

**ANNUAL RESEARCH REVIEW WORKSHOP
2023-24**

Program Area: Crop-Soil-Water Management

VII: AGRONOMY DIVISION



BANGLADESH RICE RESEARCH INSTITUTE

GAZIPUR-1701

Contents

Sl.	Name of the experiments under different program	Page #
1	Present manpower situation in Agronomy Division (July, 2023 to June 2024)	i
2	Summary	ii
3	Proposed Technology	
	3.1 Maximizing yield of BRRI-developed Boro varieties through influencing some Agronomic Critical Factors	1
	3.2 Maximizing yield of BRRI developed different growth duration T Aman varieties through influencing some Agronomic Critical Factors	1
	3.3 Optimizing Seedling Age and Nitrogen Management for BRRI hybrid dhan7	2
4	Planting Practices	
	4.1 Effect of time of planting on the agronomic output of newly developed BRRI varieties in different eco-system	3
	4.2 Screening of inbred rice varieties having ratooning ability in the irrigated ecosystem	5
	4.3 Increasing productivity of Ratoon Rice	9
5	Fertilizer Management	
	5.1 Determination of optimum seedling age and N scheduling for yield maximization of BRRI hybrid dhan7	10
	5.2 Effect of foliar application of Nano-Zinc Oxide on growth and yield of rice under salinity stress	12
	5.3 Effect of N levels and growth stage-based N application on yield and nitrogen use efficiency of Rice	14
	5.4 Yield loss assessment due to skip of N at certain growth stage of rice	17
	5.5 Effect of foliar application of chitosan on growth, yield and physio-biochemical characteristics of rice under salinity stress	19
	5.6 Mitigation of heavy metals bio-accumulation in rice varieties through agronomic management under polluted soils of Gazipur	22
	5.7 Residue analysis of herbicide, insecticide and fungicide in soil and rice under irrigated ecosystem	26
6	Good Agricultural practices	
	6.1 Yield maximization of Boro rice through good agricultural practice (GAP)	31
7	Yield maximization	
	7.1 Effect of agronomic factors for maximizing yield of Long Slenderer Premium Quality Fine Rice-BRRI dhan70 (<i>Katarivog type</i>) through developing sustainable production management protocol in T Aman season	34
	7.2 Effect of agronomic factors for maximizing yield of medium duration BRRI dhan94 through developing sustainable production management protocol	35
	7.3 Effect of some agronomic factors for maximizing yield of long duration variety BRRI dhan92 through developing sustainable production management protocol in Boro season	36
	7.4 Effect of agronomic critical factors-based managements for different yield goal level on lodging behavior of T. Aman varieties at Middle and Northern parts of Bangladesh	37
	7.5 Evaluation of improved agronomic management practice for yield maximization of BRRI-developed modern boro rice in the hill ecosystem	38
	7.6 Evaluation of improved agronomic management practice for yield maximization of BRRI-developed modern aman rice in the hill ecosystem	40
8	Soil Health management	
	8.1 Isolation and characterization of salt-tolerant PGPR isolated from coastal saline soil in Bangladesh	42
	8.2 Effect of salt-tolerant PGPR (ST-PGPR) inoculation on the growth of rice seedlings under salt-stress condition	46
9	Weed Management	
	9.1 Evaluation of candidate herbicide for weed control efficiency	49
	9.2 Effect of adding urea with Herbicides for controlling weeds and the growth and yield of transplanted Rice in T Aman season	51
	9.3 Effect of adding urea with Herbicides for controlling weeds and the growth and yield of transplanted Boro rice	54

	9.4 Reduce weed seed in weed Seed Bank of soil in long-term fallow management and herbicide uses in Rice- rice Cropping System	57
	9.5 Degradation pattern of herbicide in rice field soil under irrigated ecosystem	61
10	Technology Transfer	
	10.1 Ecosystem based integrated production technology development in haor areas	63

1. Manpower situation of Agronomy Division (July, 2023 - June, 2024)

Sl.	Name	Position	Working days
1.	Dr. Md. Shahidul Islam	CSO & Head	365
2.	Dr. Md Abu Bakar Siddique Sarker	PSO	365
3.	Dr. Md. Khairul Alam Bhuiyan	PSO	365
4.	Shah Ashadul Islam	SSO	365 Days (Deputed at RAL)
6	Dr. Rakiba Shultana	SSO	365
7.	Dr. Amena Sultana	SSO	365
8	Dr. Nasima Akter	SSO	365 Days (Deputed at RAL)
9.	Dr. Md. Masud Rana	SSO	365
10	Dr. Md. Zakaria Ibne Baki	SSO	365
11.	Md. Mostafa Mahbub	SSO	365
12	Mrs. Romana Akter	SO	365
13	Md. Monir Hossain	SA	365
14	Md. Saiful Islam	SA	365
15	Md Momen	SA	365
16	Asmani Khanam	UDA	365

2. SUMMARY

1. In T. Aman season, short duration varieties, BRRRI dhan75 and BRRRI dhan87 yielded higher when transplanting on 5th August.
2. The highest yields of medium duration T. Aman varieties, BRRRI dhan52, BRRRI dhan79 and BRRRI dhna93 were observed during transplanting on 20th July - 5th August.
3. In boro season, short duration varieties, BRRRI dhan88 and BRRRI dhan96 yielded higher when transplanting on 25th January.
4. The highest yields of long duration boro varieties, BRRRI dhan89, BRRRI dhan92 and BRRRI dhan102 were observed when transplanting on 10th January.
5. Screened eleven genotypes (BR17, BRRRI dhan28, BRRRI dhan81, BRRRI dhan84, BRRRI dhan86, BRRRI dhan88, BRRRI dhan96, BRRRI dhan97, Bangabandhu dhan100, Bina dhan-25 and Tata Miniket) showed ratooning potentiality. Tata Miniket and BRRRI dhan97 exhibit remarkable ratoon yield, indicating that it is particularly efficient at producing a second crop after the main harvest.
6. Ratooning of BRRRI dhan88 affected by cutting height & nitrogen fertilizer dose. The highest grain yield (1.40 t ha⁻¹) was recorded from 30 cm cutting height along with 60 kg ha⁻¹ nitrogen fertilizer application.
7. The optimum seedling age of 15 days and N split application in 1/3rd basal 1/3 after 4-5 tiller (15 DAT) and 1/3 before PI (around 25-30 DAT) will likely result in the highest yields for BRRRI hybrid dhan7.
8. Seed priming with 25 ppm Nano-Zinc Oxide accelerates germination of rice seed. 50 ppm Nano-ZnO spray improves plant growth at seedling stage in both saline and non-saline conditions.
9. Exogenous application of chitosan significantly improved the growth, ameliorated the adverse effects of salt stress on rice by decreasing the Na⁺ /K⁺ ratio and higher grain weight of both varieties in response to salt stress.
10. Contaminated soil is rich in nutrients but loaded with different heavy metals beyond the permissible limit for crop production. Plant did not uptake adequate amount of nutrients from waste water. BRRRI dhan29 gave the highest yield along with the application of water hyacinth compost + 50% RDF.
11. In the soil samples, Bensulfuron methyl and Ethoxy sulfuron ethyl were detected up to 28 days after herbicide application (DAHA), while Pendimethalin was detectable up to 42 DAHA. Acetachlore was not detected in any samples, which may be attributed to its volatility.
12. No residues of herbicide were found in the soil and rice grain matrix after the harvest of rice samples from the field. The pesticide residues were below the maximum residue limits (MRL) set by FSSAI for pesticides in rice (FSSAI, 2018).
13. Although management practices (GAP vs. BRP) did not show statistically significant effects, GAP consistently resulted in slightly higher yields, likely due to enhanced agronomic care, such as better nutrient and water management.

14. The highest grain yield (5.89 t/ha) of BRR1 dhan70 was obtained from the agronomic-based treatment combination of STB based fertilizer + 15-day old seedling + 20 x 20 cm and seeding will be done on 15 July.
15. For obtaining the highest grain yield, BRR1 dhan94 will be seeding on 15 July and transplanting with 15 days old seedling, maintaining 25 x 25 cm spacing.
16. The researcher recommended practices (considered for seedling age, time of planting, growth stage-based fertilizer management, herbicide applications, 1% potash spray) that might be used for yield maximization of BRR1-developed modern rice varieties in hilly ecosystems.
17. The highest grain yield (8.06 t/ha of BRR1 dhan92 was obtained from the treatment STB based fertilizer + 15-day old seedling + 25 x 25 cm spacing
18. Based on their salt-tolerance and plant growth-promoting traits, potential strains KB1, KB3, KB5, KB6, KB7, KB9, KB11, KB13, and KB14 could be identified as salt-tolerant PGPR strains.
19. Herbicides like Penoxulam + Butachlor, Quinclorac + Bispyribac sodium, and Pretilachlor + Bensulfuron methyl show high WCE across both seasons, particularly effective against *Cynodon dactylon*, *Monochoria vaginalis*, and *Cyperus difformis*.
20. Late post-emergence herbicides, such as Flumioxazim and Bispyribac sodium + Pyrazosulfuron Ethyl, also exhibit high efficiency in the Boro season.
21. It is recommended to broadcast Penoxsulam (post-emergence) at 93.7 ml/ha with urea (5 kg/bigha) during Aman season effectively controls weeds and boosts nutrient availability, leading to better crop growth and higher grain yield.
22. It is recommended to broadcast Bispyribac sodium SC at 150 ml/ha with urea (5 kg/bigha) during Boro season effectively controls weeds and boosts nutrient availability, leading to better crop growth and higher grain yield.
23. Both T. Aman 2023 and Boro 2024 highlight that integrated weed management strategies, such as **W₁** (stale seedbed technique) and **W₃** (herbicide followed by hand weeding), are most effective in reducing weed seed banks.

3. PROPOSED TECHNOLOGY

3.1: Maximizing yield of BRRI-developed Boro varieties through influencing some Agronomic Critical Factors

For obtaining higher yield (8 to 9 t/ha) in Boro season from long duration variety (>150 day), it may recommend that-

- Seeding would be done on 1st - 2nd week of December
- TP should be done on 3rd - 4th week of December
- Younger seedlings (15 to 25-day old) should be transplanted
- Wider spacing (25 x 25 cm) should be followed
- Upper soil stirring should be done at 25 & 40 DAT
- STB fertilizer management should be followed
- Additional 1% MoP solution to be sprayed at 30 and 45 DAT
- Vermi-compost @ 1.0 t/ha to be applied as basal

Other recommended agronomic management would be followed when necessary.



3.2: Maximizing yield of BRRI developed different growth duration T Aman varieties through influencing some Agronomic Critical Factors

In T Aman season obtaining higher grain yield (>6 to 7 t/ha) from short, medium, and long-duration varieties, it may be recommended;

- Short duration T Aman (BRRI dhan71): Will be needed for seeding within 2nd week of July and transplanting within 1st week of August using 20–25-day-old seedlings with 1-2 seedlings per hill. The following Spacing should be 25 x 15 cm and STB fertilizer management would be followed, additionally 1% MoP solution is to be sprayed at 25 and 40 DAT. To maintain good growth, an additional 1.0 t/ha varmi compost should be applied just before transplanting.

- Medium duration T Aman (BRRI dhan87): Will be needed to seeding within 1st week of July and transplanting before 1st week of August with 25 days old seedlings and 1-2 seedlings per hill. The following Spacing should be 25 x 15 cm and STB fertilizer management would be followed additionally 1% MoP solution is to be sprayed at 30 and 45 DAT. To maintain good growth, an additional 1.0 t/ha varmi compost should be applied just before transplanting.
- Long duration T Aman (BRRI dhan52): Will be needed for seeding in 4th week of June and transplanting with in 3rd week of July with 20 -25-day-old seedlings and 1-2 seedlings per hill. The following Spacing should be 25 x 15 cm and STB fertilizer management would be followed additionally 1% MoP solution to be sprayed at 30 and 45 DAT. To maintain good growth, an additional 1.0 t/ha varmi compost should be applied just before transplanting.



3.3: Optimizing Seedling Age and Nitrogen Management for BRRI hybrid dhan7

- **Seedling age:** 17 days
- **Date of transplanting:** 30 April
- **Economic N rate:** 90 kg/ha
- **N schedule:** 1/3rd as basal + 1/3rd at 4-5 tiller + 1/3rd at the panicle initiation stage

How country/farmer/user will be benefitted

- The optimum seedling age of BRRI hybrid dhan7 can boost grain yield to over 7.0 tons per hectare during the Aus season.
- Farmers in the Aus-growing regions, particularly those in the southern and central parts of Bangladesh, will greatly benefit from this approach.



