PLANTING DENSITY AND WEED MANAGEMENT TECHNIQUES AFFECTING WEED FLORA AND YIELD OF FINE RICE CV. BRRI DHAN50

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Key words: Planting density, Weed control efficiency, Herbicide, Fine rice

Abstract

A field trial was carried out to observe the performance of fine rice cv. BRRI dhan50 under different planting density and weed management strategies. Experiment field was infested by18 weed species and *Cyperus michelianus* (36.73%) at 30 DAT, *Cyperus esculentus* (25.13%) and *Alternanthera sessilis* (21.54%) at 60 DAT, *Fimbristylis miliaceae* (19.50%) at 90 DAT were dominant. Application of Sunrice 150WG showed highest weed control efficiency 80.94 and 61.52% at (30 and 60 DAT). Two seedlings/hill (P_1) showed highest weed control efficiency 58.92% at 30 DAT and 4 seedlings/hill (P_2) 39.18% at 60 DAT. Both planting density and weed management techniques significantly influenced the growth, yield and yield contributing parameters of BRRI dhan50. The result showed that 2 seedlings/hill (P_1) planting density performed maximum grain yield (5.70 t/ha), straw yield (7.81 t/ha) and harvest index (42.06%) and among the weed management methods, post-emergence herbicide Sunrice 150WG managed weeds very successfully which showed highest grain yield (5.36 t/ha), straw yield (7.42 t/ha) and harvest index (41.63%). The interaction effect of planting density and weed management methods showed that 2 seedlings/hill paired with Sunrice 150WG showed the highest grain yield (6.81 t/ha), straw yield (8.69 t/ha) and harvest index (43.96%).

Introduction

Fine rice is recognized as a special type of rice which is unique for its best quality and characteristic aroma. According to Singh *et al.* (2000), fine rice contains 15 times more 2-acetyl-1-pyrroline than non-aromatic rice (0.14 and 0.009 ppm, respectively) and some other compounds, which are associated with the aroma development in rice, about 100 other volatile compounds, including 13 hydrocarbons, 14 acids, 13 alcohols, 16 aldehydes, 14 ketones, 8 esters, 5 phenols. Fine rice cultivation is gaining popularity in Bangladesh recently, because of its huge demand both for internal consumption and export (Das and Baqui 2000).

Growth and development of rice primarily depend on temperature, solar radiation, moisture and soil fertility. A dense population of crops may have limitations in the maximum availability of these factors. Optimum plant population ensures plants to grow properly both in their aerial and underground parts through different utilization of solar radiation and nutrients. Significant effect of planting density on the yield and yield components of rice was also found by Baloch *et al.* (2002). Therefore, it is necessary to determine the optimum density of plant population per unit area for obtaining maximum yield as quality is of prime importance in case of fine rice.

Poor weed control is one of the major factors responsible for reduction in yield including type of weed flora and their intensity (Amarjit *et al.* 1994) as weeds 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 (Mamun *et al.* 1993). Therefore, weed control with minimum cost and less adverse

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effect on environment is of great priority. In Bangladesh, the traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Usually two/three hand weedings are normally required for optimum yield from rice crop keeping in view the nature of weeds and their intensity. Hand weeding is very laborious, time consuming and expensive. In addition, during the peak period, the availability of labor is also becoming a serious problem by time. However, 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 (Chowdhury *et al.* 2014).

