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EFFECT OF BISPYRIBAC-SODIUM AND SPACING ON THE WEED CONTROL AND PERFORMANCE OF AROMATIC RICE VARIETIES

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Abstract

Rice (*Oryza sativa* L.), a staple grain, serves as a fundamental dietary component for billions by providing carbohydrates, vitamins, and minerals, supporting livelihoods, and stimulating national economies. A field experiment was led from July to December 2019 at the Sher-e-Bangla Agricultural University's agronomy field in Dhaka, Bangladesh, to determine how a post-emergent herbicide and spacing impacts aromatic rice varieties' growth, yield, and weed control. The investigation consisted of three factors, i.e., weed control treatments: weedy check (no weeding) and Bispyribac-sodium WP @ 150 g ha^{-1}, aromatic rice varieties: Kalizira and BRRI dhan37 and spacing: 20 cm × 15 cm, 25 cm × 15 cm, 20 cm × 20 cm, and 25 cm × 25 cm in a split-split plot design with three replications. Thirteen dissimilar types of weeds invaded the experimental plots. Among them, *Monochoria vaginalis* was the most prevalent weed at 30 and 60 DAT (24.67 and 19.67 weed population m^{-2} and 15.24 and 13.02% relative weed density sequentially). Among all the factors, the application of Bispyribac-sodium WP (W_1), BRRI dhan47 (V_2, grain yield 2.99 t ha^{-1}) and 20 cm × 20 cm (S_3, grain yield 2.87 t ha^{-1}) spacing provided promising results. According to the findings, BRRI dhan37 planted at 20 cm × 20 cm spacing, along with the suggested application of Bispyribac-sodium WP could provide the best result.

Introduction

Bangladesh, an agrarian country with a large population, relies heavily on profound rice (*Oryza sativa* L.) cultivation. According to BBS (2022), Bangladesh's agricultural sectors accounted for 11.66% of the country's GDP in the fiscal year 2021-2022. The total area covered by aman rice was speculated to be 5625907 hectares, 0.87% greater than the financial year 2019-2020. In 2020, 4.44 million hectares of cultivable land were accustomed to HYV varieties, 0.75 million hectares for local varieties, 0.31 million hectares for B. *Aman*, and 0.24 million hectares for hybrid varieties. A total of 5.71 million hectares of land were covered by the aman crop (Magzter, 2021). However, as per the Statistical Yearbook Bangladesh (BBS, 2022), *Aman* rice was cultivated for 34.11% of the gross area, and the production was 14959 MT.

Aromatic rice, known as Basmati in India, Jasmine in Thailand, and Kataribhog in Bangladesh, has a 15-fold higher amount of 2-Acetyl-1-pyrroline (2AP) (Singh, 2000). Scented rice varieties in Bangladesh are conventional, photoperiod-sensitive and cultivated during the aman season. Despite low yields, these cultivars generate higher turnover due to low cultivation costs (Tanchotikul and Hsieh, 1991).

Weeds are undesired plants that grow in locations where they are not deliberately cultivated. According to Ramana *et al*. (2014), weeds pose the greatest drawback to agricultural productivity, with losses ranging from 30 to almost 100%. According to Rao *et al*. (2007), weeds had a devastating effect on crop production caused loss of 32% across the globe. When weeds existed, the grain production of T. *Aman*, *Boro*, and *Aus* rice were lessened by 70–80, 30, and 36%, respectively, prompting increased use of herbicides for chemical weed control (BRRI, 2008).

Weed management in sustainable rice production is burdensome due to arduous and expensive physical and cultural methods. At the same time, chemical control is more inexpensive and less time-consuming, making it more likable over time.

The study intends to ascertain the effectiveness of a post-emergent herbicide and spacing in weed management and contrast the competitiveness of local and contemporary aromatic rice varieties in Bangladesh.

Materials and Methods

Site characteristics

The study was carried out in the agronomy field of Sher-e-Bangla Agricultural University in Dhaka, 8.6 m above sea level and geographically located between 23°77′ N latitude and 90°33′ E longitude during the period from July 1 to December 20, 2019. It is situated in the Agro-Ecological Zone of the Madhupur Tract, AEZ-28, a complex terrain area encompassed by sediments from floodplains, including red soil hillocks from islands. The soil utilized in the experiment was a silty clay loam with an ECE of 25-28 and a pH of 5.8-6.5. Specimens of soil were taken at depths of 0 to 15 cm. The atmospheric condition in the region was subtropical, with high temperature, humidity, and precipitation.