USEFUL SCIENTIFIC INFORMATIONS

4. PLANTING PRACTICES

4.1 Effect of time of planting on the agronomic output of newly developed BRRI varieties in different eco-system

M M Rana and M S Islam

Introduction

Changes in rice yields are closely related to meteorological factors such as altered temperature and precipitation regimes as well as phenological factors like tillering, panicle initiation, anthesis, and maturity (Zhao *et al.*, 2016). The findings of various studies have demonstrated that the maximum yield potential of rice is usually achieved when the crop is exposed to the most appropriate temperature range that may be managed by sowing at the right time (Mannan *et al.*, 2012; Patel *et al.*, 2019; Cerioli *et al.*, 2020). Planting too early in T. Aman season often causes reduced yields and grain quality as the reproductive phase coincides with the height of the heat and rice grain yield and quality are negatively affected. Planting too late can expose the crop to cold temperatures and result in higher spikelet sterility and low yield. In Bangladesh, Boro is the dry-season irrigated rice seeded from November to early February and harvested between April and June (Shelley *et al.*, 2016). Planting too early in Boro season lowers yields since the reproductive phase corresponds with cold injury, and occasionally panicles can't develop properly, which increases spikelet sterility (Mannan *et al.*, 2012). Planting too late may expose the crop to heat stress and speedy wind, which increases spikelet sterility and lowers rice yields. Thus, choosing the right timing for transplanting under specific agro-climatic conditions is the key to successful rice cultivation. This study aims to identify an optimal planting window of newly developed BRRI varieties.

Materials and methods

The experiment was conducted at BRRI farm, Gazipur during T. Aman, 2023 and Boro, 2023-24 seasons. In T. Aman season, BRRI dhan75, BRRI dhan87, BRRI dhan90, BRRI dhan52, BRRI dhan79 and BRRI dhan93 were used as test materials. The 25-day-old rice seedlings were transplanted in the field at five scheduled times (5th July, 20th July, 5th August, 20th August, and 5th September). In boro season, the 40-day-old seedlings of BRRI dhan88, BRRI dhan96, BRRI dhan101, BRRI dhan89, BRRI dhan92 and BRRI dhan102 were transplanted in the field on six scheduled times at a 15-day interval, starting on 20th November, 2022. It was a factorial experiment conducted in a split-plot design with three replications. Maturity of rice occurred at different times irrespective of planting time and test varieties. Harvesting was done depending upon the maturity (80%) of the tested entries. The harvested rice was then dried, threshed, and cleaned and necessary data were collected. The collected data were compiled and tabulated for statistical analysis. Data were analyzed statistically for analysis of variance (ANOVA).

Results and discussion

Planting time significantly influenced the grain yields in both the seasons. In T. Aman season, BRRI dhan75 and BRRI dhan87 yielded higher during transplanting on 5th August (**Table 1**). The highest yields of medium duration varieties BRRI dhan52, BRRI dhan79 and BRRI dhna93 were

observed during transplanting on 20th July to 5th August (**Table 2**). In boro season BRRI dhan88 and BRRI dhan96 yielded higher during transplanting on 25th January (**Table 3**). The highest yields of long duration varieties BRRI dhan89, BRRI dhan92 and BRRI dhan102 were observed during transplanting on 10th January (**Table 4**).

Table 1: Effect of planting time on the yield and growth duration of short duration aman rice varieties at BRRI, Gazipur during T. Aman 2023

Variety	Grain yield and growth duration									
	5 th July		20 th July		5 th August		20 th August		5 th September	
	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)
BRRI dhan75	4.04	117	4.60	114	4.94	114	4.82	111	3.51	109
BRRI dhan87	4.70	128	4.87	130	5.72	130	5.46	126	2.78	122
BRRI dhan90	3.85	124	4.50	119	4.14	120	5.07	116	4.02	110
LSD _(0.05)	1.53	4.0	1.05	3.5	1.30	3.7	0.94	4.5	1.46	4.4
CV (%)	6.2	0.2	10.0	0.3	11.7	0.1	7.3	0.2	8.8	0.1

Table 2: Effect of planting time on the yield and growth duration of medium duration aman rice varieties at BRRI, Gazipur during T. Aman 2023

Variety	Grain yield and growth duration									
	5 th July		20 th July		5 th August		20 th August		5 th September	
	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)
BRRI dhan52	6.26	146	6.73	135	6.75	130	5.36	126	3.96	118
BRRI dhan79	5.60	144	5.39	137	5.14	130	5.01	128	2.20	122
BRRI dhan93	5.65	145	6.18	136	6.15	131	5.55	127	3.49	125
LSD _(0.05)	1.39	-	0.92	0.6	1.46	-	1.37	-	0.60	1.2
CV (%)	10.6	0.2	6.7	0.1	10.2	0.1	11.4	0.2	8.3	0.3

Table 3: Effect of planting time on the yield and growth duration of short duration rice varieties at BRRI, Gazipur during boro 2023-24

Variety	Grain yield and growth duration											
	10 th Dec.		25 th Dec.		10 th Jan.		25 th Jan.		10 th Feb.		25 th Feb.	
	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)
BRRI dhan88	5.77	167	5.43	154	5.33	149	6.38	143	3.00	133	2.86	125
BRRI dhan96	5.54	165	5.17	153	5.71	143	6.37	141	3.32	130	2.02	120
BRRI dhan101	6.20	171	6.20	158	6.44	151	6.33	144	7.07	139	2.89	127
LSD _(0.05)	1.39	4.6	1.22	2.0	2.0	3.0	0.29	2.5	0.44	2.4	1.09	0.75
CV (%)	10.5	1.2	9.7	0.0	15.2	0.0	2.1	0.0	4.4	0.0	6.7	0.3

Table 4: Effect of planting time on the yield and growth duration of long duration rice varieties at BRRI, Gazipur during boro 2023-24

Variety	Grain yield and growth duration											
	10 th Dec.		25 th Dec.		10 th Jan.		25 th Jan.		10 th Feb.		25 th Feb.	
	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)
BRRI dhan89	6.86	176	6.77	166	7.99	161	7.71	150	7.62	139	4.98	132
BRRI dhan92	4.40	178	5.74	166	8.02	163	6.91	150	6.93	140	2.58	134
BRRI dhan102	5.81	180	5.80	167	7.74	164	6.92	152	7.11	142	3.42	134
LSD _(0.05)	3.00	0.75	2.38	1.02	0.89	3.5	1.93	2.00	2.11	3.00	1.07	2.7
CV (%)	13.3	0.1	17.2	0.2	5.0	0.3	11.9	0.3	12.9	3.00	0.2	0.2

Conclusion

In T. Aman season, BRRI dhan75 and BRRI dhan87 yielded higher during transplanting on 5th August. The highest yields of medium duration varieties BRRI dhan52, BRRI dhan79 and BRRI dhna93 were observed during transplanting on 20th July to 5th August. In boro season, the optimum transplanting date of BRRI dhan89, BRRI dhan92 and BRRI dhan102 to achieve maximum grain yield at Gazipur is 10th January.

4.2 Screening of inbred rice varieties having ratooning ability in the irrigated ecosystem

M M Rana, S Zahan, M A Badshah and M Hasanuzzaman

Introduction

Screening rice varieties for their capacity to ratoon effectively is essential in developing resilient and productive crops that support sustainable agriculture while addressing food security challenges. In Bangladesh, economic development has exacerbated labor shortages in rural areas. The perennial rice production system holds great promise for increasing productivity with lower input and labor requirements. Ratoon rice has emerged as a significant benefit for many marginalized farmers in Bangladesh, although it has not received much research attention. Some farmers practice ratoon rice after harvesting Boro rice, which requires only about a month, while more than a quarter (26.92%) of the country's net cropped area follows a Boro rice- Fallow-T. aman rice pattern. In this system, the field typically remains fallow for 2-3 months after harvesting Boro rice before being prepared for T. aman rice, creating an opportunity to implement ratoon rice during the fallow period. Although the yields of ratoon rice are relatively low (1.0 -1.5 t ha⁻¹) compared to the main crop, the associated costs are minimal. Ratoon technology can be extended to 10% of Bangladesh's area where Aus cultivation or other crops are not viable due to early flooding. However, for profitability, a ratooning variety must yield at least 3.0 t ha⁻¹. This study aims to screen and identify inbred rice varieties with perennial characteristics and higher grain yields.

Materials and methods

To screen and identify rice varieties with strong ratooning ability and other desirable agronomic traits an experiment was conducted at BRRI farm, Gazipur during Boro season, 2023-24. Thirty-four popular and widely adopted rice cultivars were tested for ratooning ability under 20 cm stubble cutting heights. The 35-day-old seedlings of the tested rice cultivars were transplanted in the field maintaining 20×20 cm spacing. The BRRI recommended fertilizer doses for N, P, K, S, Zn were applied @ 120, 18, 75,38 and 3.5 kg ha⁻¹, respectively. Harvesting is done after 95% panicle ripening by cutting at a height of 20 cm from the soil surface. Irrigation (2-3 cm) should be given three days after harvesting of main crop and continued for one week. Urea fertilizers was applied in the plots at the rates of 30 kg ha⁻¹ after harvesting of main crop (and tiller-promoting) followed by mulching. Maintenance of ratoon plants was similar to those conducted for main crop. Ratooning ability was measured as a ratio of total ratoon tiller to main crop tiller.

Results:

Effect of different yield contributing traits on yield of various rice genotypes

Different genotypes exhibit varying degrees of performance and the performance of these genotypes may vary for various agronomic traits and grain yield. Among the 34 rice cultivars

BR17 and Bina dhan-25 showed the longest and BR3, BRRi dhan50, BRRi dhan81, BRRi dhan86, BRRi dhan88, BRRi dhan96 shortest plant height (**Fig. 1**). The highest number of tiller was demonstrated by BRRi dhan28, BRRi dhan67, BRRi dhan97, BRRi dhan102 and BRRi dhan104 and lowest number of tiller by BR(bio)15086-AC16-3-21, BR17, Tata Miniket, BRRi dhan50, BRRi dhan75 and BRRi dhan101. The highest number of panicle was found in BRRi dhan102 followed by BRRi dhan67, BRRi dhan87, BRRi dhan89, BRRi dhan92 and BRRi dhan97 while the lowest number of panicle was observed in BRRi dhan50, BRRi dhan75, BRRi dhan96, BRRi dhan101 and BR(bio)15086-AC16-3-21. The highest leaf area index (LAI) was observed in BRRi dhan102 followed by BRRi dhan50, BRRi dhan89, BRRi dhan97, BRRi dhan101, Naria choddo and Tata Miniket. The lowest LAI was found in BR3, BR17, BRRi dhan81, BRRi dhan95 and Bina dhan-24. The superior number of grain panicle⁻¹ was observed in Tata Miniket and inferior number of grain panicle⁻¹ observed in Bina dhan-24, BRRi dhan28, BRRi dhan47, BRRi dhan84, BRRi dhan86, BRRi dhan96 and BRRi dhan105. The superior thousand grain weight was found in BR3, BRRi dhan47, BRRi dhan74, BRRi dhan97, BR(bio)15086-AC16-3-21 and Bina dhan-24 while inferior was observed in Tata Miniket followed by Bina dhan-25. BR3, BR16, BRRi dhan29, BRRi dhan89, BRRi dhan92, BRRi dhan99, BRRi dhan102, Bina dhan-5 and Bina dhan-25 was the long duration rice cultivars, whereas BRRi dhan28, BRRi dhan81, BRRi dhan88, BRRi dhan96, BRRi dhan101 and Bina dhan-10 was the short duration cultivars. Among the cultivars BRRi dhan102 showed superior grain yield followed by BRRi dhan29, BRRi dhan89 and BRRi dhan92 but Bina dhan-10, BRRi dhan28, BRRi dhan81, BRRi dhan88, BRRi dhan96 and BRRi dhan101 showed comparatively inferior grain yield (**Fig. 1**).



Fig. 1: Comparison of yield and different yield contributing traits of thirty-four rice cultivars

Correlation among yield and yield contributing traits

The estimates of correlation coefficients computed between 8 characters of HYV rice under study area were presented in **Fig. 2**. There was negative and significant association between TGW and LAI (-0.32), NG (-0.40). NG had significant and positive association with PH (0.44), GD (0.60)

and GY (0.27). Other-hand GY had significantly positive association with LAI (0.31), PH (0.29), PN (0.23) and GD (0.28). While GD and PH (0.34), PN and TN (0.51) were positive and significantly associated. Similar types of finding were demonstrated by (Roy et al., 2024).