Materials and Methods

The field experiment was conducted in medium fertile soil at Sher-e-Bangla Agricultural University (90º33´ E longitude and 23º77´ N latitude), Dhaka-1207, Bangladesh during November 30, 2012 to May 05, 2013 in *boro* season. The pH value of the soil was 5.60. BRRI dhan50 was used as plant materials for the present study. It is the only fine rice for boro season released by Bangladesh Rice Research Institute (BRRI) in 2008. The experiment was carried out with four planting densities i.e. 2 seedlings/hill (P_1), 4 seedlings/hill (P_2), 6 seedlings/hill (P_3) and 8 seedlings/hill (P_4) in the main plot and five weed management methods *viz.* no weeding (control) (W_0), two hand weeding at 20 and 35 DAT (W_1), weeding by BARI rice weeder at 20 and 35 DAT (W_2), Topstar 400SC (Oxadiargyl 400 g/l) @ 100 ml/ha as pre-emergence (W_3) and Sunrice 150WG (Ethoxysulfuron 150 g/l) @ 185 ml/ha as post-emergence herbicide (W_4) in the sub plot in a split plot design. Topstar 400SC was applied @ 100 ml/ha at 5 DAT in 4 - 5 cm standing water for 3 - 5 days as pre-emergence herbicide and Sunrice 150WG was applied @ 185 ml/ha at 10 DAT when weeds were at 2 - 3 leaf stage, as post-emergence herbicide. The size of the individual plot was 5.0 m × 2.25 m and total numbers of plots were 60. Seeds of BRRI dhan50 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur. The field was fertilized with nitrogen, phosphate, potash, sulphur and zinc at the rate of 150, 100, 70, 60 and 10 kg/ha, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT (BRRI 2000).

Weed control efficiency was calculated with the following formula developed by Sawant and Jadav (1985):. Weed control efficiency (WCE) $= \dfrac{DWC - DWT}{DWC} \times 100$

where, DWC = Dry weight of weeds in unweeded treatment; DWT = Dry weight of weeds in weed control treatment.

Harvest index is the relationship between grain yield and biological yield (Gardner *et al.* 1985). HI $(\%) = \dfrac{\text{Grain yield}}{\text{Biological yield}} \times 100$

where, biological yield = Grain yield + straw yield.

The recorded data were subjected to analyze statistically and analysis of variance was done following two factor split plot design with the help of computer package MSTAT-C. The mean differences among the treatments were adjusted by DMRT at 5% level of significance (Gomez and Gomez 1984).

Results and Discussion

Weed species belonging to eleven families were found to infest the experimental field where six grasses, six sedges, six aquatic, three broad leafed and one fern species were most dominant. Several weed species were found competitive in the rice field at different dates (Table 1). This may be due to crop-weed competition, weed-weed competition or allelopathic effect (chemical secretion of one plant that inhibit the growth of others) of one plant to others. Although, occurrence of weed in the crop field mainly depends on various environmental factors (climate, rainfall etc.) and abiotic factors (soil types, topography of land etc.). At 30 DAT, sedge weeds *Cyperus michelianus* and *Cyperus esculentus* (36.73% and 17.31%) dominated the experimental field. *Cyperus esculentus* (17.31%), *Alternanthera sessilis* (21.54%) and *Cyperus difformis* (15.79%) were the most competitive at 60 DAT. However, at 90 DAT *Fimbristylis miliaceae* (19.50%), *Cyperus esculentus* (15.32%), *Echinochloa crussgalli* (12.53%) and *Eleusine indica* (12.26%) were dominant. This result supports Chowdhury *et al.* (2014) who observed that grasses and sedges were most dominating weed species during the early stages and broadleaves during later stages.

Table 1. Relative density (%) of different weed species infested the experimental area.

Sl. No.	Common Name	Scientific Name	Days after transplanting (DAT)		
			30	60	90
1	Bermuda grass	*Cynodon dactylon* L.	1.84	0.43	0.70
2	Sessile joyweed	*Alternanthera sessilis* L.	5.25	21.54	3.06
3	Alligator weed	*Alternanthera philoxeroides* Mart.	0.47	0.57	0.84
4	Barnyard Grass	*Echinochloa crussgalli* L.	4.20	6.46	12.53
5	Duck weed	*Sagittaria guyanensis*	2.36	0.79	0.70
6	European waterclover	*Marsilea quadrifolia* L.	4.20	0.43	0.84
7	Nutsedge	*Cyperus michelianus* L.	36.73	1.58	0.70
8	Fringerush	*Fimbristylis miliaceae* L.	1.31	8.61	19.50
9	Nutgrass	*Cyperus rotundus* L.	6.82	0.57	1.11
10	Gooseweed	*Sphenoclea zeylanica* Gaertn.	2.20	2.15	0.70
11	Willow primrose	*Ludwigia octovalvis* Jacq.	3.67	3.59	9.19
12	Rice grass	*Leersia hexandra* Sw.	0.79	0.36	0.84
13	Small flower umbrella	*Cyperus difformis* L.	4.72	15.79	3.06
14	Yellow nutsedge	*Cyperus esculentus* L.	17.31	25.13	15.32
15	Eclipta	*Eclipta alba*	4.72	0.36	0.84
16	Red sprangletop	*Leptochloa panicea* Retz.	0.10	3.59	9.75
17	Indian goosegrass	*Eleusine indica* L.	2.31	4.74	12.26
18	Jungle rice	*Echinochloa colonum* L.	0.31	2.73	6.13