Experimental design and treatments

Three variables were included in this experiment: aromatic rice varieties (V_1 and V_2), weed control treatments (W_0 and W_1) and spacings (S_1, S_2, S_3, and S_4). The seeds of Kalizira (V_1) and BRRI dhan37 (V_2) were procured from BRRI (Bangladesh Rice Research Institute) located in Joydebpur, Gazipur, after undergoing a typical selection process to ensure their health and absence of illness.

A post-emergent herbicide called Xtra Power 20 WP (sodium 2,6-bis[(4,6-dimethoxypyrimidin-2-yl)oxy]benzoate, W_1) was used in the experiment, which was registered by ACI Crop Care and applied on August 23, 2019, at the rate of 150 g ha^{-1}. It averts the synthesis of plant amino acids through being fastidious, systematic, and absorbed by the foliage and roots. Due to its minimal mammalian toxicity and great activity at modest treatment rates, this herbicide has gained popularity (De *et al*., 2014). The herbicide was administered through a knapsack sprayer, maintaining a 4-5 cm water level for 65-70 days following transplanting at the rate of 150 g $ha^{-1.}$ The other weed control treatment was W_0 for which we applied no herbicides.

The spacings were 20 cm × 15 cm, 25 cm × 15 cm, 20 cm × 20 cm, and 25 cm × 25 cm which were denoted by S_1, S_2, $S_{3,}$ and S_4 consecutively. For weed treatment and variety, the investigation used a split-split plot design with three replications, having a unit plot size of 5.04 m^2 (2.8 m × 1.8 m).

N, P, K, S, and Zn were supplied to rice plants by urea (150 Kg ha^{-1}), triple superphosphate (100 Kg ha^{-1}), muriate of potash (70 Kg ha^{-1}), gypsum (60 Kg ha^{-1}) and zinc sulfate (10 Kg ha^{-1}). The amounts of fertilizer used followed the criteria BRRI provided for cultivating T. *Aman* rice. Three split applications were made for urea: 21 DAT, 45 DAT as top dressing, and 60 DAT at the panicle initiation stage. All other fertilizers were applied in basal doses during final land preparation.

Data Collection and calculations

To better understand weed interference, the study identified specific weed species and counted their population in a weedy check plot of 1 m^2 listed at 30 and 60 DAT. The weeds were uprooted, and the fresh and dry weight, relative weed density, weed control efficiency, and weed control index were measured by applying the following formulas:

$$\text{RWD (\%)} = \frac{\text{Number of individuals of same species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{WCE (\%)} = \frac{\text{Weed population in control-weed population in treated plot}}{\text{Weed population in control}} \times 100$$

$$\text{WCI (\%)} = \frac{\text{Weed dry weight in control-weed dry weight in treated plot}}{\text{Weed dry weight in control}} \times 100$$

Grain yield was adjusted to 14% moisture, sun-dried, and weighed carefully. After measuring the dry weight of grains in a central 1 m^2 area, the final grain yield was recorded for each plot and then converted to t ha^{-1}. Grain yield was calculated using the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield per unit plot (Kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

An arbitrary sample of 1000- cleaned dried seeds was weighed using a digital electric balance at 12% moisture, and the mean weight was expressed in grams.

Results and Discussion

In the experiment field, the names and populations of individual weed species were noted at 30 and 60 DAT on a pre-marked area of 1 m^2 of weedy check plots. Thirteen different weed species were heeded, with broadleaf and sedge weeds prevailing. The findings comprise 7 broad leaf weeds and 3 grass and sedge weeds each. The result is tabulated below:

Table 1. Weed flora of the experiment field

Local name	English name	Scientific name	Family	Habitat	Weed type
Shama	Barnyard Grass	*Echinochloa cruss-galli*	Poaceae	Annual	Grass
Choto shama	Jungle rice	*Echinochloa colona*	Poaceae	Perennial	Grass
Chapra	Indian goosegrass	*Eleusine indica*	Poaceae	Annual	Grass
Cechra	Dwarf Club-rush	*Scirpus maritimus*	Cyperaceae	Perennial	Sedge
Holde mutha	Yellow nutsedge	*Cyperus diformis*	Cyperaceae	Perennial	Sedge
Mutha	Java grass	*Cyperus rotundus*	Cyperaceae	Perennial	Sedge
Chondro mala	Water snowflake	*Nymphoides cristatum*	Menyanthaceae	Perennial	Broadleaf
Helenca	Buffalo spinach	*Enydra fluctuans*	Asteraceae	Annual	Broadleaf
Jheel-morich	Gooseweed	*Sphenoclea zeylanica*	Sphenocleaceae	Annual	Broadleaf
Pani kochu	Pickerel weed	*Monochoria vaginalis*	Pontederiaceae	Perennial	Broadleaf
Pani Long	Mexican Primrose Willow	*Ludwigia octovalvis*	Onagraceae	Perennial	Broadleaf
Shusni shak	European water clover	*Marsilea quadrifolia*	Papayeraceae	Perennial	Broadleaf
Chad mala	Duckweed	*Sagittaria guayansis*	Alismataceae	Perennial	Broadleaf