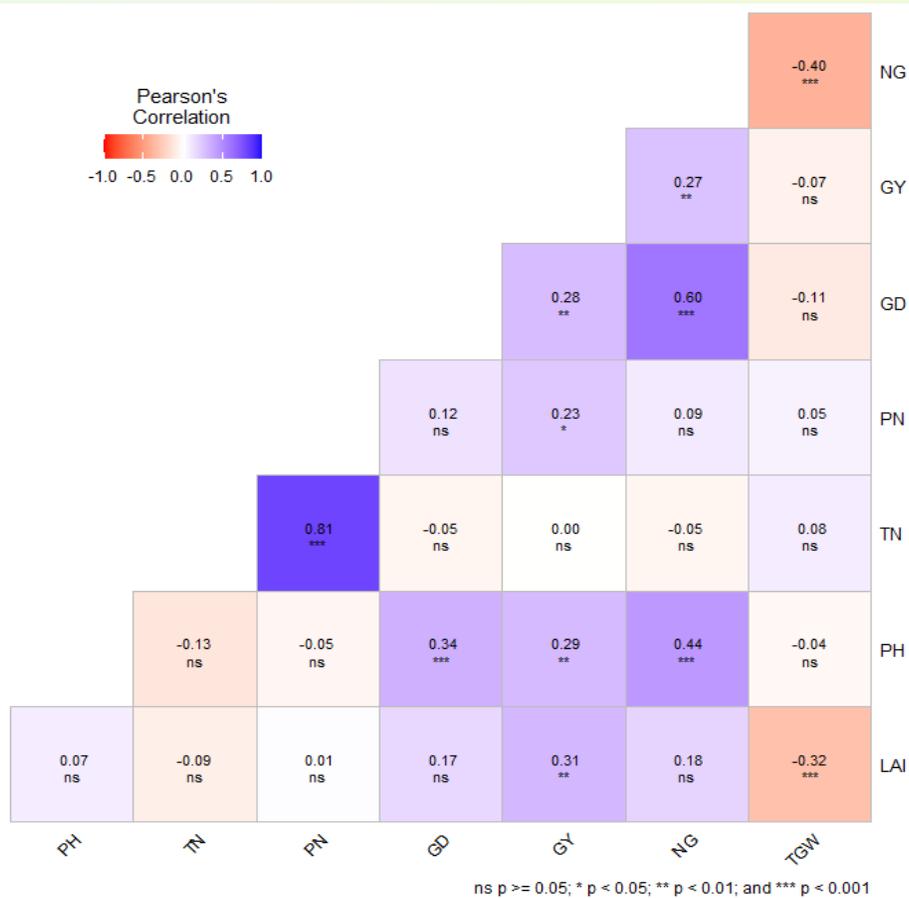


Fig. 2: Correlation co-efficient of yield and yield contributing traits

Performance of Ratoon Crops

The data presented in **Table 5** summarizes the agronomic performance of various rice cultivars evaluated at BRRI, Gazipur, focusing on ratoon crop. Key metrics include ratoon height, and ratooning ability, growth duration, and yield. Ratoon height, which can affect the subsequent growth of ratoon crops, varied from 30.00 cm (BR3) to 64.33 cm (BR17). Ratooning ability, measured as a ratio of total ratoon tiller to main crop tiller, indicates how well a cultivar can regenerate after the main harvest. There was considerable variation in ratooning ability between genotypes. Most cultivars showed relatively low ratooning ability, with several below 0.5. This suggests that while the main crop may yield well, the potential for subsequent ratoon crops varies significantly and may require careful selection of cultivars. Screened eleven genotypes (BR17, BRRI dhan28, BRRI dhan81, BRRI dhan84, BRRI dhan86, BRRI dhan88, BRRI dhan96, BRRI dhan97, Bangabandhu dhan100, Bina dhan-25 and Tata Miniket) showed ratooning potentiality, with values of 0.78 to 1.10. Ratoon crop growth durations were generally shorter than those of main crops resulting low yield. Ratoon yields ranged from 0.236 t ha⁻¹ to 1.553 t ha⁻¹. of the eleven genotypes, BRRI dhan28, BRRI dhan81, BRRI dhan97, Bangabandhu dhan100, and Tata Miniket only capable to produce yield of ratoon at least 1.00 t ha⁻¹. Tata Miniket and BRRI dhan97 exhibit remarkable ratoon yield, indicating that it is particularly efficient at producing a second crop after the main harvest (**Fig. 3**). mperature during harvesting accelerates the reproductive growth and reduced the yield of 1st ratoon crop (**Fig. 4**).

Table 5: Ratoon crop performance of the tested cultivars at BRR, Gazipur

Genotypes	Ratoon height (cm)	Ratooning ability	Growth duration (days)	Yield (t ha ⁻¹)
BR3	30.0±3.00	0.48±0.08	39±1	0.24±0.065
BR16	48.0±6.24	0.50±0.21	34±1	0.40±0.069
BR17	64.3±5.51	0.78±0.12	51±2	0.97±0.087
BRR dhan28	56.0±7.00	1.09±0.02	49±2	1.14±0.445
BRR dhan29	49.3±6.51	0.36±0.14	60±1	0.41±0.077
BRR dhan47	46.3±3.79	0.45±0.15	54±1	0.32±0.134
BRR dhan50	37.0±8.19	0.46±0.15	42±1	0.56±0.299
BRR dhan58	42.7±2.52	0.53±0.04	49±1	0.37±0.109
BRR dhan67	47.0±1.00	0.33±0.16	49±1	0.42±0.116
BRR dhan74	51.7±3.06	0.83±0.05	46±3	0.50±0.047
BRR dhan75	58.7±6.11	0.76±0.49	35±2	0.71±0.101
BRR dhan81	49.3±2.52	0.98±0.28	41±2	1.03±0.155
BRR dhan84	49.3±2.52	0.96±0.10	35±5	0.94±0.009
BRR dhan86	46.7±4.04	0.85±0.04	38±4	0.99±0.285
BRR dhan87	46.3±5.30	0.56±0.10	34±4	0.56±0.119
BRR dhan88	41.7±1.53	0.74±0.19	34±5	0.93±0.047
BRR dhan89	45.7±4.73	0.42±0.15	57±3	0.50±0.115
BRR dhan92	50.0±5.00	0.50±0.02	55±5	0.49±0.139
BRR dhan96	37.7±1.53	1.02±0.36	41±3	0.95±0.316
BRR dhan97	58.3±3.51	0.97±0.22	50±5	1.37±0.389
BRR dhan98	49.0±2.65	0.40±0.18	31±1	0.26±0.116
BRR dhan99	53.0±2.00	0.46±0.22	34±4	0.56±0.248
Bangabandhu dhan100	49.3±3.00	1.39±0.21	47±3	1.06±0.078
BRR dhan101	49.3±3.00	0.61±0.02	41±3	0.55±0.089
BRR dhan102	46.7±3.51	0.38±0.10	54±3	0.51±0.088
BRR dhan104	46.3±5.29	0.72±0.20	46±3	0.44±0.139
BRR dhan105	41.7±4.51	0.61±0.34	47±3	0.48±0.169
Bina dhan-5	45.7±2.08	0.45±0.16	34±4	0.76±0.195
Bina dhan-10	50.0±3.79	0.34±0.15	49±6	0.43±0.084
Bina dhan-24	37.7±3.06	0.55±0.10	44±4	0.41±0.076
Bina dhan-25	58.3±11.50	1.41±0.40	58±3	0.67±0.081
Naria Choddo	49.0±1.73	0.60±0.25	48±4	0.50±0.104
Tata Miniket	53.0±5.13	1.50±0.21	59±3	1.55±0.329
BR (Bio)15086-AC16-3-21	49.3±4.16	0.40±0.14	33±3	0.26±0.089



Fig. 3: 1st Ratoon crop performance of BRR dhan97 (A), Bangabandhu dhan100 (B) and Tata Minket (C) at BRR, Gazipur

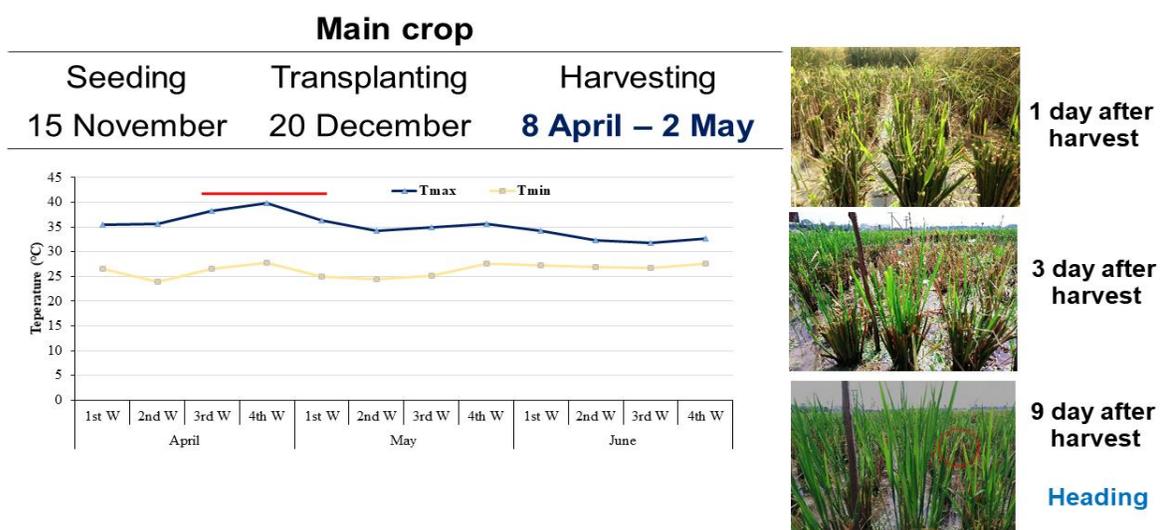


Fig. 4: Effect of high temperature during harvesting of main crop on reproductive growth of ratoon crop

Conclusion

Different genotypes exhibit varying degrees of performance and the performance of these genotypes may vary for different agronomic traits and grain yield. In main season, the cultivar BRR1 dhan102 produced higher grain yield followed by BRR1 dhan29, BRR1 dhan89 and BRR1 dhan92. There was considerable variation in ratooning ability among the genotypes. Screened eleven genotypes (BR17, BRR1 dhan28, BRR1 dhan81, BRR1 dhan84, BRR1 dhan86, BRR1 dhan88, BRR1 dhan96, BRR1 dhan97, Bangabandhu dhan100, Bina dhan-25 and Tata Miniket) showed ratooning potentiality. Tata Miniket and BRR1 dhan97 exhibit remarkable ratoon yield, indicating that it is particularly efficient at producing a second crop after the main harvest.

4.3 Increasing productivity of Ratoon Rice

M M Rana, S Zahan, N Akter, M S Islam

Introduction

Achieving high yields from ratoon rice requires careful management of cutting height and fertilizer application. The cutting height during the initial harvest plays a crucial role in determining the growth potential of the ratoon crop. A higher cutting height can promote better tillering and root development, leading to improved nutrient uptake and overall plant vigor. Conversely, cutting too low might hinder the ratoon crop's growth, limiting its yield potential. Fertilizer management is equally vital in maximizing ratoon rice productivity. The nutrient requirements of ratoon crops differ from those of the main crop, necessitating tailored fertilization strategies to ensure optimal growth and yield. This research seeks to explore the effect of both cutting height and nitrogen fertilizer management practices ratoon rice yields.

Materials and methods

To develop suitable agronomic management practices for productivity enhancement of ratoon rice an experiment was conducted at BRR1 farm, Gazipur during Boro season, 2023-24. The treatments of the experiment were included three levels of cutting height (10, 20, and 30 cm) and three levels of nitrogen fertilizer rates (25, 50 and 75% N of main crop). It was a factorial experiment conducted in a split-plot design with three replications. The 35-day-old seedlings of BRR1 dhan88 were transplanted in the field maintaining 20×20 cm spacing. In main season, the BRR1

recommended fertilizer doses for N, P, K, S, Zn were applied @ 120, 18, 75,38 and 3.5 kg ha⁻¹, respectively.

Results: Results of experiment showed that, ratooning of BRRi dhan88 affected by cutting height & nitrogen fertilizer doses. In ratoon, crop cutting height of culm at above 30 cm was found to be favourable for ratooning ability and grain yield. (Fig. 5). The highest grain yield (1.40 t ha⁻¹) was recorded from 30 cm cutting height along with 60 kg ha⁻¹ nitrogen fertilizer application. The yield and ratooning ability were lower and field duration was also shorter in ratoon crop due to high temperature during harvesting period in the last week of April.

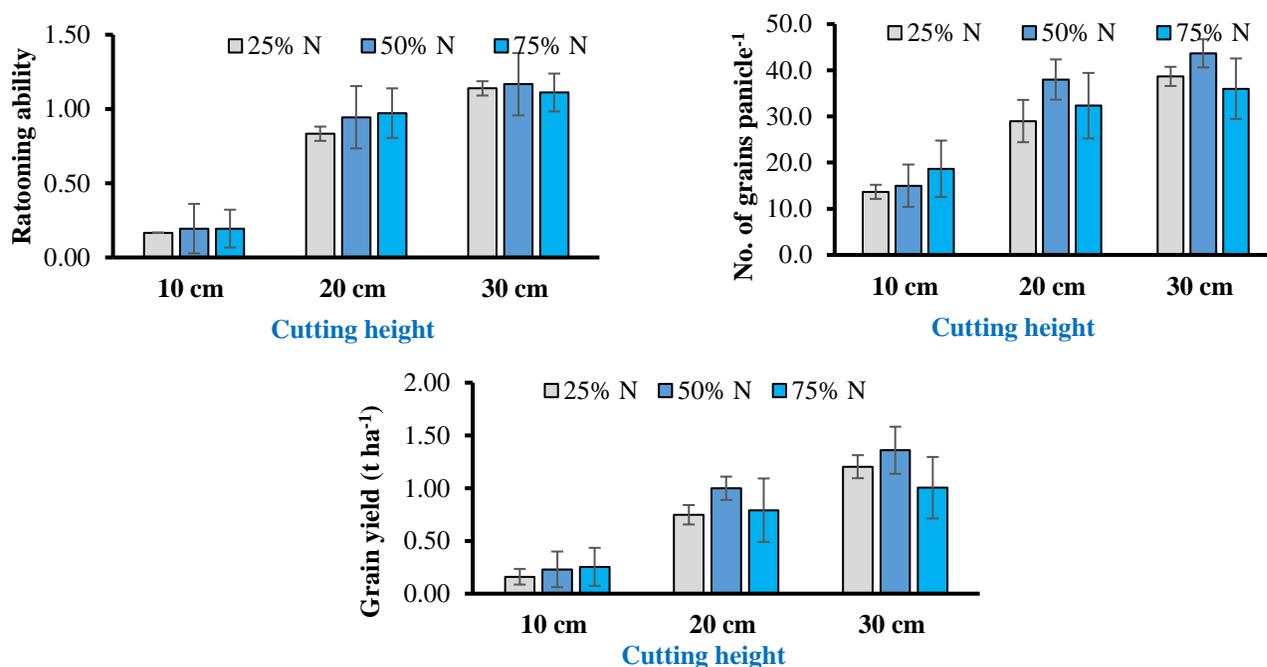


Fig. 5: Effect of cutting height and nitrogen fertilizer doses on the ratooning ability and grain yield of BRRi dhan88.