Weed biomass and weed control efficiency varied significantly due to planting density and weed management techniques (Fig. 1A, B). An increasing trend of weed biomass observed with increasing plant density (8 seedlings/hill) in this experiment which was due to the increasing competition between intra plant population which favored the increasing weed biomass, the highest weed biomass was observed at 60 DAT and lowest was from 30 DAT. Highest weed control efficiency was observed from 2 seedlings/hill and efficiency decreased with increasing

planting density. Weed biomass showed a significant relationship with weed management techniques (Fig. 2A). Application of pre- and post emergence herbicides controlled weeds successfully and weed biomass was least in case of herbicide treated plots. On the other hand, highest weed biomass was recorded from no weeding (control) (W_0) due to severe weed infestation. Pre- and post emergence herbicides showed highest weed control efficiency than the other treatments throughout the growing periods (Fig. 2B). This statement is in agreement with Bhuiyan *et al.* (2011) and Al-Mamun *et al.* (2011). Weed biomass (g/m) and weed control efficiency had a significant effect on various combinations of planting density and weed management methods. Herbicidal treatment combined with 2 seedlings/hill was superior over other treatment combinations in case of weed biomass and weed control efficiency.
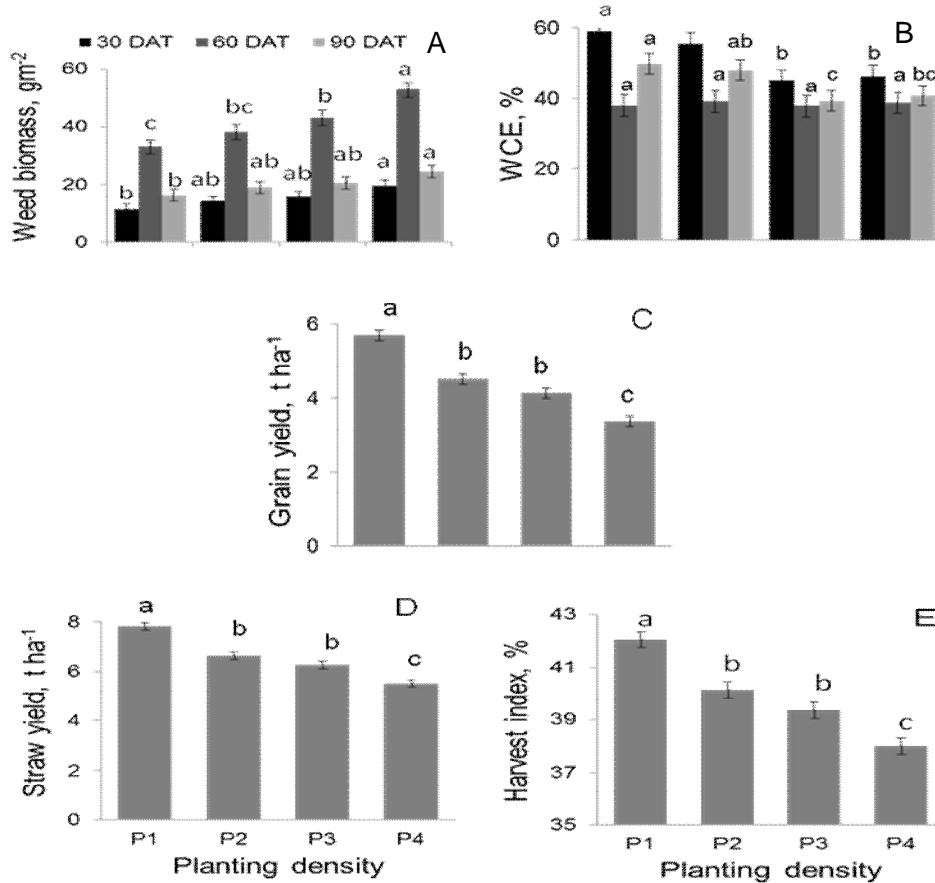

