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## Crop Management

### ORIGINAL ARTICLE

## Plant spacing and weeding regime interaction in transplant *aus* rice

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#### ABSTRACT

Spacing is one of the determinants of crop growth and development while weed is a limiting factor. Optimum spacing and proper weed management greatly facilitate the growth and yield of rice. A field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to study the interaction of spacing and weeding regime on the performance of transplant *aus* rice cv. BR26 (*Shraboni*). The experiment comprised four spacing viz. 25 cm × 15 cm, 20 cm × 15 cm, 15 cm × 10 cm, 10 cm × 10 cm and five weeding regimes viz. no weeding, one weeding (at 15 DAT), one weeding (at 25 DAT), two weeding (at 15 and 30 DAT) and two weeding (at 20 and 40 DAT). The experiment was laid out in a randomized complete block design with three replications. Plant spacing and weeding regime greatly influenced the performance of *aus* rice. The highest number of effective tillers hill<sup>-1</sup> (9.47) and grains panicle<sup>-1</sup> (98.27) were recorded from 20 cm × 15 cm spacing which in consequence resulted in the highest grain yield (4.20 t ha<sup>-1</sup>). The lowest number of effective tillers hill<sup>-1</sup> (4.31), grains panicle<sup>-1</sup> (87.07), grain yield (2.86 t ha<sup>-1</sup>) were recorded from 10 cm × 10 cm spacing. The highest number of total tillers hill<sup>-1</sup> (13.52), effective tillers hill<sup>-1</sup> (10.95), grains panicle<sup>-1</sup> (103.30) and grain yield (4.48 t ha<sup>-1</sup>) were found from two weeding done at 15 and 30 DATs. The interaction of 20 cm × 15 cm spacing and two weeding at 15 and 30 DATs gave the highest number of total tillers hill<sup>-1</sup> (16.33), effective tillers hill<sup>-1</sup> (13.77), grains panicle<sup>-1</sup> (105.00) and grain yield (5.23 t ha<sup>-1</sup>). The lowest grain yield (2.24 t ha<sup>-1</sup>) was recorded from the interaction of 10 cm × 10 cm spacing with no weeding. *Aus* rice cv. BR26 (*Shraboni*) may be cultivated following 20 cm × 15 cm spacing along with two weeding at 15 and 30 DATs to ensure higher yield.

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#### INTRODUCTION

Rice (*Oryza sativa*) is the staple food for more than half of the earth population (Anwar et al. 2010; Chauhan and Johnson 2011). World's rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth and therefore, meeting ever increasing rice demand in a sustainable way with shrinking natural resources is a great challenge (Juraimi et al. 2013). Rice is the staple food crop in Bangladesh and grown on about 72% of the total cultivated land. Rice is considered to be the most important crop for food security of the country. There are three rice seasons in Bangladesh namely *aus*, *aman* and *boro*. Among the three rice seasons, *aus* rice covers about 12.27% of the rice growing area. The country's

total *aus* rice production is 2.16 million tons which contributes about 8% of total rice production (BBS 2012). The yield of *aus* rice can be increased through the improvement of cultivation practices and proper weed management.

Plant spacing of a crop determines solar radiation interception, leaf area index, canopy coverage and biomass accumulation which have cumulative effect on its yield and weed suppressive ability (Anwar et al. 2011). Rice plants compete among themselves for space, nutrient, water, sunlight, air and other factors. High plant density is considered to be one of the important factors reducing growth and lowering yield of rice.

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Therefore, optimum plant spacing ensures the plant to grow properly both in aerial and underground parts and gives a maximum number of fertile tillers per square meter through efficient utilization of solar radiation and nutrients. However, higher planting density may bring about problems like mutual shading, intra-specific competition and high insect and disease infestation (Sunyob et al. 2012). Therefore, planting density should be optimized considering different aspects of cropping. Planting density of a crop determines solar radiation interception, canopy coverage and biomass accumulation which have cumulative effect on its weed suppressive ability (Anwar et al. 2011). High planting density of a crop develops canopy rapidly and suppresses weeds more effectively, and in contrast, widely spaced plants encourage weed growth (Guillermo et al. 2009). Higher planting density up to 300 plants/m<sup>2</sup> has been suggested for better weed competitiveness for aerobic rice (Anwar et al. 2011). Sunyob et al. (2012) also opined that increasing seeding rate up to 300 seeds m<sup>-2</sup> may be worthwhile to reduce weed pressure without sacrificing rice yield. Anwar et al. (2013) opined that proper plant spacing can be an effective and sustainable tool for weed management in rice.