Conclusion

Ratooning of BRRi dhan88 affected by cutting height & nitrogen fertilizer dose at BRRi H/Q. The highest grain yield (1.40 t ha⁻¹) was recorded from 30 cm cutting height along with 60 kg ha⁻¹ nitrogen fertilizer application.

5. FERTILIZER MANAGEMENT

5.1 Determination of optimum seedling age and N scheduling for yield maximization of BRRi hybrid dhan7

MKA Bhuiyan, MM Mahbub, ZI Baki and M Jamil Hasan

Introduction

The significance of determining the optimum seedling age and nitrogen (N) scheduling for BRRi hybrid dhan7 lies in maximizing rice yield potential. Proper seedling age ensures robust plant establishment and optimal tillering, while efficient N scheduling enhances plant growth and grain formation. Together, they lead to improved resource use efficiency, higher grain yield, and better overall crop performance, contributing to increased productivity and food security.

Objectives:

To find out the optimum seedling age of BRRi hybrid dhan7 for maximum yield and the best N scheduling for BRRi hybrid dhan7.

Materials and methods

The experiment comprised five seedlings' ages; 10, 15, 20, 25, and 30 days and three N (90 kg ha⁻¹) splitting schedule; Basal 1/3, 1/3 after 4-5 tiller (15 DAT) and 1/3 before PI (around 25-30 DAT) (N₁), 1/2 at 10-12 DAT and 1/2 before PI (N₂) and 1/2 at basal and 1/2 before PI (around 25-30 DAT) (N₃). The experiment followed RCB design with three replications. Date of sowing of the variety was April 15, 2023 and date of transplanting was 25 April, 30 April, 5 May, 10 May and 15 May. The experiment was conducted in both Gazipur and Tok, Kapasia during Aus season 2023.

Results

Results indicated that 15 days old seedlings of BRRI hybrid dhan7 obtained the highest grain yield in three N splitting in both Gazipur and Kapasia. In Gazipur, N scheduling in 1/3rd basal, 1/3rd after 4-5 tiller (15 DAT) and 1/3rd before PI (around 25-30 DAT) showed the highest (5.93 t ha⁻¹) grain yield with 15 days old seedling and the lowest (3.78 t ha⁻¹) was observed in N scheduling in 1/2 at 10-12 DAT and 1/2 before PI with 30 days old seedlings. On the other hand, at Kapasia, N scheduling in 1/3rd basal, 1/3rd after 4-5 tiller (15 DAT) and 1/3rd before PI (around 25-30 DAT) showed the highest (6.39 t ha⁻¹) grain yield with 15 days old seedling and the lowest yield (3.51 t ha⁻¹) was observed in N scheduling in 1/2 at basal and 1/2 before PI (around 25-30 DAT) with 30 days old seedlings (Table 6).

Discussion:

The study highlights the impact of seedling age and nitrogen (N) scheduling on the grain yield of BRRI hybrid dhan7 during the Aus 2023 season at Gazipur and Kapasia. Grain yield declined with increasing seedling age at both locations, with the highest yields observed for 15-20-day-old seedlings, emphasizing the importance of younger seedlings for better crop vigor and productivity. Among the three N scheduling treatments, N₁ (split N application: basal, 1/3 after 4-5 tiller, and 1/3 before panicle initiation) consistently outperformed N₂ and N₃, likely due to improved synchronization with the crop's nutrient demand. The interaction of seedling age and N scheduling was significant at Kapasia, where yields were generally higher than at Gazipur, reflecting location-specific environmental influences. These findings recommend using 15-20-day-old seedlings combined with N₁ scheduling for optimal yield, while further site-specific studies could refine nutrient management strategies for sustainable rice production.

Table 6. Effect of seedling age and N scheduling on grain yield of BRRI hybrid dhan7 at BRRI farm, Gazipur and Kapasia during Aus 2023

N scheduling	Seedling age(days)	Location	
		Gazipur	Kapasia
Basal 1/3, 1/3 after 4-5 tiller (15 DAT) and 1/3 before PI (around 25-30 DAT) (N ₁)	10	5.69	5.73
	15	5.93	6.39
	20	5.65	6.26
	25	4.85	5.84
	30	4.10	4.39
1/2 at 10-12 DAT and 1/2 at before PI (N ₂)	10	5.42	5.49
	15	5.47	6.10
	20	5.29	5.68
	25	4.32	5.01
	30	3.78	4.08
	10	5.45	5.72

1/2 at basal and 1/2 at before PI (around 25-30 DAT) (N ₃)	15	5.57	6.18
	20	5.01	5.82
	25	4.35	5.24
	30	3.85	3.51
Lsd _(.05) for seedling age (S)		0.38	0.21
Lsd _(.05) for N scheduling (N)		0.30	0.16
Lsd _(.05) for N × S		ns	0.37
CV (%)		8.1	4.1

Conclusion

Through systematic experimentation, the optimum seedling age of 15 days and N split application in 1/3rd basal 1/3 after 4-5 tiller (15 DAT) and 1/3 before PI (around 25-30 DAT) will likely result in the highest yields for BRRI hybrid dhan7. The local environment, soil type, and management practices should guide adjustments to these recommendations.

Findings

For maximizing the yield of BRRI hybrid dhan7, it is recommended to transplant 15-day-old seedlings and apply nitrogen (90 kg N ha⁻¹) in split doses, with 33 % at basal, 33% at 4-5 tillering, and 33% at the panicle initiation stage.

5.2 Effect of foliar application of Nano-Zinc Oxide on growth and yield of rice under salinity stress

M M Rana, S A Islam and R Shultana

Introduction

Salinity stress poses a significant challenge to rice cultivation, impacting both plant growth and yield. As the global population continues to expand, there is an urgent need to develop effective strategies that can mitigate the adverse effects of salinity on crop. Rice, as a staple for millions worldwide, is particularly vulnerable to salinity stress due to its susceptibility to sodium chloride in soils. The detrimental effects on plant physiology often result in reduced growth and diminished. Consequently, there is a growing interest exploring innovative approaches such as Nano-Zinc Oxide foliar application as a potential solution to rice productivity under saline conditions. The present experiment was carried out to investigate the effect of Nano-Zinc Oxide on growth, yield, and mineral status of rice under under salinity and chilling stresses

Methodology

In this study, <100 nm ZnO NPs was used (Sigma Aldrich, Saint Louis, MO, USA). Suspension of nano ZnO were prepared with varying concentrations (0, 25 and 50 mg/L) in deionized water and dispersed by ultrasonic vibration (100 W, 40 kHz) for 30 min to avoid aggregation. Rice seeds of two different cultivars were used as planting materials. Prior to experimentation, to avoid surface contamination, seeds were surface sterilized for 30 s by 70% ethanol, following 30 min treatment of 2.5% sodium hypochlorite, and then rinsed three times with deionized water. Next, seeds were placed in sterile Petri dishes (50 seeds on each plate) on filter paper moistened with about 2 mL of deionized water (control) or treatment solution (25 mg/L). The dishes were arranged in a simple randomized design with single factor and three replicates. Petri dishes were wrapped with an aluminum foil, incubated at 28 ± 2 °C, and kept in the dark. The number of seeds

germinated was counted day after day 3. In the second stage, in order to evaluate the effect of ZnO-NPs on seedlings growth pre-germinated seeds were placed in 230-mL plastic pots filled with rice nursery culture soil. The experiment consisted of four treatments: 0 (control), and 50 mg/L. Nano zinc oxide was foliar sprayed ten days after germination. The salt stress was imposed fourteen days after germination. The experiment used three biological replicates, each with 10 seedlings. Phenotype was evaluated 2 weeks after salt was imposed.

Results

No significant difference in seed germination was observed. The results indicated an increase in plumule and radicle length for both rice varieties treated with 25 ppm ZnO-NPs (Fig. 6). Both the rice varieties had significantly better shoot growth treated with zinc oxide nano particle in both saline and non-saline conditions (Fig. 7).

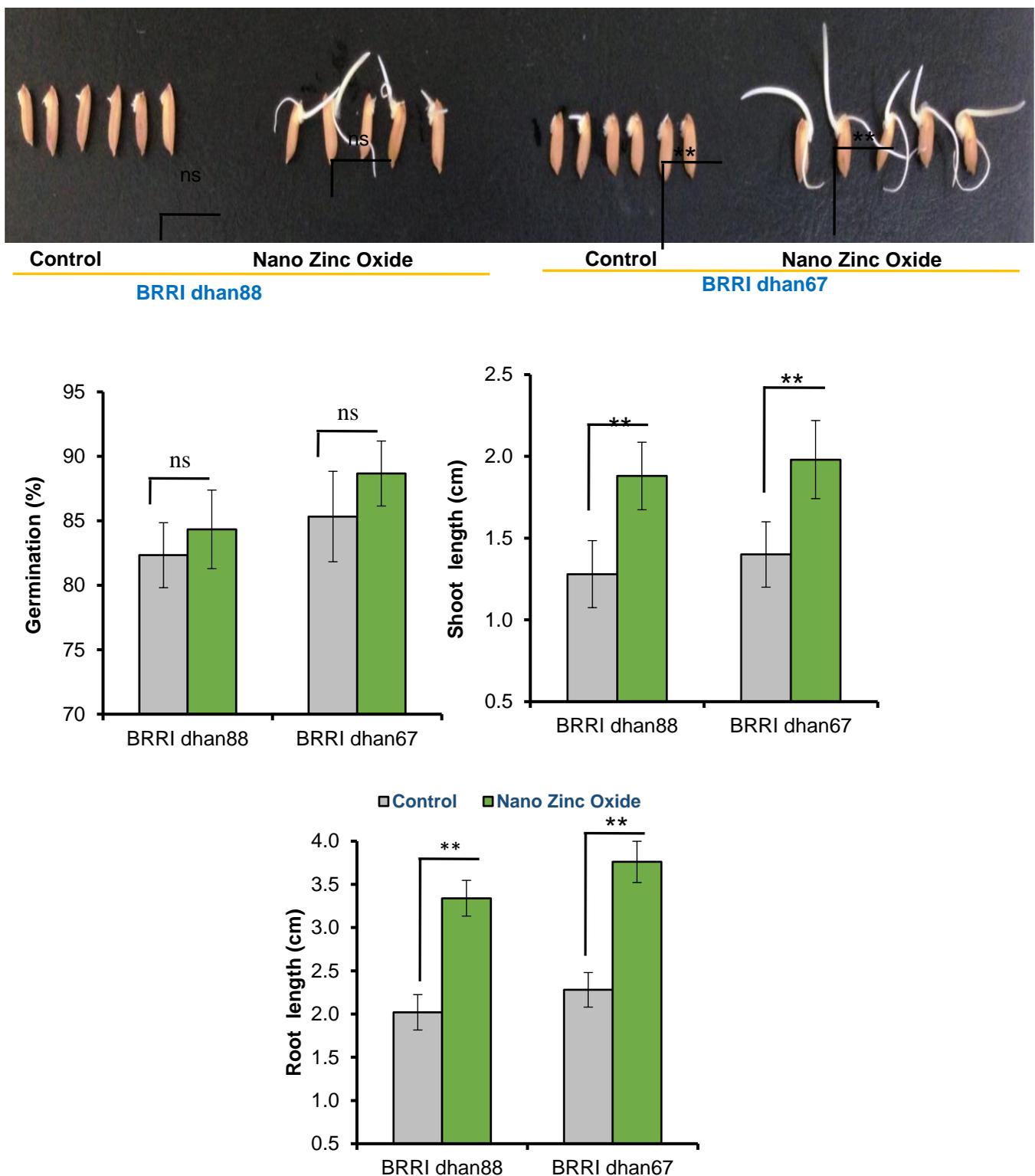


Fig. 6: Effect of zinc oxide NPs on the seed germination of the tested rice cultivars