Fig 1. Effect of planting density on weed management and yield performance of BRRI dhan50, mean ± SE (n = 3). Panel A and B show weed biomass and weed control efficiency (WCE), respectively. Panel C, D and E show grain yield, straw yield and harvest index of BRRI dhan50, respectively. P_1, P_2, P_3 and P_4 indicate 2, 4, 6 and 8 seedlings/hill, respectively. Values labelled with different lower case letters are significantly different at $p < 0.05$.

Significant variations were observed in case of yield contributing characters due to different planting density and weed management techniques (Table 2). Longest panicle (22.93 cm), highest effective tillers/hill (15.01), filled grains/panicle (80.26) and 1000-grain weight (18.70) was

recorded from 2 seedlings/hill (P_1) which was attributed due to the lesser competition within the plant populations and higher dry matter partitioning to the sink. On the contrary, increasing planting density showed least yield contributing parameters than others. This result supports the findings of Hasan *et al.* (2010) who observed the same trend with increasing planting density. Present study revealed that application of Sunrice 150WG (W_4) resulted in longest panicle (23.86 cm), highest effective tillers/hill (15.22), filled grains/panicle (83.53) and 1000-grain weight (18.36) which was due to the weed free condition of the field and proper growth and development of the rice plants. The result supports the finding of Chowdhury *et al.* (2014) and Hasanuzzaman *et al.* (2008). It was also prominent that 2 seedlings/hill combined with Sunrice 150WG (P_1W_4) was the best treatment combination in case of all the yield contributing parameters than rest of the others (Table 3).

Table 2. Effect of planting density and weed management techniques on yield contributing attributes of BRRI dhan50.

Treatments	Panicle length (cm)	Effective tillers/hill	Filled grains/panicle	1000-grain weight (g)
Planting density				
P_1	22.93 a	15.01 a	80.26 a	18.70 a
P_2	20.30 b	12.16 b	70.33 b	17.52 b
P_3	18.60 bc	9.655 c	65.12 bc	17.14 b
P_4	17.19 c	8.742 c	60.16 c	16.39 c
SE	0.67	0.61	2.34	0.14
Weed control techniques				
W_0	15.53 d	7.597 d	54.56 d	16.52 d
W_1	19.59 bc	11.47 bc	68.19 bc	17.38 bc
W_2	18.12 c	9.659 c	63.05 c	17.12 c
W_3	21.67 b	13.02 b	75.50 b	17.81 b
W_4	23.86 a	15.22 a	83.53 a	18.36 a
SE	0.7542	0.6812	2.624	0.1517

Mean ± SE (n = 3). P_1, P_2, P_3 and P_4 indicate 2, 4, 6 and 8 seedlings/hill, respectively. W_0, W_1, W_2, W_3 and W_4 indicate W_0 =No weeding (control), W_1 = Hand weeding at 20 and 35 DAT, W_2 = Weeding by BARI rice weeder at 20 and 35 DAT, W_3 = Topstar 400SC, W_4 = Sunrice 150WG. Values labelled with different lower case letters are significantly different at $p < 0.05$.