Data on the species-specific weed population (no. m^{-2}) and relative density (%) were recorded in the experiment area after 30 and 60 DAT, and *Monochoria vaginalis* was found to be predominant. *Cyperus rotundus* followed it, and *Sagittaria guayansis* was the least prominent, with *Scirpus maritimus* and *Marsilea quadrifolia* at 30 and 60 DAT subsequently.

Table 2. Weed population by species (No. m^{-2}) and relative weed density (%) in the experimental area at 30 and 60 DAT

Scientific name	Weed population (No. m^{-2})		Relative weed density (%)	
	30 DAT	60 DAT	30 DAT	60 DAT
Monochoria vaginalis	24.67	19.67	15.24	13.02
Cyperus rotundus	20.21	18.86	12.48	12.48
Sagittaria guayansis	19.1	17.85	11.80	11.81
Cyperus diformis	18.08	15.34	11.17	10.15
Ludwigia octovalvis	14.34	14.23	8.86	9.42
Sphenoclea zeylanica	13.44	12.34	8.3	8.17
Enydra fluctuans	12.5	11.45	7.72	7.58

Echinochloa colona	11.66	11.5	7.2	7.61
Eleusine indica	8.33	7.54	5.15	4.99
Nymphoides cristatum	7.8	9.1	4.82	6.02
Echinochloa cruss-galli	5.34	4.35	3.3	2.87
Marsilea quadrifolia	3.3	3.34	2.04	2.21
Scirpus maritimus	3.1	5.54	1.92	3.67
Total weed	161.87	151.11	100	100

Presence of weeds m^{-2} in different weed control treatments

Different weed-control treatments have various impacts on the number or population of weeds. Among the different treatments, herbicide-based weed control (W_1) reduced weed m^{-2} at different DAT levels.

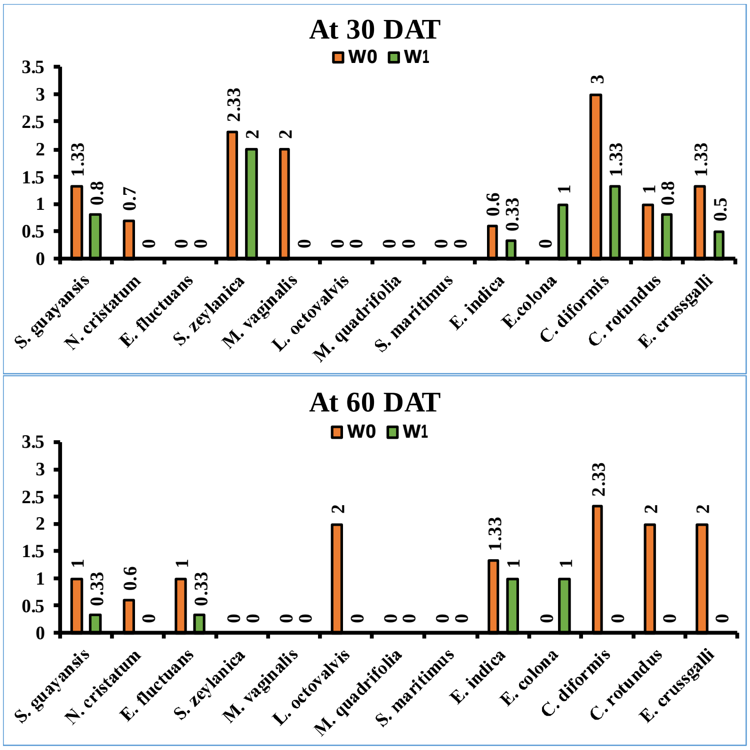


Fig. 1. Presence of weeds m^{-2}; Here, W_0: Weedy, W_1: Weeds control

The population or quantity of weeds was impacted by 2 different weed control techniques at varying DATs. The study revealed that the weedy check plots had the highest weed density, with 13.89 and 11.85 weeds m^{-2} at 30 and 60 DAT, respectively. Contrarily, the Bispyribac-sodium WP plots had the lowest density, with only 6.35 and 7.04 weeds m^{-2}.