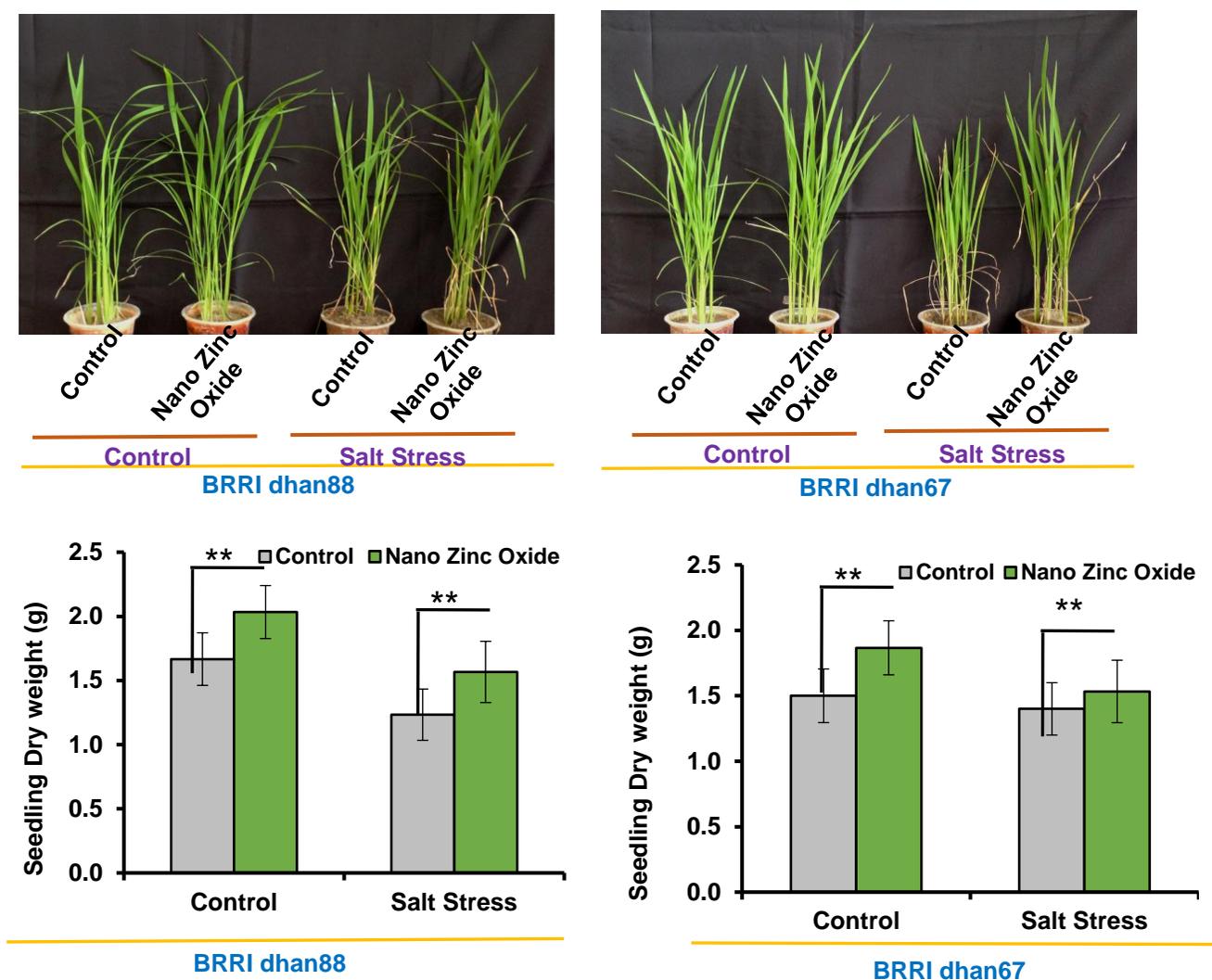


Fig. 7: Phenotypic comparison of BRRi dhan88 and BRRi dhan67 seedlings treated with 50 mM Nano zinc oxide in both saline and non-saline conditions

Conclusion

Seed priming with 25 ppm Nano-Zinc Oxide accelerates germination of rice seed. 50 ppm Nano-ZnO spray improves plant growth at seedling stage in both saline and non-saline conditions.

5.3 Effect of N levels and growth stage-based N application on yield and nitrogen use efficiency of Rice

M M Mahbub, M K A Bhuiyan, R Akter and M Sh Islam

Introduction

Nitrogen is one of the most important essential elements for plants and is required in comparatively larger amounts. Nitrogen is often applied to plants to ensure economically viable grain yields. Yield levels presently achieved by Bangladeshi farmers depend on large amounts of N fertilizer. But excess fertilizers can reduce soil fertility. Successful nitrogen management in different growth stage of rice can optimize crop yields.

Objective:

1. To find out the influence of growth stage-based nitrogen application on yield of rice
2. To find out optimum N rate for higher yield and uptake in grain & straw

Materials and Methods

The experiment was conducted at the Bangladesh Rice Research Institute (BRRRI) farm, Gazipur, during T. Aman, 2023 to find out the influence of growth stage-based nitrogen application on growth and yield of rice. N fertilizer was applied on rice plant growth stage basis (According to Ricard and Jony 2005: Louisiana rice production handbook; De datta 1981; Yousida, 1981). The treatments were; A: Nitrogen level (kg ha⁻¹): i) N₁: STB (78kg ha⁻¹), ii) N₂: BRRRI recom. (92 kg ha⁻¹), iii) N₃: STB + 10% (86 kg ha⁻¹), iv) N₄: STB + 20% (94kg ha⁻¹), v) T₅: Control (N₀); and B. Varieties: i) V₁: BRRRI dhan87 and ii) V₂: BRRRI dhan95. Urea was applied 1st top dress at 1st tillering (9 DAT); 2nd top dress at mid tillering (24 DAT) and 3rd top dress before PI stage (41 DAT). The treatments were distributed in factorial RCBD with three replications. Twenty-six-day-old seedlings were transplanted during Aman season. All fertilizers except urea were applied during final land preparation. Irrigation, weeding, disease and insect control were done as and when necessary. Yield data were recorded during harvesting. Statistical analysis was done by CropStat program. Initial soil status of the experimental field was pH = 6.3, Total N = 0.11%, P = 8.9 ppm, K = 0.14 me/100 g soil, S =21.2 ppm and Zn = 2.1 ppm.

Nitrogen content and Nitrogen uptake by rice plants

After harvest grain and straw samples were taken from respective plots and all samples were oven-dried, weighed, ground, and then subsamples were taken for N determination. N content in grain and straw was measured by the standard micro-Kjeldahl procedure. N uptake in grain and straw was calculated by following formulae.

$$\text{Nitrogen uptake by grain (kg ha}^{-1}\text{)} = \frac{\% \text{ N in grain} \times \text{Grain yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}\text{)} = \frac{\% \text{ N in straw} \times \text{straw yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{NUE (\%)} = \frac{\text{Total N uptake from fertilized plot} - \text{Total N uptake from unfertilized plot}}{\text{Rate of Fertilizer N applied}} \times 100$$

The optimum N dose for the tested T. Aman rice variety was determined by regression the grain yield with the N rates: $Y = a + bN + cN^2$ Where, Y was rice yield (kg/ha), N was nitrogen dose (kg/ha), a was intercept (estimated yield without N application), b and c were coefficients, respectively (Saleque *et al.*, 2004). Differentiating Y with respect to N of the equation gives the nitrogen dose for the maximum yield. The estimated nitrogen dose for maximum yield calculated by $N = -b/2c$.

Results and discussion

BRRRI dhan87 gave the highest grain yield 5.88 t ha⁻¹ with BRRRI recommended dose followed by STB + 20% N (5.50 t ha⁻¹) (Table 7) due to produce higher panicle m⁻², grains panicle⁻¹ and thousand grain weight. Whereas, the lowest grain yield 3.16 t ha⁻¹ found in N₀ treatment. BRRRI dhan95 gave highest grain yield 5.67 t ha⁻¹ with STB treatment due to produce higher panicle m⁻², grains panicle⁻¹ and thousand grain weight. The lowest grain yield 3.03 t ha⁻¹ found in N₀ treatment in BRRRI dhan95.

It is observed (Table 8) that highest grain N uptake was observed in BRRRI dhan87 with BRRRI recom. dose and STB + >20% N and BRRRI dhan95 with STB treatment. On the other hand, N

uptake is higher in STB treatment of BRRi dhan87 and BRRi recommended dose treatment of BRRi dhan95 in straw. Partitioning of N in grain is higher compared to straw in these treatments, hence NHI is higher in these treatments. The highest N harvest index found in BRRi recom. dose and STB + 20% treatment of BRRi dhan87 and STB treatment of BRRi dhan95. Figure 1 showed that the highest Nitrogen use efficiency (%) was found in BRRi recom. dose treatment and STB + 20% of BRRi dhan87, respectively and in case of BRRi dhan95, highest NUE found in STB treatment. Hence, BRRi dhan87 gave highest grain yield in BRRi recon dose treatment; whereas, BRRi dhan95 gave highest grain yield in STB treatment (Fig. 8).

Table 7. Effect of Nitrogen levels on yield and ancillary characters of BRRi dhan87 and BRRi dhan95 during T. Aman, 2023 at BRRi farm, Gazipur

Variety	Nitrogen rate	Plant ht. (cm)	Panicle m ⁻²	Grains panicle ⁻¹	1000 grain wt. (g)	Grain yield (t ha ⁻¹)
BRRi dhan87	STB	113	223	112	24.3	4.71
	BRRi recom. dose	116	251	113	24.2	5.88
	STB + 10%	115	215	110	24.3	4.96
	STB + 20%	114	238	112	24.1	5.50
	N ₀	109	160	105	24.2	3.16
BRRi dhan95	STB	117	266	106	21.5	5.67
	BRRi recom. dose	114	245	104	21.6	5.29
	STB + 10%	112	239	104	21.5	5.15
	STB + 20%	113	236	103	21.5	5.07
	N ₀	111	165	97	21.4	3.03
Lsd (0.05)		2.38	10.36	3.53	0.54	0.34
CV (%)		5.82	5.72	6.73	7.64	5.87

Table 8. Nitrogen (%), uptake and NHI of different treatments during T. Aman season, 2023

Variety	N rate	N (%) in grain	N (%) in Straw	N uptake in grain (kg ha ⁻¹)	N uptake in straw (kg ha ⁻¹)	N harvest index
BRRi dhan87	STB	1.12	0.72	52.84	52.12	50.29
	BRRi recom. dose	1.20	0.69	70.62	45.44	60.72
	STB + 10%	1.13	0.70	56.07	48.37	53.64
	STB + 20%	1.17	0.73	64.46	49.73	56.42
	N ₀	1.11	0.66	35.16	44.48	43.45
BRRi dhan95	STB	1.10	0.62	62.43	42.51	59.42
	BRRi recom. dose	1.03	0.69	54.53	45.19	54.66
	STB + 10%	1.05	0.64	57.74	41.15	58.37
	STB + 20%	1.02	0.67	51.24	44.86	53.20
	N ₀	1.07	0.60	32.52	40.5	44.46
Lsd (0.05)		0.15	0.09	4.86	6.51	3.12
CV%		7.34	8.46	7.39	9.14	5.62

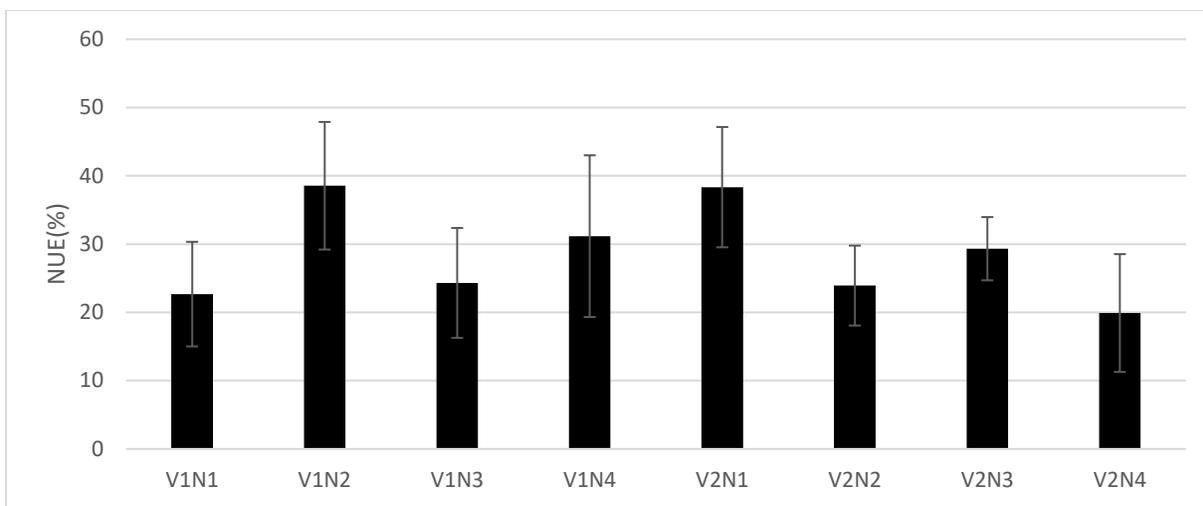


Fig 8: Nitrogen Use Efficiency of BRRRI dhan87 (V₁) and BRRRI dhan95 (V₂) with different N rates

Conclusion:

BRRRI dhan87 gave highest grain yield at BRRRI recommended dose. BRRRI dhan95 gave higher yield with STB nitrogen dose that 15% less than BRRRI recommended dose.