Result of this study indicated that yield parameters of fine rice showed significant variation due to various planting density (Fig. 1C, D and E). Highest grain yield (5.70 t/ha), straw yield (7.81 t/ha) and harvest index (42.06%) was recorded from 2 seedlings/hill (P_1). Increasing planting density decreased yield parameters of fine rice, a major trend observed in this study. Optimum planting density which ensured the maximum plant stand and higher dry matter partitioning which attributed the increasing grain and straw yield compared to other increased planting density treatments. Hasanuzzaman *et al.* (2009) reported that grain yield decreased with transplanting more than 2 seedlings/hill. Ghosh *et al.* (1998) also observed that increasing seedling number/hill at a constant level did not influence on grain yield production, but after that grain yield decreased.

Weeds compete with crop plants for the limited resources available in the crop field. Completely weed free condition allows plants to utilize those resources solely and results in better yield in respect of grain and straw compared to weedy check (control). Results revealed that various weed management techniques controlled weeds differently and showed a highly significant variation among the treatments. Results revealed that application of Sunrice 150WG (W_4) controlled weeds completely and produced maximum grain yield (5.36 t/ha), straw yield

(7.42 t/ha) and harvest index (41.63%) over manual weeding (Fig. 2C, D and E). This may be due to the initial weed control by post and pre-emergence herbicide which promoted plant stand significantly as weed population failed to establish properly later (Chowdhury *et al.* 2014). Other treatments failed to control weeds successfully and severe weed infestation interfered the physiological processes of rice plants while grain and straw yield decreased drastically. This result supports the observations of Khan and Tarique (2011) and Salam *et al.* (2010).
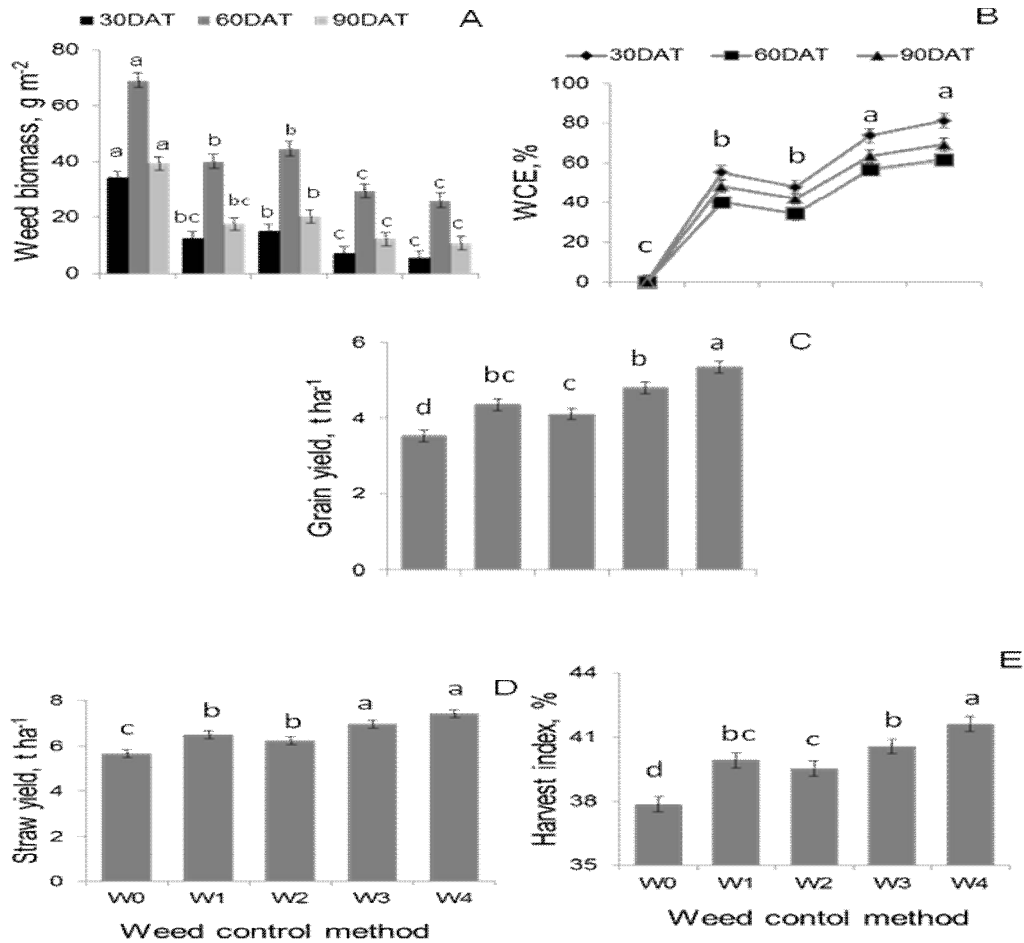