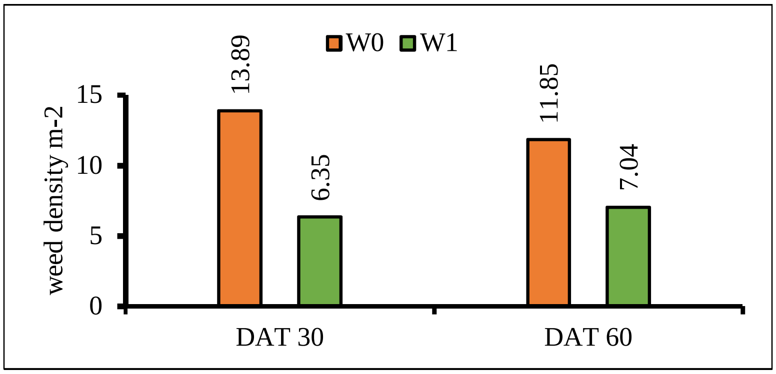


Fig. 2. Weed Density m^{-2} .Here, W_0: Weedy, W_1: Weeds control.

Presence of weeds m^{-2} in different rice varieties

Rice variety treatments affected weed numbers. BRRI dhan37 (V_2) was a particular rice variety that functions well by lessening weed m^{-2} at different DATs. It had the lowest weed density, as competing rice varieties with finer vigor are more productive in repressing weed infestation.

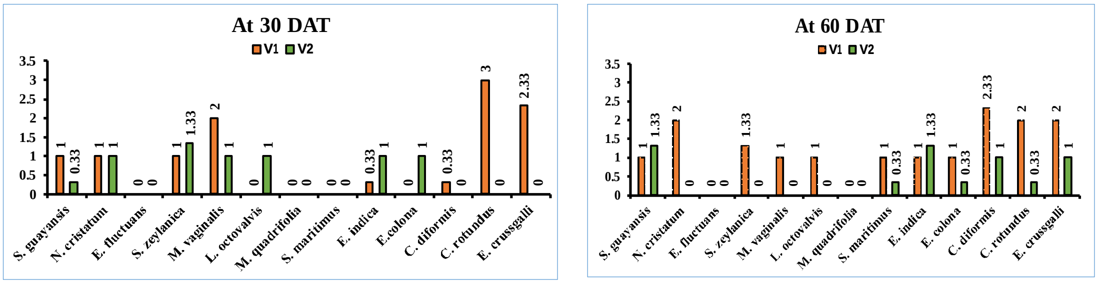


Fig. 3. Varieties of rice with weed m^{-2} .Here, V_1: Kalizira, V_2: BRRI dhan37.

The study was found that weed m^{-2} significantly influenced rice varieties at different time intervals (DAT). Kalizira had the highest weed densities (10.84 and 9.69 m^{-2}), and BRRI dhan37 (V_2) had the lowest (9.40 and 9.20 m^{-2}).

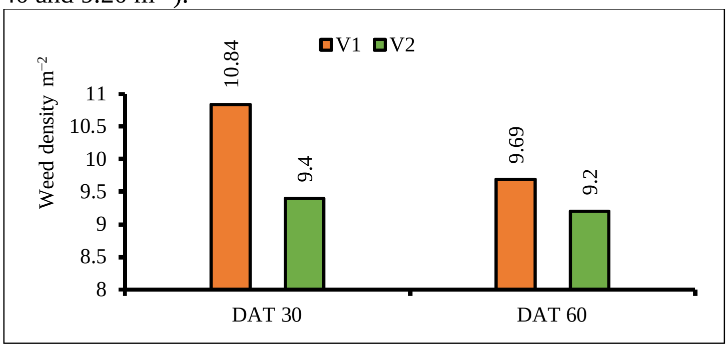


Fig. 4. Effect of variety on weed density m^{-2} at different DAT.Here, V_1: Kalizira, V_2: BRRI dhan37.

Presence of weeds m^{-2} in different spacing:

As per the column chart, the maximum weed density was recorded at 25 cm × 25 cm spacing, S_4, and the lowest at 20 cm × 20 cm, S_3. We can conclude that the prevalence of weeds and the requirement for herbicides can be lessened with the S_3 spacing, as it can provide shading and lower weeds' competing abilities.