5.4 Yield loss assessment due to skip of N at certain growth stage of rice

MM Mahbub, R Akter and MKA Bhuiyan

Introduction

Agronomic management (especially fertilizer) is very important for every stage of the life cycle of rice plant (Bhuiyan *et al.*, 2022). Nitrogen is one of the most important essential elements for rice plants. Successful nitrogen management in different growth stage of rice can optimize crop yields (Bhuiyan *et al.*, 2020). N application increases the rice dry matter (Qiao *et al.*, 2013) and yield. If Nitrogen application have avoided in any part of growth stage, then it will reduce the yield and it is essential to find out the effect of N application on rice yield in each stage of life cycle.

Objective

To identify yield loss of rice due to improper N application

Materials and Methods

The experiment was conducted at the Bangladesh Rice Research Institute (BRRRI) farm, Gazipur, during Boro, 2023-24 to find out the yield loss of rice due to improper N application. N fertilizer was applied on rice plant growth stage basis (According to Ricard and Jony 2005: Louisiana rice production handbook; De datta 1981; Yousida, 1981). The treatments were; A: Nitrogen level (kg ha⁻¹): i) N₁: Control (N₀), ii) N₂: 3 split (1st tillering =1/3 N, Active tillering =1/3 N, before PI = 1/3 N), iii) N₃: 2 split (1st tillering =0 N, Active tillering =1/3 N, before PI = 1/3 N), , iv) N₄: 2 split (1st tillering =1/3 N, Active tillering =0 N, before PI = 1/3 N), v) N₅: 2 split (1st tillering =1/3 N, Active tillering =1/3 N, before PI = 0 N); and B. Varieties: i) V₁: BRRRI dhan92 and ii) V₂: BRRRI dhan96. The treatments were distributed in RCB two factor design with three replications. Urea was applied 1st top dress at 1st tillering (V₁=13 DAT and V₂=11 DAT); 2nd top dress at mid tillering (V₁=29 DAT and V₂=26 DAT) and 3rd top dress before PI stage (V₁=48 DAT and V₂=42 DAT). Thirty-six-day-old seedlings were transplanted during Boro season. BRRRI recommended fertilizer dose (BRRRI dhan92: N:P:K:S=138:20:84:21 kg ha⁻¹ and BRRRI dhan96: N:P:K:S=115:18:75:21 kg ha⁻¹) was applied. All fertilizers except urea were applied during final

land preparation. Irrigation, weeding, disease and insect control were done as and when necessary. Yield data were recorded during harvesting. Statistical analysis was done by CropStat program. Initial soil status of the experimental field was pH = 6.3, Total N = 0.11%, P = 8.9 ppm, K = 0.14 me/100 g soil, S = 21.2 ppm and Zn = 2.1 ppm.

Nitrogen content and Nitrogen uptake by rice plants

After harvest grain and straw samples were taken from respective plots and all samples were oven-dried, weighed, ground, and then subsamples were taken for N determination. N content grains and straw was measured by the standard micro-Kjeldahl procedure. N uptake in grain and straw was calculated by following formulae.

$$\text{Nitrogen uptake by grain (kg ha}^{-1}\text{)} = \frac{\% \text{ N in grain} \times \text{Grain yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}\text{)} = \frac{\% \text{ N in straw} \times \text{straw yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{NUE (\%)} = \frac{\text{Total N uptake from fertilized plot} - \text{Total N uptake from unfertilized plot}}{\text{Rate of Fertilizer N applied}} \times 100$$

The optimum N dose for the tested Boro rice variety was determined by regression the grain yield with the N rates: $Y = a + bN + cN^2$ Where, Y was rice yield (kg/ha), N was nitrogen dose (kg/ha), a was intercept (estimated yield without N application), b and c were coefficients, respectively (Saleque *et al.*, 2004). Differentiating Y with respect to N of the equation gives the nitrogen dose for the maximum yield. The estimated nitrogen dose for maximum yield calculated by $N = -b/2c$.

Results and discussion

From the experiment BRRRI dhan92 gave the highest grain yield 7.23 t ha⁻¹ on N₂ treatment. N₄, N₃ and N₅ treatment produced 6.40 t ha⁻¹, 6.07 t ha⁻¹ and 5.87 t ha⁻¹ grain yield, respectively which is 11%, 16% and 19% less than N₂ (Table 9) and consequently panicle m⁻², grains panicle⁻¹ and thousand grain weight also higher in these treatments. Whereas, the lowest grain yield 3.68 t ha⁻¹ found in N₀ treatment. BRRRI dhan96 gave highest grain yield 6.27 t ha⁻¹ on N₂ treatment. N₄, N₃ and N₅ treatment grain yield produced 5.67 t ha⁻¹, 5.49 t ha⁻¹ and 5.32 t ha⁻¹, respectively which is 10%, 12% and 15% less than N₂ (Table 10) and consequently panicle m⁻², grains panicle⁻¹ and thousand grain weight also higher in these treatments. The lowest grain yield 3.51 t ha⁻¹ found in N₀ treatment of BRRRI dhan95.

It is observed from Table 10 that highest N uptake was in N₂ treatment of both BRRRI dhan92 and BRRRI dhan96 in grain. On the other hand, N uptake in straw is higher in N₀ treatment of both BRRRI dhan92 and BRRRI dhan96. Partitioning of N in grain is higher compared to straw in these treatments, hence NHI is higher in these treatments. The highest N harvest index found in N₂ treatment of both varieties. When 3 split of N fertilizer applied at appropriate stage (growth stage based) than grain yield is highest. When N fertilizer avoid at a certain stage than found that, if fertilizer avoid at 1st tillering stage than yield loss 12 – 16%, if fertilizer skip at active tillering than yield loss 10- 11% and if N fertilizer missed at before PI stage than yield loss 18 – 24%.

Table 9. Effect of Nitrogen scheduling on yield during Boro, 2023-24 at BRRI, Gazipur

Variety	N scheduling	Panicle m ⁻²	Grains panicle ⁻¹	1000 grain wt. (g)	Grain yield (t ha ⁻¹)
BRRI dhan92	N ₁	181	102	23.5	3.68
	N ₂	270	116	24.1	7.23
	N ₃	232	115	23.9	6.07
	N ₄	243	115	23.8	6.40
	N ₅	231	113	23.6	5.53
BRRI dhan96	N ₁	192	104	19.8	3.51
	N ₂	280	114	20.1	6.27
	N ₃	252	116	20.3	5.49
	N ₄	263	113	19.9	5.67
	N ₅	248	113	20.1	5.14
LSD _(0.05)		11.42	2.16	0.48	0.46
CV (%)		7.63	9.17	6.37	6.19

N₁: Control (N₀), N₂: 3 split (1st tillering =1/3 N, Active tillering =1/3 N, before PI = 1/3 N), N₃: 2 split (1st tillering =0 N, Active tillering =1/3 N, before PI = 1/3 N), N₄: 2 split (1st tillering =1/3 N, Active tillering =0 N, before PI = 1/3 N), N₅: 2 split (1st tillering =1/3 N, Active tillering =1/3 N, before PI = 0 N)

Table 10. Nitrogen uptake and NHI of different treatments during Boro season, 2023-24

Variety	N scheduling	N% in grain	N% in Straw	N uptake grain (kg ha ⁻¹)	N uptake straw (kg ha ⁻¹)	N harvest index
BRRI dhan92	N ₁	1.08	0.72	40.36	51.21	44.11
	N ₂	1.23	0.71	86.56	49.67	63.51
	N ₃	1.14	0.67	69.24	46.41	59.88
	N ₄	1.17	0.70	74.94	48.25	60.70
	N ₅	1.15	0.69	63.61	46.85	57.56
BRRI dhan96	N ₁	1.06	0.63	37.26	42.98	46.40
	N ₂	1.16	0.72	72.79	48.74	59.87
	N ₃	1.10	0.66	60.40	44.59	57.52
	N ₄	1.11	0.70	62.98	46.73	57.35
	N ₅	1.09	0.63	58.03	41.01	58.58
Lsd _(0.05)		0.17	0.09	2.63	3.76	4.27
CV%		5.47	6.25	7.49	8.16	7.14

Conclusion

Before PI stage is the most crucial time for N fertilizer application. If fertilizer application is missed at this stage than yield loss drastically.

5.5 Effect of foliar application of chitosan on growth, yield and physio-biochemical characteristics of rice under salinity stress

N Akter, M M Rana and R Akter

Introduction

Salinity is a serious threat to the crop production in the southern region of Bangladesh and it is one of the adverse environmental factors that affect plants growth from seed germination to productivity. Reduced plant growth and photosynthesis occurs in saline condition due to osmotic stress and ion toxicity. Salinity-induced yield reduction of rice is alarming for the food security of the ever-growing population of the world, especially in Asia. So, it is an urgent task of agronomists to salinity management to ensure food security of rising population, since the expansion of rice-

growing areas is limited because of various stresses including salinity (Munns 2002). Chitosan (CS) similar to plant growth regulators, is a partially deacetylated form of chitin, a natural biopolymer from the exoskeleton of crab, shrimp and fungal cell walls, which is biocompatible, biodegradable and a sustainably renewable cheap resource that has many applications, including plant defense, confer resistance against salinity stress. Exogenous chitosan application could mitigate salt stress by increasing antioxidant enzyme and foliar application of chitosan on plant yield has been evaluated. Despite all this knowledge, there are still many points that need to be clarified about the variety-specific alleviating capability of chitosan under salt stress. The present study aims to elucidate the chitosan's response on growth, chlorophyll content, proline content, malondialdehyde (MDA) content and yield of salt-sensitive and salt-tolerant rice cultivars under salinity stress.

Materials and Methods

A pot experiment was conducted at rain-out shelter of the Agronomy Division, BRRI, Gazipur in T Aman, 2023. The pots were set as split-split design with three replications. The main plots represent two salinity levels; i. 0 mM NaCl, ii. 65 mM NaCl (Approximately 6.5 dS m⁻¹). Sub-plots represent two concentrations of chitosan; i. 0 ppm, ii. 250 ppm. Sub-sub-plots represented two rice varieties; i. BRRI dhan49 (salt sensitive), ii. BRRI dhan73 (salt tolerant). Chitosan was sprayed two times at active tillering and at heading stages. Twenty-five-day-old seedling was transplanted using two seedlings per hill on 30 July, 2023. The full dose of P-K-S was applied during final pot preparation and N was applied in three splits (1/3rd at 15 DAT, 1/3rd at 30 DAT and 1/3rd at 45 DAT) following BRRI recommended dose. Each pot (10 kg soil) received 1.2 g N, 0.8 g P, 0.50 g K 0.8 g S and Zn 0.15 g, as Urea, TSP, MOP, Gypsum and ZnSO₄ respectively. Lipid peroxidation was determined by measuring malondialdehyde (MDA) formation using the thiobarbituric acid method as previously reported by Madhava Rao and Sreaty, 2000. Chlorophyll content was determined according to the method developed by Coombs et al., (1985). Proline content was determined by method of Bates et al. (1973). Leaf sample (100 mg) was homogenized in a chilled mortar with pestle using 10 mL of 3% sulfosalicylic acid. The homogenate was centrifuged (10500 g for 10 min) and then two milliliters of the sample extract were pipette into the test tube followed by 2 mL acid ninhydrin and 2 mL glacial acetic acid and then incubated for 1 hour at 100 °C. The reaction was started by adding 4 mL of toluene. The absorbance of the collected toluene was measured at 520 nm in a uv spectrophotometer (Shimadzu, Japan).

Results and Discussion

Chlorophyll content, relative water content, proline content, MDA content and Na⁺ /K⁺ ratio in rice plants

Chlorophyll content indicates the greenness of leaves, which differed significantly due to different salinity level. The highest chlorophyll content; chlorophyll a (3.46 mg g⁻¹ FW) was measured in BRRI dhan49. Salt stress (65 mM) caused a drastic reduction (1.45 mg g⁻¹ FW) in Chl 'a' and Chl 'b' contents compared to non-stress condition in the BRRI dhan49, whereas salt tolerant cultivar BRRI dhan73 showed a slight reduction (1.77 mg g⁻¹ FW). The content of Chl 'a' was found higher in the sensitive cultivar compared to tolerant cultivar. On the contrary, supplementation of CS showed significant alleviation (3.36 and 3.2 mg g⁻¹ FW) of Chl 'a' and Chl 'b' content in BRRI dhan49 and BRRI dhan73 (Fig. 9A).