Fig. 2. Effect of weed control methods on weed management and yield performance of BRRI dhan50, mean ± SE (n = 3). Panel A and B show weed biomass and weed control efficiency (WCE), respectively. Panel C, D and E show grain yield, straw yield and harvest index of BRRI dhan50, respectively. W_0, W_1, W_2, W_3 and W_4 indicate W_0 = No weeding (control), W_1 = Hand weeding at 20 and 35 DAT, W_2 = Weeding by BARI rice weeder at 20 and 35 DAT, W_3 = Topstar 400SC, W_4 = Sunrice 150WG. Values labelled with different lower case letters are significantly different at $p < 0.05$.

The interaction effect of planting density and weed management techniques varied significantly for yield attributes of fine rice (Table 3). It was observed that herbicidal treatments combined with lower planting density (P_1W_4) performed better than rest of the other treatment

Table 3. Interaction effect of planting density and weed management techniques on yield contributing attributes of BRRI dhan50.

Treatment combination	Weed biomass (g/m²)			Weed control efficiency (%)			Panicle length (cm)	Effective tillers/hill	Filled grains/ panicle	1000-grain weight (g)	Yield and harvest index		
	30	60	90	30	60	90					Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
P₁W₀	32.30 a	55.11 b-e	37.30 a	0.00 g	0.00 f	0.00 h	19.43 b-f	9.347 f-h	68.00 b-e	17.65 c-f	4.65 c-f	6.88 c-f	40.33 b-f
P₁W₁	10.89 bc	32.22 f-i	15.89 bc	54.52 c-e	38.50 c-e	47.25 d-g	23.08 a-c	15.00 b-d	80.77 a-c	18.77 b	5.77 b	7.89 a-c	42.20 ab
P₁W₂	7.33 c	31.65 f-i	12.33 c	64.64 b-d	38.90 c-e	55.76 a-f	21.65 a-e	13.03 c-f	75.77 a-d	18.35 bc	5.350 bc	7.43 b-d	41.80 a-c
P₁W₃	3.33 c	23.33 hi	8.33 c	83.35 ab	54.92 a-d	70.21 a-c	24.04 ab	17.85 ab	84.13 ab	18.94 ab	5.937 ab	8.193 ab	42.02 a-c
P₁W₄	2.22 c	22.22 i	7.22 c	92.12 a	57.62 a-c	76.44 a	26.47 a	19.81 a	92.64 a	19.81 a	6.807 a	8.687 a	43.96 a
P₂W₀	33.10 a	63.89 bc	38.10 a	0.00 g	0.00 f	0.00 h	15.77 f-h	7.417 h	56.00 e-g	16.22 hi	3.220 hi	5.340 gh	37.54 g-i
P₂W₁	12.78 bc	35.89 f-i	17.78 bc	57.39 c-e	41.63 b-e	49.93 c-f	19.66 b-f	12.29 d-g	67.33 b-e	17.29 d-g	4.287 d-g	6.407 d-g	39.81 c-g
P₂W₂	13.66 bc	40.66 d-i	18.66 bc	54.29 c-e	34.36 de	47.30 d-g	17.83 d-g	10.02 e-h	61.00 d-g	17.19 e-h	4.190 e-h	6.310 e-g	39.83 c-g
P₂W₃	5.26 c	25.26 hi	10.26 c	81.98 ab	59.30 a-c	70.83 a-c	22.22 a-e	14.23 b-e	76.33 a-d	18.19 b-d	5.190 b-d	7.310 b-e	41.51 b-d
