M3W4) among all the treatment combination. Elsewhere the lowest number of total tillers hill^{-1} (3.70) was found in sprouted seeds in broadcasting method with no weeding (M2W0). Similar observation was reported by Subramanian *et al.* (2006). Similar trend was observed in effective tillers hill^{-1}. The highest number of effective tillers hill^{-1} (7.70) was observed in transplanting of seedling in line method with application of herbicide. Besides the lowest number of effective tillers hill^{-1} (3.27) was found in sprouted seeds in broadcasting method with no weeding. Hugar *et al*. (2009) and Sinha and Talati (2006) also opined similarly. The panicle length, grains panicle^{-1} and sterile grains panicle^{-1} dint differed significantly. The panicle length (22.31cm) was higher in transplanting of seedlings in line method with application of herbicide (M3W4) and lower panicle length (20.74 cm) was obtained in sprouted seeds in line method with no weeding (M1W0). Paul (1999) found the long panicle in transplanted of seedlings with weed management practice compared to the clonally propagated tillers. It was observed that numerically the highest number of grains panicle^{-1} (105.5) was found in transplanting of seedlings in line method with application of herbicide (M3W4) and sprouted of seeds in line method with no weeding (M1W0) showed the lowest number of grains panicle^{-1} (94.15). Dwivedi *et al.* (1996) found highest total grains panicle^{-1} in transplanting of seedling in weed controlled condition. Xiang *et al.* (1999) also found the similar result. The highest weight of 1000-grain was observed (24.54 g) in transplanting of seedlings in line method with application of herbicide and the lowest 1000-grain weight (22.66g) was obtained in sprouted of seeds in broadcasting method with no weeding.



Rahman (1992) found highest 1000-grains weight in the combination of transplanted of seedling and controlled weed practice. The highest grain yield (4.48 t ha^{-1}) and straw yield (6.84t ha^{-1}) were observed in transplanting of seedlings in line method with application of herbicide and the lowest grain yield (2.86 t ha^{-1}) was in sprouted seeds in line method with no weeding. Ang *et al.* (2002) reported that the grain yield of the line transplanted of seedling in rice with weeding increased compared to others conventional methods. Chandrapala (2009) also reported similar results. The highest harvest index (47.20 %) was obtained in sprouted of seeds in line with application of herbicide (M1W4) and the lowest harvest index (39.81%) was obtained in transplanting of seedlings in line method with three hand weeding. Sreenivas (1992) also reported similar observations.

Table 1. Effect of plant establishment method on yield contributing characters and yield of b*oro* rice (cv. BRRI dhan28)

Plant establishment method	Plant height (cm)	Number of total tiller $hill^{-1}$	Number of effective tiller $hill^{-1}$	Panicle length (cm)	Number of grains $panicle^{-1}$	1000 grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
M_1	80.08b	5.20b	4.48b	21.20	98.03	23.51b	9.26b	42.65b
M_2	76.62c	4.58c	3.74c	21.58	96.97	23.23c	7.48c	44.51a
M_3	85.26a	6.39a	5.93a	21.62	99.28	24.16a	10.38a	40.36c
Sig. level	**	**	**	NS	NS	**	**	**
CV (%)	3.01	7.41	7.18	2.36	4.97	1.47	3.14	2.55

In a column, figures having dissimilar letter (s) differ significantly as per DMRT; **=Significant at 1% level of probability; NS=Not significant; LSD = Least Significant Difference; DAP = Day after planting; Where, M1= sprouted seeds in line, M2= sprouted seeds in broadcasting, M3= transplanting of seedlings in line

Table 2. Effect of weeding regimes on yield contributing characters and yield of *Boro* rice (cv. BRRI dhan28)

Plant establishment method	Plant height (cm)	Number of total tiller $hill^{-1}$	Number of effective tiller $hill^{-1}$	Panicle length (cm)	Number of grains $panicle^{-1}$	1000 grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
W_0	79.33	4.38c	3.83c	21.14ab	90.84b	23.51	7.93d	43.12a
W_1	79.96	5.27b	4.65b	21.27b	98.85a	23.63	8.68c	42.51b
W_2	80.99	5.45b	4.75b	21.40b	99.64a	23.66	9.00b	42.44b
W_3	81.23	5.85a	5.09a	21.39a	99.76a	23.68	9.72a	41.76c
W_4	81.77	6.03a	5.28a	21.80ab	101.4a	23.69	9.86a	41.78c
Sig. level	NS	**	**	*	**	NS	**	NS
CV (%)	3.01	7.41	7.18	2.36	4.97	1.47	3.14	2.55