Weed is considered as a major constraint of lowering rice yield. In tropic, average rice yield losses from weeds is 35% (Oerke and Dehne 2004). Rice yield losses due to weed depends on many factors. On average, rice yield loss due to weed ranges from 15 to 20%, but in severe cases the yield loss may exceed 50% (Hasanuzzaman et al. 2009) or even 100% (Mishra and Singh 2007; Jayadeva et al. 2011). IRRI (1998), on the other hand, reported that weeds can reduce rice yields by 68-100% for direct seeded *aus* rice, 16-48% for *aman* rice and 22% for modern *boro* rice. Because of agro-climatic conditions and

production practices, weed is the major constraint in *aus* rice and thus yield losses is much higher in *aus* rice compared to *aman* and *boro* rice. Therefore proper weed management is necessary to ensure potential yield of *aus* rice.

Interaction of plant spacing weeding regime in rice especially in *aus* season has not been given due consideration and, therefore, a better understanding is necessary before suggesting any plant spacing for higher yield and better weed management in *aus* rice. This research was therefore initiated to reveal the interaction effect of plant spacing and weeding regime on the yield performance of rice cv. BR26 in *aus* season.

## MATERIALS AND METHODS

### Experimental Site and Soil

The experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh in order to study the interaction effect of spacing and weeding regime on the performance of transplant *aus* rice cv. BR26 (*Shraboni*). The experimental field was located at 24.75°N latitude and 90.50°E longitudes at an average altitude of 18m above the mean sea level. The experimental site belongs to the Sonatola series of the dark grey floodplain soil type under Old Brahmaputra Floodplain Agro-Ecological Zone (AEZ-9). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period is presented in Table 1. The field was a medium high land with well drained silty-loam texture having pH value 6.5 and moderate fertility level with 1.67% organic matter content.

**Table 1.** Monthly record of air temperature, rainfall, relative humidity, sunshine hours and soil temperature of the experimental site during the growing season

Months	Average air temperature (°C)			Total rainfall (mm)	Average relative humidity	Total sunshine (hours)	Average soil temperature (°C) at depth		
	Max	Min	Mean				5 cm	10 cm	20 cm
April	30.98	21.92	26.45	499.30	80.23	194.22	28.4	28.80	28.10
May	32.04	24.14	28.09	413.20	82.55	187.67	29.6	29.80	29.50
June	31.13	25.75	28.44	335.50	87.67	67.12	29.4	29.80	29.50
July	32.03	26.69	29.36	306.50	86.52	159.09	30.5	30.90	30.60
August	32.45	26.43	29.44	365.80	85.42	182.30	31.3	31.60	31.20

Source: Weather Yard, Department of Irrigation and Water Management, BAU, Mymensingh.

### Experimental Treatments and Design

The experiment comprised four spacing viz. 25 cm × 15 cm, 20 cm × 15 cm, 15 cm × 10 cm, 10 cm × 10 cm and five weeding regimes viz. no weeding, one weeding (at 15 DAT), one weeding (at 25 DAT), two weeding (at 15 and 30 DATs) and two weeding (at 20 and 40 DATs). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of the unit plot was 10 m<sup>2</sup> (4 m × 2.5 m) and the spaces between blocks and plots were 1m and 0.75 m, respectively.