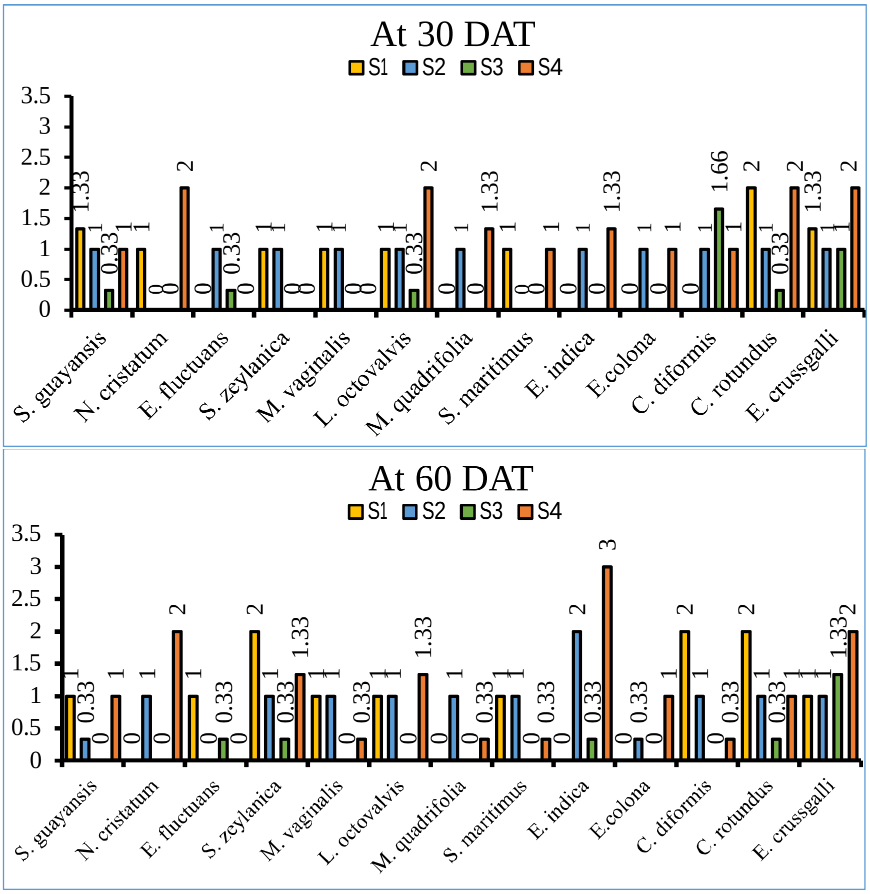


Fig. 5. Presence of weeds m^{-2} in different spacing. Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm.

The experiment also revealed that varying spacing significantly impacted weed density at various DATs, with maximum density in 25 cm × 25 cm (S_4) and minimum in 20 cm × 20 cm (S_3).

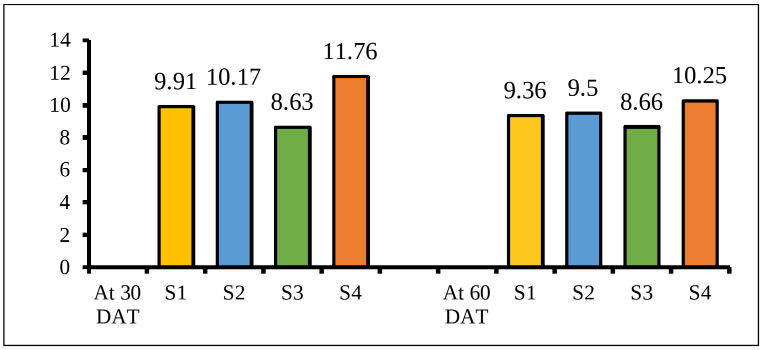


Fig. 6. Effect of spacing on weed density m^{-2} at different DATs.

Weed Control Efficiency

The weed control efficiency stretched from 19.34% to 27.88% over the weedy check plot, which is attributable to the different rice varieties used in the experiment. The cultivation of BRRI dhan37 (V_2) resulted in the foremost weed control efficiency at both 30 and 60 DAT, with a percentage of 27.88% and 21.09%, respectively.

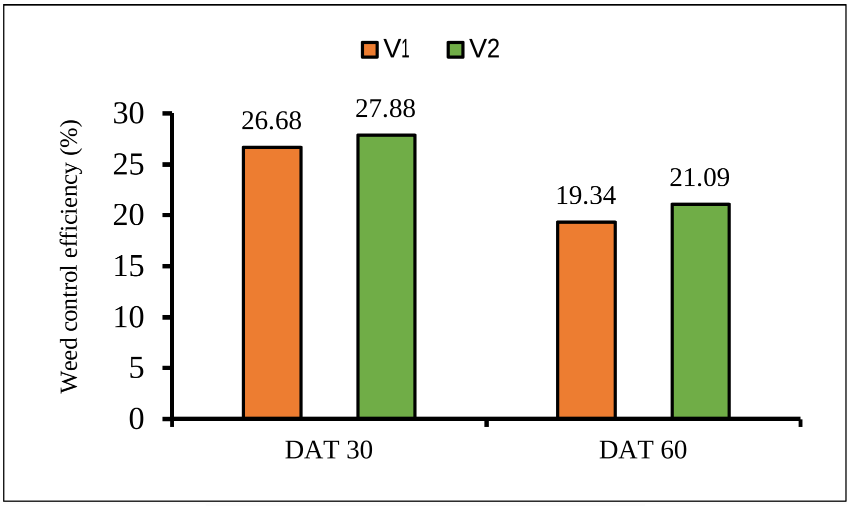


Fig. 7. Effect of variety on weed control efficiency.