P₂W₄	4.55 c	24.55 hi	9.55 c	84.12 ab	60.63 a-c	72.69 ab	26.00 a	16.85 a-c	91.00 a	18.69 b	5.690 b	7.810 a-c	42.08 a-c
P₃W₀	35.06 a	70.66 ab	40.06 a	0.01 g	0.00 f	0.01 h	12.82 h	6.737 h	44.88 g	16.21 hi	3.207 hi	5.327 gh	36.61 i
P₃W₁	12.67 bc	41.89 d-h	17.67 bc	47.27 d-f	38.11 c-e	41.95 e-g	18.48 c-g	9.887 e-h	64.66 c-f	17.01 f-i	4.007 f-i	6.127 f-h	39.41 d-g
P₃W₂	15.00 bc	47.33 c-g	20.00 bc	41.48 ef	30.72 e	36.97 fg	17.46 e-h	7.737 gh	61.10 d-g	16.65 g-i	3.647 g-i	5.767 gh	38.68 e-i
P₃W₃	9.00 c	29.00 g-i	14.00 c	61.31 b-e	57.84 a-c	53.01 b-f	21.59 a-e	10.66 d-h	75.55 a-d	17.71 c-f	4.707 c-f	6.827 c-f	40.73 b-e
P₃W₄	5.89 c	25.89 hi	10.89 c	76.19 a-c	62.68 ab	64.50 a-d	22.68 a-d	13.25 c-f	79.39 a-c	18.14 b-e	5.140 b-e	7.260 b-e	41.40 b-d
P₄W₀	36.89 a	86.37 a	41.89 a	0.00 g	0.00 f	0.00 h	14.11 gh	6.887 h	49.39 fg	16.02 i	3.020 i	5.140 h	37.00 hi
P₄W₁	13.96 bc	49.42 c-f	18.96 bc	61.44 b-e	41.36 b-e	54.03 b-f	17.14 e-h	8.693 f-h	60.00 d-g	16.44 g-i	3.443 g-i	5.563 gh	38.21 f-i
P₄W₂	24.66 ab	57.88 b-d	29.66 ab	31.21 f	32.78 de	27.63 g	15.52 f-h	7.847 gh	54.33 e-g	16.31 g-i	3.307 g-i	5.427 gh	37.78 g-i
P₄W₃	11.55 bc	38.89 e-i	16.55 bc	67.92 b-d	54.81 a-d	59.74 a-e	18.86 c-g	9.330 f-h	66.00 c-f	16.41 g-i	3.407 g-i	5.527 gh	38.00 g-i
P₄W₄	10.22 bc	30.22 g-i	15.22 bc	71.33 a-c	65.14 a	62.77 a-e	20.31 b-f	10.95 d-h	71.11 b-e	16.79 f-i	3.793 f-i	5.913 f-h	39.05 e-h
SE	4.56	5.7	4.56	6.91	6.69	6.31	1.51	1.36	5.25	0.3	0.3033	0.3246	0.6848
CV (%)	52.59	23.74	39.45	23.22	30.11	24.53	13.22	20.71	13.18	3.01	11.84	8.57	2.97

Mean ± SE (n = 3). P_1, P_2, P_3 and P_4 indicate 2, 4, 6 and 8 seedlings/hill, respectively. W_0, W_1, W_2, W_3 and W_4 indicate W_0 =No weeding (control), W_1 = Hand weeding at 20 and 35 DAT, W_2 = Weeding by BARI rice weeder at 20 and 35 DAT, W_3 = Topstar 400SC, W_4 = Sunrice 150WG. Values labelled with different low case letters are significantly different at $p < 0.05$.

combinations. Minimum planting density coupled with herbicide (2 seedlings/hill with Sunrice 150WG) produced highest grain yield (6.80 t/ha), straw yield (8.69 t/ha) and harvest index (43.96%). These are happened due to minimization of competition between intra and inter plant species provided by herbicide application and lesser planting density.

Acknowledgements

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