### Crop Husbandry

Sprouted rice seeds were sown in the wet nursery bed on 18 April. Thirty days old seedlings were transplanted in the puddled main field using two seedlings hill<sup>-1</sup> on 17 May. The nitrogen, phosphorus, potassium, sulphur and zinc fertilizers were applied in form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 220, 100, 60, 60 and 10 kg ha<sup>-1</sup>, respectively. Urea was top dressed in three equal splits at 15, 30 and 45 DAT. Intercultural operations were done as and when necessary. The flood irrigation was applied to maintain a constant level of standing water up to 6 cm in

early stage to enhance tillering and 10-12 cm in later stage to discourage late tillering. Seven irrigations were given throughout the growing season. The field was finally drained out before 15 days of harvest to enhance maturity. Plants were infested with rice stem borers and leafhoppers which were successfully controlled by applying Basudin 10G @ 20 kg ha<sup>-1</sup>. Malathion 57EC was also applied @ 1L ha<sup>-1</sup> to control other insects. The crop damage by diseases like blast and brown spot was negligible.

### Data Collection

Five hills (excluding border hills) were randomly selected from each unit plot prior to harvest for recording different data on plant characters and yield components. The whole plot was harvested when 90% of the grains became golden yellow in color. The harvested crop was then threshed, cleaned and dried to a moisture content of 14%. Weight of grain and straw were recorded and converted into t ha<sup>-1</sup>. Data on yield contributing and other characters such as plant height, number of total tillers hill<sup>-1</sup>, effective tillers hill<sup>-1</sup>, non-effective tillers hill<sup>-1</sup>, panicle length, total grains panicle<sup>-1</sup>, sterile spikelets panicle<sup>-1</sup> and 1000 grain weight were recorded at harvest from five sample hills.

### Statistical Analysis

Data obtained were analyzed by M-STAT Statistical Computer Package Program using the "Analysis of variance" technique at 5% level of significance and mean differences were adjudged by Duncan Multiple Range Test (DMRT).

## RESULTS AND DISCUSSION

### Plant Spacing Influence

Plant spacing exerted significant influence on yield and yield contributing characters of *aus* rice cv. BR26 (Table 2). Number of effective tillers hill<sup>-1</sup>, number of grains panicle<sup>-1</sup>, grain yield, straw yield, biological yield and harvest index were significantly affected by different spacings. The highest grain yield (4.2 t ha<sup>-1</sup>) was recorded in 20 cm × 15 cm spacing due to highest number of total tillers hill<sup>-1</sup> (13.00), effective tillers hill<sup>-1</sup> (9.47) and grains panicle<sup>-1</sup> (98.27) (Table 2). Rahman et al. (2007) also obtained highest grain yield from BR26 rice

when 20 cm × 15 cm spacing was followed. The highest yield in 20 cm × 15 cm spacing might be resulted in the optimum plant population which ensured the plants to grow properly utilizing maximum solar radiation and nutrients (Mian et al. 1966). The increased yield loss in wider spacing (25 cm × 15 cm) may be attributed to the increased competition due to increased weed population and reduced plant population per unit land area. The biological yield (10.1 t ha<sup>-1</sup>) and harvest index (40.56%) were also observed highest in 20 cm × 15 cm spacing. This result coincides with that of Khan et al. (2013). In contrast, the lowest grain yield (2.86 t ha<sup>-1</sup>) was recorded in 10 cm × 10 cm spacing for lowest number of effective tillers hill<sup>-1</sup> (4.31) and grains panicle<sup>-1</sup> (87.07) (Table 2). Although reduced weed pressure in closer spacing has been reported by many researchers (Shinggu et al. 2009; Anwar et al. 2011), which hampered intercultural operations, increased competition among the plants for nutrients, air and light which resulted in weaker plants and consequently reduced yield.

**Table 2.** Effect of spacing on different plant characters and yield of *aus* rice cv. BR26

Spacing	Plant height (cm)	Number of total tillers hill <sup>-1</sup>	Number of effective tillers hill <sup>-1</sup>	Panicle length (cm)	Number of grains panicle <sup>-1</sup>	Number of sterile spikelets panicle <sup>-1</sup>	1000-grain weight (g)	Grain yield (t ha <sup>-1</sup> )	Straw yield (t ha <sup>-1</sup> )	Biological yield (t ha <sup>-1</sup> )	Harvest index (%)
S <sub>1</sub>	99.51	11.41 b	7.79 b	21.31	94.80 b	18.91 c	21.09	3.66 b	5.57 b	9.20 b	39.37 b
S <sub>2</sub>	97.43	13.00 a	9.47 a	20.88	98.27 a	17.33 d	21.49	4.20 a	6.06 a	10.10 a	40.56 a
S <sub>3</sub>	95.91	10.71 c	7.26 c	21.44	92.80 c	19.55 b	21.06	3.58 c	5.45 c	9.02 c	39.27 c
S <sub>4</sub>	94.14	8.67 d	4.31 d	21.17	87.07 d	22.58 a	20.09	2.86 d	4.72 d	7.58 d	37.55 d
Level of significance	NS	**	**	NS	**	**	NS	**	**	**	**