Aromatic rice cultivated at 20 cm × 20 cm (S_3) spacing recorded the highest weed control efficiency (29.27% and 22.98%) at 30 and 60 DAT, which was statistically identical to the result when it was cultivated at 20 cm × 15 cm (S_1) spacing (29.09%) at 30 DAT.

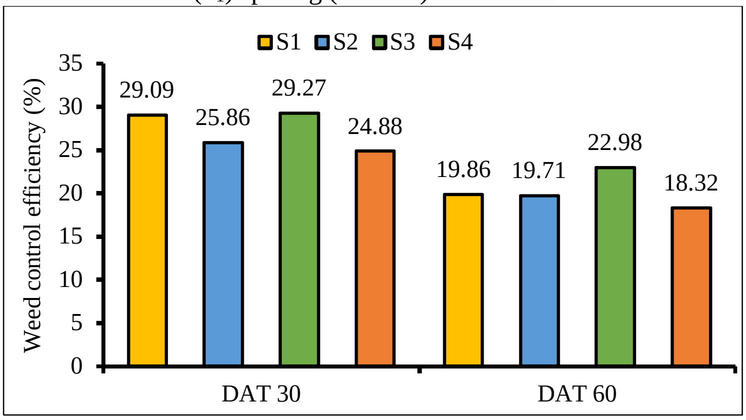


Fig. 8. Effect of spacing on weed control efficiency. Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm. and S_4: 25 cm × 25 cm.

Weed Control Index

The weed control index of aromatic rice at 30 and 60 DAT is remarkably affected by the varieties of rice used. It ranged from 16.32% to 30.40% over the weedy check plot. The experiment revealed that BRRI dhan37 (V_2) recorded the maximum weed control index (30.40% and 28.81%), while Kalizira (V_1) recorded the minimum weed control index (24.46% and 16.32%) at 30 and 60 DAT.

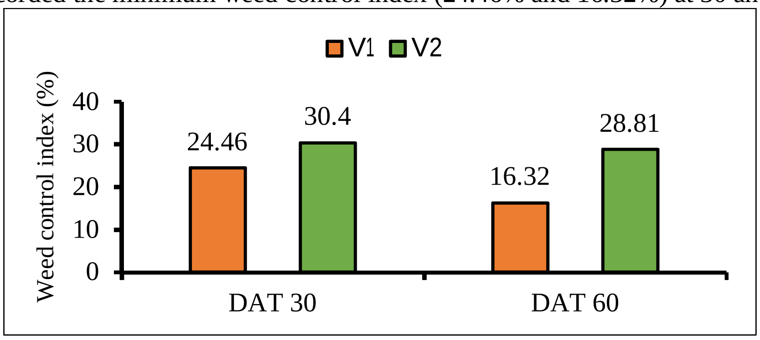


Fig. 9. Effect of variety on weed control index.

The highest weed control index was achieved when aromatic rice was cultivated at 20 cm × 20 cm (S_3) spacing with weed control indices of 30.20% and 23.92% and cultivation at a spacing of 25 cm × 25 cm (S_4) resulted in the minimum weed control index of 21.69% and 20.24% at 30 and 60 DAT respectively.

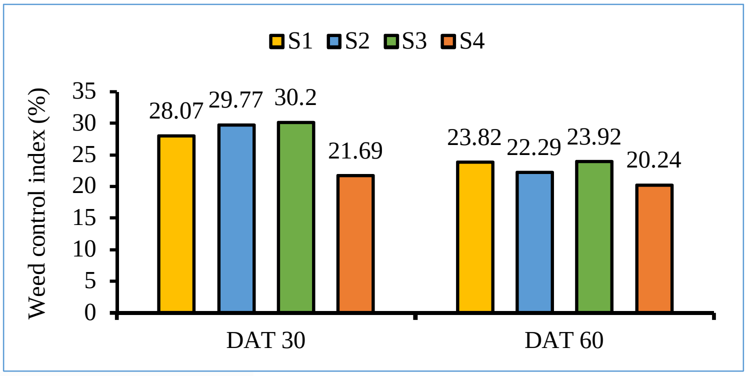


Fig. 10. Effect of spacings on weed control index. Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm.