BRRi dhan49 recorded the highest (80%) relative water content compared to BRRi dhan73. Sharp decreases in relative water content (51% in BRRi dhan49 and 41% in BRRi dhan73 at 65 mM salt-stressed condition) was observed in response to salt stress, compared to untreated control (Fig 9B). CHT could increase relative water content under salt-stressed conditions. In both varieties, significant differences of proline contents were found in both saline and non-saline conditions. The proline and MDA content were significantly higher in BRRi dhan49 ($65.8 \mu\text{g g}^{-1}$ of FW and $15.87 \mu\text{mol g}^{-1}$ of FW) in saline conditions (Fig. 9C-D).

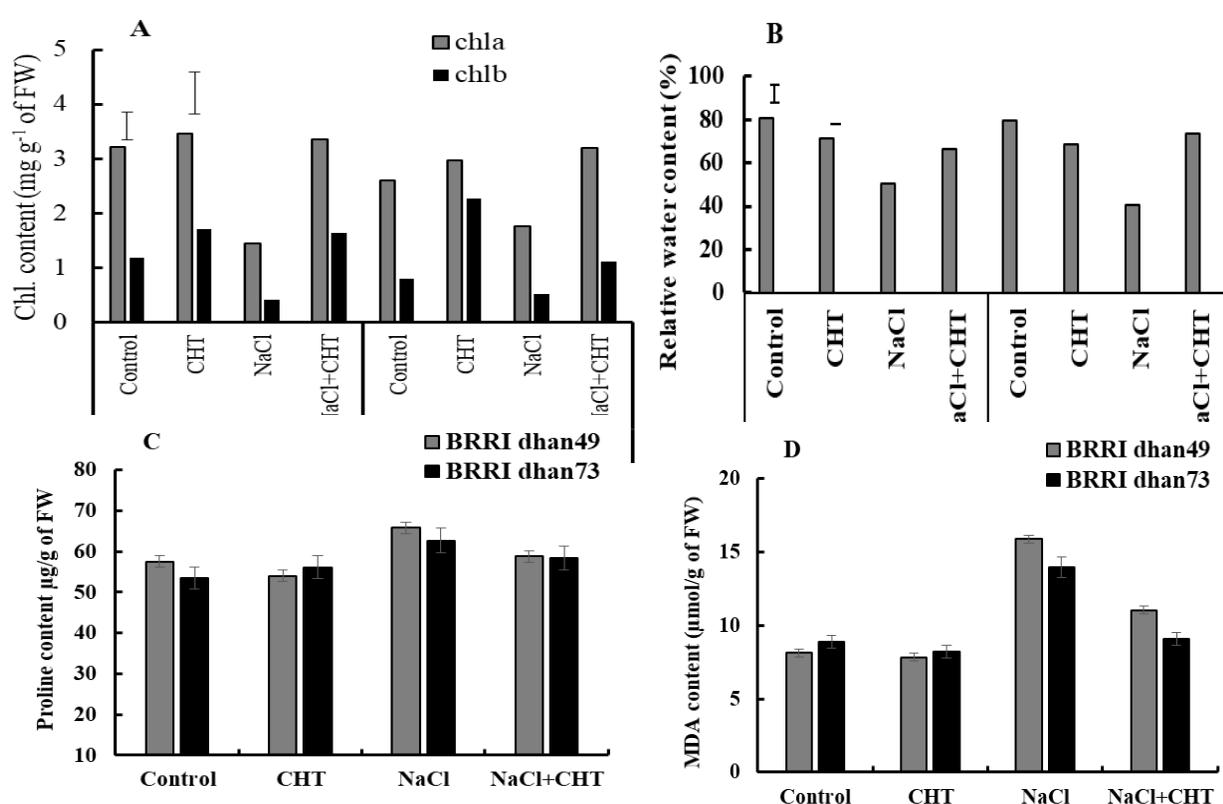


Fig. 9: Chlorophyll content, Relative water content, Proline content and MDA content (A, B, C, D) at heading stage of BRRi dhan49 and BRRi dhan73 under salinity stress. Vertical bars represent Lsd (0.05).

Saline conditions supplemented with 250 ppm of CHT mitigate the up regulation of the relative water content, proline and MDA content of both varieties (Fig. 9 C, D). After exposure to 65 mM NaCl, BRRi dhan49 accumulated less Na^+ and maintained higher K^+ levels in straw and grain, compared to BRRi dhan73 (Fig. 10 A, B). Significant increases in Na^+/K^+ ratio in grain and straw of both varieties were observed in response to salt stress. On the contrary, CHT application showed a significant decrease in grain Na^+/K^+ ratio in both varieties' response to salt stress (Fig. 10 A, B).

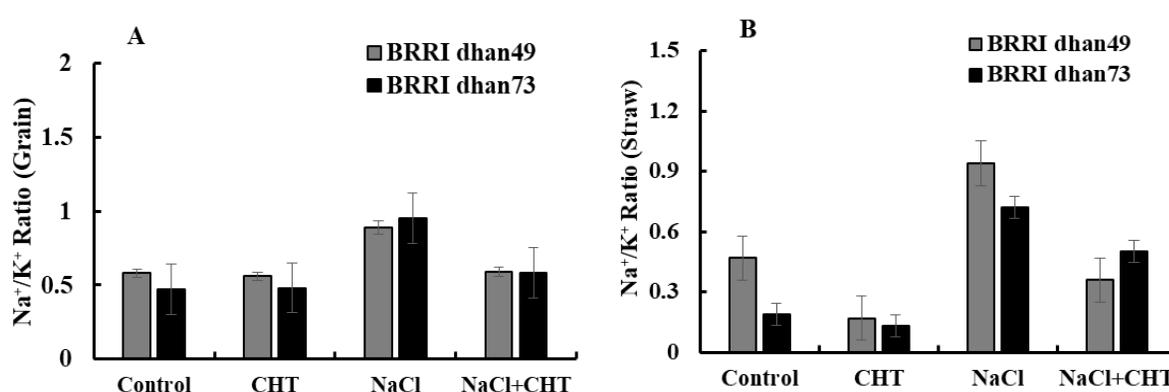


Fig. 10: Na^+/K^+ ratio in grain and straw (A, B) at maturity stage in the two rice cultivars under salinity stress. Vertical bars represent Lsd (0.05).

Salinity (65 mM NaCl) caused a significant reduction (22.3% and 33.7%) in plant height of BRRi dhan49 and BRRi dhan73 compared with respective control plants during growth stages. In both varieties 65 mM salinity level reduced panicle hill⁻¹. Grains panicle⁻¹ was significantly influenced by different treatments in BRRi dhan49 compared to BRRi dhan73. In saline conditions, yield reduction was found from both variety and chitosan spray, which could slightly mitigate the saline stress in BRRi dhan73. In BRRi dhan49, grains panicle⁻¹ and grain yield reduced in saline conditions but with 250 ppm chitosan spray grains panicle⁻¹ and grain yield increased in both saline and non-saline conditions (Table 11). BRRi dhan49 gave a higher yield compared to BRRi dhan73 for all treatments. In 65 mM salinity level BRRi dhan49 gave 46.8% higher grain yield with 250 ppm chitosan spray than without spray (Table 11).

Table 11. Effect of salinity and Chitosan spray on growth and yield components of BRRi dhan49 and BRRi dhan73 in T. Aman 2023, BRRi, Gazipur

Salinity level	Chitosan spray	Variety	Plant height (cm)	Panicle hill ⁻¹	Grains panicle ⁻¹	1000 GW (g)	Grain wt. (g pot ⁻¹)
0 mM	0 ppm	BRRi dhan49	112.6	17	121	16.5	33.8
		BRRi dhan73	135.0	14	111	19.0	29.4
	250 ppm	BRRi dhan49	116.0	16	120	16.6	32.8
		BRRi dhan73	131.6	13	129	19.1	31.3
65 mM	0 ppm	BRRi dhan49	92.0	23	24	12.6	7.7
		BRRi dhan73	101.6	14	15	13.6	3.7
	250 ppm	BRRi dhan49	96.0	26	39	14.3	14.5
		BRRi dhan73	116.0	19	19	14.6	5.3
Lsd (0.05)			7.96	4.27	20.11	1.66	6.25
CV%			4.0	13.2	15.6	6.0	17.8

Conclusion

Salt stress caused a reduction in growth, chlorophyll content, relative water content and yield of both varieties. In summary, the foliar application of chitosan was an effective way to improve the salt tolerance of rice. The enhanced salt tolerance could be partially attributed to the improved water status and enzyme activity in the leaves. Exogenous application of chitosan significantly improved the growth, ameliorated the adverse effects of salt stress on rice by decreasing the Na⁺/K⁺ ratio and higher grain weight of both varieties in response to salt stress.

5.6 Mitigation of heavy metals bio-accumulation in rice varieties through agronomic management under polluted soils of Gazipur

N Akter, M M Rana and R Akter

Introduction

Soil contamination with heavy metals represents a global environmental issue with adverse consequences for the environment and human health. Long-term use of wastewater on agricultural lands contributes significantly to the build-up of the elevated levels of these metals in soils and plants (Mapanda *et al.*, 2005; Sharma *et al.*, 2007) which is of serious concern. High concentration of different heavy metals in soils of industrial areas may cause reduction in crop yields as well as long term risks to ecosystems and humans health.

In Bangladesh, industrial wastes and effluents are released into the soil, canals, and rivers without treatment. Heavy metals like arsenic, lead, cadmium, and chromium are non-biodegradable toxic chemicals found in natural mineral deposits and industrial wastes (Qin *et al.*, 2021). Heavy metals are the most prevalent contaminants in Bangladesh's ecosystems, which include agricultural land, foodstuffs, urban soil, and rivers (Proshad *et al.*, 2020; Hasan *et al.*, 2021). Rapid population growth, economic demand, an industrial revolution, the textile and composite industries, had been

occurred in Bangladesh during the last decade, at the same time industrial pollution or waste-water pollution had been producing massive amounts. The waste-water from industries and municipalities has various negative impacts on the surrounding ecosystem due to the lack of effluent treatment plants, improper disposal and management practices for waste-water and presence of toxic substances in waste-water in deleterious amounts (Makino *et al.*, 2006).

Tongi-Gazipur is considered as one of the most important industrial areas in Bangladesh. Different types of industrial units in this area such as dyeing and textile, garments, pharmaceutical industries, chemical industries, etc. Especially in some blocks like Bonomala, Tongi, the water channels surrounded the farmlands where factories discharged waste materials into the canals. The water of the canals is almost blackish in color, dirty smelled and polluted with heavy metals. The dominant cropping pattern of these areas is rice based and huge water is needed to irrigate for rice cultivation. In Boro season no option is left for farmers other than to use the polluted canal waters for irrigation. Except for the Boro seasons, most of the time lands remain inundated by this polluted canal's water. In Boro season most of the farmers are using that contaminated canal water for irrigation in rice field. Applications of different organic materials transform into stable forms of carbon with high adsorption sites which might help heavy metal adsorption and ultimately helps in environmental amelioration. It is hypothesized that agronomic management practices (liming, cowdung, water hyacinth-compost, etc.) can improve soil resilience, reduce heavy metal uptake and increase its productive capacity in the polluted areas and therefore study are needed in these issues.

Objectives

- i. To characterize the chemical properties of soil in heavy metal polluted areas of Tongi, Gazipur
- ii. To determine the effects of liming and compost amendment on As, Pb, Cd, Cr, Hg immobilization on contaminated soil of Tongi, Gazipur and to determine the metal concentrations in rice.
- iii. To determine the effect of organic materials on crop growth and yield.

Materials and Methods

This experiment was carried out at farmers field, Bonomala, Tongi (23°91'N, 90°40'E) Gazipur, during December to May, 2023-24. The soil samples were collected from a depth of 15 cm in a zig-zag manner before land preparation to analyze the textural class and inherent physicochemical status. The soil characteristics of the experimental fields were acidic nature having pH: 5.6, organic carbon: 1.87 %, total N = 0.19%, available P = 4.18 ppm, exchangeable K = 0.27me/100g, available S = 60.66 ppm, Zn = 0.66 ppm, Fe = 190 ppm, Cu = 5.5 ppm, Mn = 38 ppm, As = 5.9 ppm, Pb = 33.1 ppm, Cd = 3.02 ppm, Cr = 29.7 ppm, Hg = 0.017 ppm. The 36-day-old seedlings of rice cultivars, BRRI dhan84, BRRI dhan100, BRRI dhan29 and BRRI dhan89 were transplanted on 26 December, 2023 in the field maintaining 25×25 cm spacing. The treatments were included T₁ = Unfertilized soil treatment (control), T₂ = RDF (100%), T₃ = Lime 1.5 t ha⁻¹ + RDF (75%), T₄ = Compost 1.5 t ha⁻¹ (water hyacinth compost) + RDF (75%), T₅ = Farmer's practice (only MoP). The experiment was conducted in two-factorial randomized complete block design with three replications. The BRRI recommended fertilizer doses for N, P, K, S, Zn were applied @ 120, 18, 80, 38 and 4.0 kg ha⁻¹, respectively. At maturity time, samples were harvested separately and the fresh samples were oven-dried at 72° C for 24 h and then weighed as dry weight. Cold vapor

method (Aqua regia solution, hydroxyl amine hydrochloride, potassium permanganate and stannous chloride) was used for mercury analysis and di-acid extraction method, HNO₃: HClO₄ was used for Pd, Cd, Cr, As analysis. For mercury analysis, mercury vapor unit along with AA-7000 atomic absorption spectrophotometer was used. AA-7000 atomic absorption spectrophotometer (Shimadzu) was used to determine the concentration of all metals Zn, Fe, Cu, Mn, Pd, Cd, Cr, As and Hg.