S<sub>1</sub> = 25 cm × 15 cm; S<sub>2</sub> = 20 cm × 15 cm; S<sub>3</sub> = 15 cm × 10 cm; S<sub>4</sub> = 10 cm × 10 cm

\*\* = Significant at 1% level of probability; NS = Not-significant.

In a column, figures with dissimilar letter differ significantly as per DMRT.

### Weeding Regime Influence

Significant influence of weeding regimes on yield and yield contributing characters of *aus* rice cv. BR26 was observed. The highest number of effective tillers hill<sup>-1</sup> (10.95) and grains panicle<sup>-1</sup> (103.3) were recorded in two weeding at 15 and 30 DATs (Table 3). The highest grain yield (4.48 t ha<sup>-1</sup>) and harvest index (40.88%) were found also in two weeding at 15 and 30 DATs (Table 3). In fact, it is not necessary to keep rice field weed free throughout the growing season. Weeding during critical period of weed competition (CPWC) can ensure high yield (Williams II and Martin 2006; Anwar et al. 2012). In this case, two times weeding at 15 and 30 DATs might cover the CPWC and as a consequence highest yield was obtained.

Similar results were also found by many researchers (Singh et al. 1999; Hossain 2000; Alam et al. 2012). Datta (1990) revealed that effective weed management increased number of effective tillers hill<sup>-1</sup> due to more availability of water, nutrients and light. Rahman et al. (2007) reported that for better yield of BR26, weeding should be done twice at 20 and 35 DATs. On the contrary, no weeding produced the lowest number of total tillers hill<sup>-1</sup> (7.98), effective tillers hill<sup>-1</sup> (3.32), grains panicle<sup>-1</sup> (77.6), grain yield (2.44 t ha<sup>-1</sup>) and harvest index (36.63%) (Table 3). In no weeding treatment, competition for nutrients between weeds and plants was severe which resulted in decreased number of total tillers hill<sup>-1</sup>, effective tillers hill<sup>-1</sup> and reduced grains panicle<sup>-1</sup>.

**Table 3.** Effect of weeding regime on different plant characters and yield of *aus* rice cv. BR26

Weeding regime	Plant height (cm)	Number of total tillers hill <sup>-1</sup>	Number of effective tillers hill <sup>-1</sup>	Panicle length (cm)	Number of grains panicle <sup>-1</sup>	Number of sterile spikelets panicle <sup>-1</sup>	1000-grain weight (g)	Grain yield (t ha <sup>-1</sup> )	Straw yield (t ha <sup>-1</sup> )	Biological yield (t ha <sup>-1</sup> )	Harvest index (%)
W <sub>0</sub>	92.05	7.98 e	3.32 e	21.62	77.6 e	25.02 a	21.08	2.44 e	4.20 e	6.63 e	36.63 e
W <sub>1</sub>	97.10	9.89 d	5.50 d	21.08	92.77 d	20.60 b	20.07	3.29 d	5.16 d	8.44 d	38.72 d
W <sub>2</sub>	98.02	10.45 c	6.15 c	20.82	94.29 c	20.05 c	20.98	3.47 c	5.34 c	8.80 c	39.17 c
W <sub>3</sub>	98.04	13.52 a	10.95 a	21.33	103.3 a	15.84 e	21.50	4.48 a	6.36 a	10.79 a	40.88 a
W <sub>4</sub>	97.90	12.90 b	10.13 b	21.16	101.3 b	16.45 d	21.41	4.25 b	6.19 b	10.39 b	40.53 b
Level of significance	NS	**	**	NS	**	**	NS	**	**	**	**

W<sub>0</sub> = No weeding; W<sub>1</sub> = One weeding at 15 DAT; W<sub>2</sub> = One weeding at 25 DAT; W<sub>3</sub> = Two weeding at 15 and 30 DAT; W<sub>4</sub> = Two weeding at 20 and 40 DAT

\*\* = Significant at 1% level of probability; NS = Not-significant.