Combined effects

The study examined the collective effect of weed control and rice variety, spacing and their interaction effect on the weed population in the aman rice field. The study revealed that using Bispyribac-sodium WP @ 150 g ha^{-1} in combination with BRRI dhan37 (W_1V_2) cultivation culminated in the lowest weed density at both time parameters.

Table 3. Effects of variety and weed management combined on weed density

Treatment Combinations	Weeds density m^{-2}	
	DAT 30	DAT 60
W_0V_1	14.75 ± 1.32a	12.00 ± 1.08a
W_0V_2	13.02 ± 1.62b	11.69 ± 0.72b
W_1V_1	6.93 ± 1.31c	7.38 ± 1.15c
W_1V_2	5.77 ± 0.93d	6.71 ± 0.48d
SE±	0.04	0.14
CV (%)	1.94	2.28

The weed density was even lower when the herbicide was used with narrow spacing (20 cm × 20 cm). Ultimately, the soundest method for curtailing weed density was using the herbicide with BRRI dhan37 cultivation and narrow spacing (20 cm × 20 cm).

Table 4. Effects of weed control, variety, and spacing combined on weed density

Treatment Combinations	Weeds density m^{-2}	
	DAT 30	DAT 60
$W_0V_1S_1$	13.00 ± 0.68d	11.67 ± 0.52b
$W_0V_1S_2$	15.00 ± 0.79c	12.00 ± 0.63b
$W_0V_1S_3$	15.00 ± 0.78c	11.67 ± 0.61b
$W_0V_1S_4$	16.00 ± 0.84a	12.67 ± 0.65a
$W_0V_2S_1$	11.34 ± 0.59f	9.98 ± 0.61c
$W_0V_2S_2$	12.44 ± 0.65e	11.67 ± 0.61b
$W_0V_2S_3$	13.00 ± 0.68d	12.67 ± 0.67a
$W_0V_2S_4$	15.30 ± 0.81b	12.44 ± 0.65a

$W_1V_1S_1$	5.37 ± 0.28k	6.67 ± 0.33fg
$W_1V_1S_2$	7.13 ± 0.38h	7.00 ± 0.37ef
$W_1V_1S_3$	6.47 ± 0.34i	6.77 ± 0.37f
$W_1V_1S_4$	8.74 ± 0.46g	9.06 ± 0.48d
$W_1V_2S_1$	5.17 ± 0.27k	6.34 ± 0.33g
$W_1V_2S_2$	6.10 ± 0.32j	7.33 ± 0.39e
$W_1V_2S_3$	4.80 ± 0.25l	6.33 ± 0.33g
$W_1V_2S_4$	7.01 ± 0.37h	6.84 ± 0.36f
SE±	0.08	0.28
CV (%)	1.39	2.43

Note viz: NS=Non- significant; W_0:Weedy check and W_1: Bispyribac-sodium WP @ 150 g ha^{-1}; V_1: Kalizira and V_2: BRRI dhan37; S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Bispyribac sodium WP @ 150 g ha^{-1} herbicide-treated plot along with BRRI dhan37 cultivation at 20 cm × 20 cm spacing recorded the maximum weed control efficiency (60.23% and 49.96%) at 30 and 60 DAT respectively.

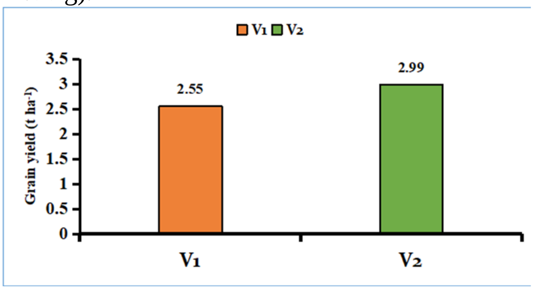
Table 5. The combined effect of weed control, variety, and spacings on weed control efficiency and weed control index of aromatic rice at different DAT