In a column, figures having dissimilar letter (s) differ significantly as per DMRT; **=Significant at 1% level of probability; NS=Not significant; LSD = Least Significant Difference; DAP = Day after planting; Where, W0= No weeding, W1= One hand weeding at 20 DAP,W2= Two hand weeding at 20 and 40 DAP, W3= Three hand weeding at 20, 40 and 60 DAP, W4= Application of herbicide (Sathi 10WP @ 185 g ha^{-1})

Table 3. Interaction effect of plant establishment method and weeding regimes on yield contributing characters and yield of *Boro* rice (cv. BRRI dhan28)

Plant establishment method	Plant height (cm)	Number of total tiller hill^{-1}	Number of effective tiller hill^{-1}	Panicle length (cm)	Number of grains panicle^{-1}	1000 grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
M_1W_0	73.0f	4.30fg	3.34g	20.74	94.15	23.40cde	2.86d	4.08hi
M_1W_1	81.00cd	4.43ef	3.50fg	21.04	97.35	23.40cde	2.95d	3.97i
M_1W_2	81.80bcd	4.67def	3.80fg	21.31	97.23	23.44cde	3.32c	4.06hi
M_1W_3	82.00bcd	4.73def	4.08ef	21.24	97.02	23.58bcd	3.54c	4.34gh
M_1W_4	83.27abc	4.80def	4.00ef	21.65	99.11	23.73cde	3.98b	4.46g
M_2W_0	72.33f	3.70g	3.27g	21.44	89.63	22.66f	3.37c	3.90i
M_2W1	74.96ef	4.89cdef	4.43de	21.47	97.67	22.92ef	3.98b	4.93f
M_2W_2	78.08de	5.27cd	4.57de	21.48	99.72	23.32de	4.07b	5.48e
M_2W_3	78.47de	5.60c	4.77d	21.62	101.6	23.60bcd	4.10b	5.81d
M_2W_4	78.60de	6.53b	5.40c	21.86	101.6	23.63bcd	4.19ab	6.26bc
M_3W_0	83.61abc	5.14cde	4.71d	21.02	88.74	23.98abcd	4.02b	5.46e
M_3W_1	84.74abc	6.29b	5.83bc	21.13	97.75	24.00abc	4.05b	5.98cd
M_3W_2	85.07abc	6.33b	5.88bc	21.20	100.5	24.05abc	4.15ab	6.17c
M_3W_3	85.71ab	6.47b	6.20b	21.44	103.9	24.20ab	4.30ab	6.50b
M_3W_4	87.20a	7.70a	7.70a	22.31	105.5	24.54a	4.48a	6.84a
Sig. level	**	**	**	NS	NS	**	**	**
CV (%)	3.01	7.41	7.18	2.36	4.97	1.47	4.49	3.32

In a column, figures having dissimilar letter (s) differ significantly as per DMRT; **=Significant at 1% level of probability; NS=Not significant; LSD = Least Significant Difference; DAP = Day after planting; Where, M1= sprouted seeds in line, M2= sprouted seeds in broadcasting, M3= transplanting of seedlings in line, W0= No weeding, W1= One hand weeding at 20 DAP,W2= Two hand weeding at 20 and 40 DAP, W3= Three hand weeding at 20, 40 and 60 DAP, W4= Application of herbicide (Sathi 10WP @ 185 g ha^{-1})

Conclusions

Results of the experiment concluded that the best performance was showed in transplanting of seedlings in line method with application of herbicide among the others for cultivation of *Boro* rice cv. BRRI dhan28. It was recorded the highest grain yield. Therefore, to get higher yield from BRRI dhn28, transplanting of seedling of seedlings in line method with application of herbicide may be recommended.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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