In a column, figures with dissimilar letter differ significantly as per DMRT.

### Plant Spacing and Weeding Regime Interaction Influence

Interaction of plant spacing and weeding regime was

significant for yield and most of the yield contributing characters except plant height, panicle length and 1000-grain weight (Table 4). The highest number of total tillers hill<sup>-1</sup>

(16.33), effective tillers hill<sup>-1</sup> (13.77) and grains panicle<sup>-1</sup> (105) were recorded in 20 cm × 15 cm spacing with two weeding at 15 and 30 DATs. Because of the highest number of effective tillers hill<sup>-1</sup> and grains panicle<sup>-1</sup>, the highest grain yield was obtained from 20 cm × 15 cm spacing with two weeding at 15 and 30 DATs (Table 4). At optimum crop density, crop captures and utilizes resources more efficiently than weeds resulting faster canopy developments (Mohler et al. 1996) and timely weeding consequently may keep the weed flora under check through smothering effects. Similar interaction effect was also observed by Alam et al. (2012) and Mondal et al. (2013). Rahman et al. (2007), on the other hand, obtained highest grain yield of BR26 from the interaction of 20 cm × 15 cm spacing and weed free regime. The highest biological yield (12.3 t ha<sup>-1</sup>) and harvest index (42.33%) were found also in 20 cm × 15 cm

spacing with two weeding at 15 DAT and 30 DAT treatments. The optimum spacing and weed free condition provided the minimum intra- and inter-plant competition for natural resources *i.e.* light, water and nutrients which resulted in maximum number of effective tillers hill<sup>-1</sup> and grains panicle<sup>-1</sup> responsible for the highest grain yield. On the other hand, the lowest grain yield (2.24 t ha<sup>-1</sup>) was found in 10 cm × 10 cm spacing with no weeding due to the lowest number of total tillers hill<sup>-1</sup> (7.28) and grains panicle<sup>-1</sup> (74.27). The lowest biological yield (6.32 t ha<sup>-1</sup>) and harvest index (35.33%) were found also in the same treatment combination. Probably the closer spacing made the field over populated and maximized the intra-species competition among the crop plants whereas no weeding facilitated maximum inter-species competition, whose combined effect finally resulted in the lowest grain yield.

**Table 4.** Effect of interaction of spacing and weeding regime on different plant characters and yield of *aus* rice cv. BR26