Treatment Combinations	Weed control efficiency		Weed control index	
	DAT 30	DAT 60	DAT 30	DAT 60
$W_0V_1S_1$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_1S_2$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_1S_3$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_1S_4$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_2S_1$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_2S_2$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_2S_3$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_0V_2S_4$	0.00 ± 0h	0.00 ± 0f	0.00 ± 0h	0.00 ± 0h
$W_1V_1S_1$	58.69± 1.17b	42.85± 0.73c	47.64± 0.95f	36.49 ± 0.46e
$W_1V_1S_2$	52.47 ± 1.05e	41.67 ± 0.83c	55.63 ± 1.11d	32.62 ± 0.65f
$W_1V_1S_3$	56.87± 1.14c	41.98 ± 0.84c	54.98 ± 1.1d	30.96 ±0.62fg
$W_1V_1S_4$	45.38 ± 0.91g	28.27 ± 0.53e	37.46 ± 0.75g	30.51 ±0.61g
$W_1V_2S_1$	57.67 ± 1.15c	36.57 ± 0.86d	64.65 ± 1.29b	58.78 ±0.97b
$W_1V_2S_2$	50.95 ± 1.02f	37.19 ± 0.74d	63.46± 1.27c	56.55 ±1.13c
$W_1V_2S_3$	60.23 ± 1.2a	49.96 ± 0.99a	65.80 ± 1.32a	64.73± 1.15a
$W_1V_2S_4$	54.15 ± 1.24d	45.00 ± 0.89b	49.30 ± 0.99e	50.44± 1.1a
SE±	0.71	0.87	1.09	1.17
CV (%)	1.94	6.11	2.04	4.63

A column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 probability level. *Note viz*: NS=Non- significant; W_0:Weedy check and W_1: Bispyribac-sodium WP @ 150 g ha^{-1}; V_1: Kalizira and V_2: BRRI dhan37; S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Grain yield and 1000-grain weight

Rice varieties have a significant impact on grain yield, with the BRRI dhan37 (V_2) rice variety achieving a maximum yield (2.99 t ha^{-1}) due to its higher filled grains per panicle and 1000 grain weight (17.56 g).



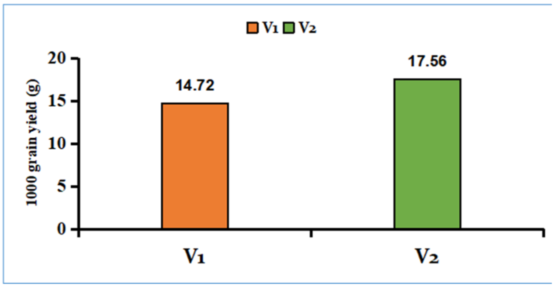


Fig. 11. Effect of variety on grain yield and 1000-grain weight. Here, V_1: Kalizira and V_2: BRRI dhan37.

The study also found that spacing significantly affects the grain yield of aromatic rice. The maximum yield and 1000-grain weight were recorded at the spacing of 20 cm × 20 cm (S_3, 2.87 t ha^{-1} and 16.68 g respectively), followed by 25 cm × 15 cm, and lowest in 25 cm × 25 cm (S_4) in both parameters.

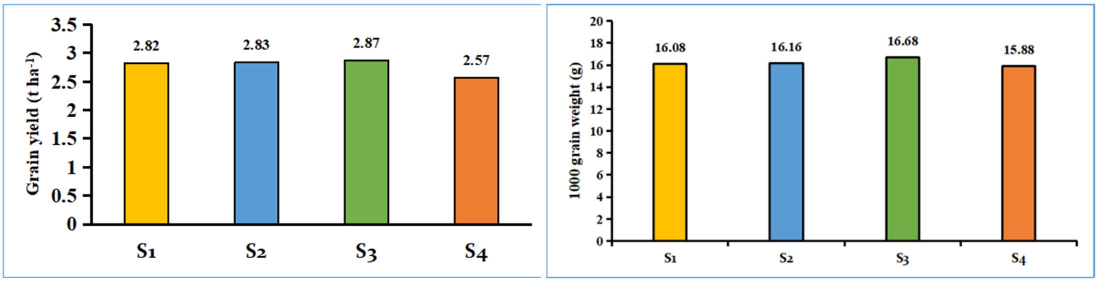


Fig. 12. Effect of spacing on grain yield and 1000−grain yield. Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm, S_4: 25 cm × 25 cm

Conclusion

The study was led to investigate the consequences of a post-emergent herbicide and spacing on the weed control and growth of two aromatic rice varieties that are extensively cultivated in Bangladesh. Among different treatments, Bispyribac-sodium WP @ 150 g ha^{-1} herbicide-treated plots (W_1) were reported as having the minimum weed density m^{-2} (6.35 and 7.04 m^{-2}) at 30 and 60 DAT. Rice varieties notably affected weeds, and BRRI dhan37 (V_2) was perceived as having the minimum weed density m^{-2} (9.40 and 9.20 m^{-2}) at 30 and 60 DAT. In terms of spacing, 20 cm × 20 cm (S_3) was proven to be outstanding. To conclude, it was recorded that cultivation of BRRI dhan37 along with Bispyribac-sodium WP @ 150 g ha^{-1} and a spacing of 20cm × 20cm influenced the outcome appreciatively. However, further trials with the same treatment combination in separate locations in Bangladesh would be more useful before delivering a closing statement.

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