Interaction (S×W)	Plant height (cm)	Number of total tillers hill <sup>-1</sup>	Number of effective tillers hill <sup>-1</sup>	Panicle length (cm)	Number of grains panicle <sup>-1</sup>	Number of sterile spikelets panicle <sup>-1</sup>	1000-grain weight (g)	Grain yield (t ha <sup>-1</sup> )	Straw yield (t ha <sup>-1</sup> )	Biological yield (t ha <sup>-1</sup> )	Harvest index (%)
S <sub>1</sub> ×W <sub>0</sub>	91.90	8.6 n	3.90 o	20.60	75.27 r	25.23 a	21.20	2.35s	4.12s	6.47s	36.23m
S <sub>1</sub> ×W <sub>1</sub>	101.00	10.37 j	6.33 j	22.60	97.23 i	19.33 f	20.90	3.15j	5.44j	8.95j	39.13g
S <sub>1</sub> ×W <sub>2</sub>	101.66	11.67 i	7.52 i	21.07	98.50 h	18.43 g	20.90	3.91i	5.79i	9.70i	40.30f
S <sub>1</sub> ×W <sub>3</sub>	102.00	13.33 e	11.20 e	22.37	102.00 d	15.50 k	21.27	4.32e	6.31e	10.60e	40.57e
S <sub>1</sub> ×W <sub>4</sub>	101.00	13.03 f	10.00 f	19.90	101.0 e	16.03 j	21.20	4.22f	6.16f	10.30f	40.60e
S <sub>2</sub> ×W <sub>0</sub>	93.13	8.06 q	3.13 r	22.60	83.02 p	24.17 b	21.00	2.61q	4.35q	6.96q	37.43l
S <sub>2</sub> ×W <sub>1</sub>	97.16	12.27 h	8.32 h	20.50	99.13 g	17.80 h	21.00	3.98h	5.87h	9.85h	40.30f
S <sub>2</sub> ×W <sub>2</sub>	98.26	12.76 g	9.12 g	20.60	100.0 f	17.23 i	21.13	4.14g	6.04g	10.13g	40.63e
S <sub>2</sub> ×W <sub>3</sub>	98.63	16.33 a	13.77 a	19.50	105.00 a	13.17 m	22.20	5.23a	7.10a	12.30a	42.33a
S <sub>2</sub> ×W <sub>4</sub>	99.96	15.60 b	13.03 b	21.20	104.0b	14.27 l	22.10	5.04b	6.93b	11.90b	42.10b
S <sub>3</sub> ×W <sub>0</sub>	92.16	7.93 r	3.03 s	22.17	78.30 q	25.23 a	20.80	2.54r	4.22r	6.76r	37.50l
S <sub>3</sub> ×W <sub>1</sub>	96.16	8.72 n	4.133 n	20.00	89.40 m	21.48 d	20.50	2.95n	4.80n	7.75n	38.00j
S <sub>3</sub> ×W <sub>2</sub>	96.27	8.88 m	4.23 m	20.87	91.30 l	21.27 d	20.67	3.01m	4.89m	7.91m	38.07j
S <sub>3</sub> ×W <sub>3</sub>	97.20	14.33 c	12.70 c	22.10	103.0 c	14.60 l	21.73	4.91c	6.80c	11.70c	41.90c
S <sub>3</sub> ×W <sub>4</sub>	95.30	13.70 d	12.20 d	22.07	102.0 d	15.23 k	21.60	4.52d	6.52d	11.00d	40.37d
S <sub>4</sub> ×W <sub>0</sub>	91.03	7.28 s	3.20 q	21.10	74.27 s	25.43a	21.33	2.24t	4.08s	6.32t	35.33n
S <sub>4</sub> ×W <sub>1</sub>	94.33	8.23 p	3.22 q	21.23	85.30 o	23.83b	20.40	2.71p	4.51p	7.22p	37.47l
S <sub>4</sub> ×W <sub>2</sub>	95.90	8.50 o	3.72 p	20.73	87.37 n	23.27c	21.23	2.81o	4.64o	7.46o	37.70k
S <sub>4</sub> ×W <sub>3</sub>	94.33	10.7 k	6.12 k	21.33	95.23 j	20.10e	20.80	3.32k	5.24k	8.56k	38.73h
S <sub>4</sub> ×W <sub>4</sub>	95.33	9.25 l	5.29 l	21.47	93.20 k	20.27e	20.73	3.22l	5.12l	8.34l	38.53i
Level of significance	NS	**	**	NS	**	**	NS	**	**	**	**

S<sub>1</sub> = 25 cm × 15 cm; S<sub>2</sub> = 20 cm × 15 cm; S<sub>3</sub> = 15 cm × 10 cm; S<sub>4</sub> = 10 cm × 10 cm

W<sub>0</sub> = No weeding; W<sub>1</sub> = One weeding at 15 DAT; W<sub>2</sub> = One weeding at 25 DAT; W<sub>3</sub> = Two weeding at 15 and 30 DAT; W<sub>4</sub> = Two weeding at 20 and 40 DAT

\*\* = Significant at 1% level of probability; NS = Not-significant.

In a column, figures with dissimilar letter differ significantly as per DMRT.

## CONCLUSION

The present research confirms that plant spacing and weeding regime interact significantly and plays a decisive role to reduce weed pressure and consequently to increase yield of *aus* rice. Based on the results of this study, it may be concluded that for obtaining higher yield, *aus* rice cv. BR26 (*Shraboni*) should be transplanted at 20 cm × 15 cm spacing and weeded out twice at 15 and 30 DATs in the study area. However, this may vary with agro-climatic conditions, management practices, weed competitiveness of the rice cultivar, weed pressure and dominant weed species of the site.

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## CONFLICT OF INTEREST

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

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