Results and Discussion

Tillering pattern

Tiller number was recorded from active tillering and continued up to maturity. Tiller number varied significantly among the variety at all crop growth stages. Maximum tiller number (372-412 m²) was observed at heading stage for all varieties. Irrespective of treatments, the highest no. of tiller was observed in BRR dhan29 followed by BRR dhan100, BRR dhan84 and BRR dhan89. All varieties produced higher number of tillers up to heading and then declined sharply for all management (Fig. 11). Total dry matter varied significantly among the varieties at all crop growth stages. The total dry matter gradually increased until at the maturity (MA) stage (Fig. 12) in all varieties. Highest dry matter (2180.5-2229.6 g m⁻²) was found in BRR dhan29 and BRR dhan89. Slightly difference observed in dry matter production between BRF and farmers practice due to lodging in almost all varieties at maturity stage (Fig. 12).

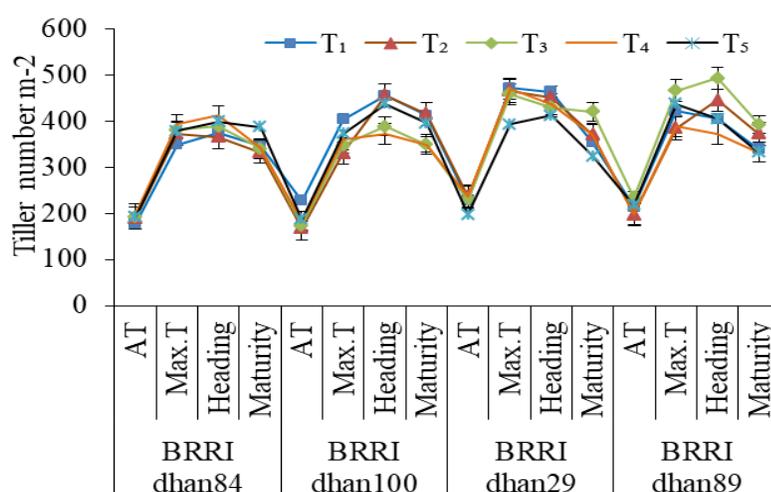


Fig. 11: Tillering pattern of tested varieties with different crop management, Vertical bars represent standard error (SE).

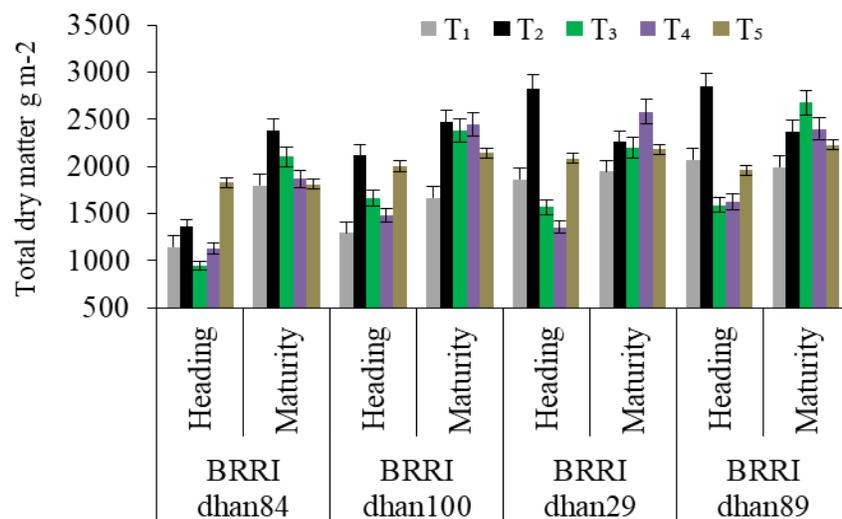


Fig. 12: Total dry matter (g m⁻²) at different growth stages of tested varieties with different crop management, Vertical bars represent SE.

Yield and yield components

The study result showed that organic amendment, WH compost + 50% RDF increased grain yield from farmers' practice. Irrespective of treatments, BRRI dhan29 gave the highest yield, higher TSW among the variety. Irrespective of treatments, BRRI dhan84, BRRI dhan100 and BRRI dhan89 gave the statistically identical result on panicle m⁻², grains panicle⁻¹ (Table 12).

Table 12. Yield and yield components of some BRRI varieties as affected by different crop management at farmer's field, Bonamala, Tongi, Gazipur

Treatment	Panicle m ⁻²	Grains panicle ⁻¹	1000 GW (g)	Grain yield (t ha ⁻¹)
Variety				
BRRI dhan84	350	108	20.9	7.81
BRRI dhan100	380	123	16.9	7.79
BRRI dhan29	357	119	22.5	9.43
BRRI dhan89	348	111	20.3	7.77
Crop Management (CM)				
Control (T ₁)	358	115	20.4	8.29
RDF (100%) (T ₂)	367	114	20.0	8.38
Lime + 75% RDF (T ₃)	370	111	20.1	8.18
WH compost + 75% RDF (T ₄)	344	123	19.9	8.42
FP (T ₅)	354	112	20.2	7.74
Lsd _(0.05) for variety	35.51	12.18	1.24	0.88
Lsd _(0.05) for CM	39.7	ns	ns	0.99
Lsd _(0.05) for V×CM	ns	ns	ns	1.98
CV (%)	13.4	14.3	8.3	14.6

T₁ = Unfertilized soil treatment (control), T₂ = RDF (100%), T₃ = Lime 1.5 t ha⁻¹ + RDF (75%), T₄ = Compost 1.5 t ha⁻¹ (water hyacinth compost) + RDF (75%), T₅ = Farmer's practice (only MoP).

Heavy metal concentration in clean rice, rice husk and straw

Among the organic amendments, application of Lime + 50% RDF reduced As and Pb uptake in clean rice, rice husk and straw of BRRI dhan84, BRRI dhan29 and BRRI dhan89. Significant lowest amount of As (0.293 and 0.263 ppm) uptake recorded in the T₂ and T₃ treatment in BRRI dhan84, BRRI dhan100, BRRI dhan29 and BRRI dhan89. Organic amendments application has no significant difference in Cd and Cr uptake in all varieties. Irrespective of treatments, the lowest uptake of As, Pb and Hg was found in clean rice, rice husk and straw of BRRI dhan29, BRRI dhan89. Pb (11.05 ppm) and (Cd 5.57 ppm) concentrations are much higher than the concentrations of As (0.496 ppm), Cr (2.41 ppm) and Hg (0.03384 ppm) metals not only in the clean rice, but also in the rice husk and straw (Fig. 13).

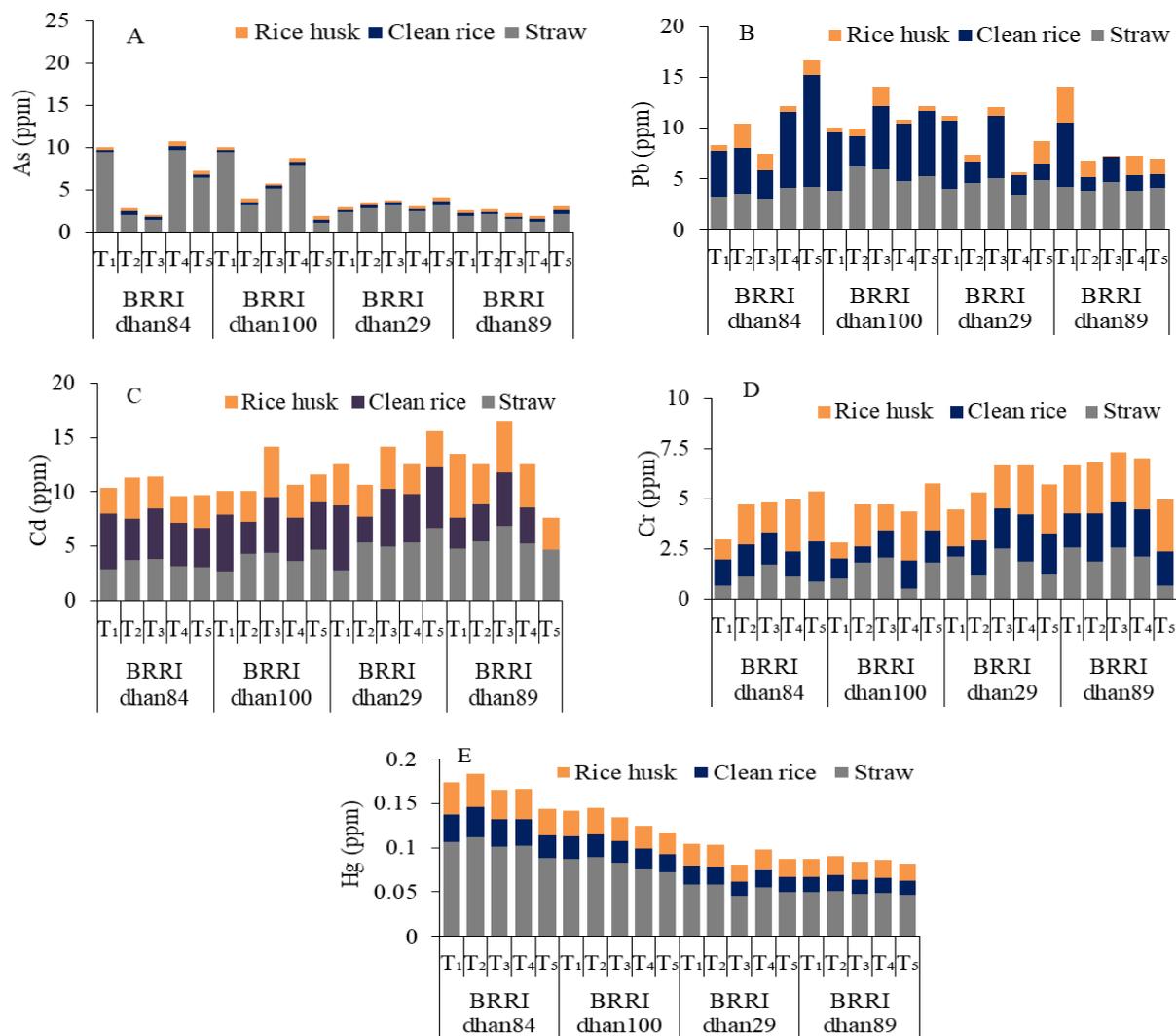


Fig. 13: Heavy metals concentration (As, Pb, Cd, Cr and Hg) in clean rice, rice husk and

Straw of some BRRI varieties under different crop management. Vertical bars represent SE.

Conclusion

This study indicates that contaminated soil was rich in nutrients but loaded with different heavy metals beyond the permissible limit for crop production (WHO). Plant did not uptake adequate amount of nutrients from waste water, which was on the growth and yield of rice. BRRI dhan29 gave the highest yield along with the application of water hyacinth compost + 50% RDF.

5.7 Residue analysis of herbicide, insecticide and fungicide in soil and rice under irrigated ecosystem

N Akter, M M Rana and R Akter

Introduction:

Rice is one of the most consumed grains in the world. As its consumption has increased in accordance with population growth, the use of pesticides, including pre-and post-emergence herbicides, insecticides, and fungicides, consequently improving its production during the various stages of cultivation (Pareja *et al.* 2011). In Bangladesh, the use of pesticides in agricultural products has a significant impact on increasing yield products and improving product quality to meet the growing food demand (Abdollahzadeh *et al.*, 2015). Bensulfuron methyl + acetachlor is a new herbicide combination reported to provide effective control of broad-leaved weeds, sedges and grasses in rice when applied at 3-6 DAT. The use of pesticides in irrigated rice has intensified in recent years due to the higher incidence of foliar diseases and insect pests and the residues of these pesticides (herbicide, fungicide and insecticide) may contaminate and accumulate in rice (Furlong, 2000). Due to widely use of pesticides has risen over in agricultural practice; it has become food safety issue. The study of pesticides residues in rice is very important to protect consumer's health. So far, little is known about which proportion of the pesticide originally applied

in the field could be found in various types of rice and rice straw, which necessitates residue analysis.

Objectives:

To analyze the maximum residue level (MRL) of pesticides in soil, water, rice and straw.

Materials and methods:

The experiment was conducted at BRRRI farm, Gazipur in T. Aman, 2023 and Boro, 2023-24. The experiment was followed by RCB design with three replications. Twenty-five (T. Aman) and thirty-five (Boro) days old seedlings were transplanted having 20 × 20 cm spacing with two seedlings per hill. BRRRI dhan103 and BRRRI dhan96 were used as for T. Aman and Boro variety. The treatments were: T₁ = Control (Untreated), T₂ = Bensulfuron methyl + Acetachlore (Recommended dose @ 750 g/ha) T₃ = Bensulfuron methyl + Acetachlore (Double the recommended dose), T₄ = Thiamethoxam + Chlorantraniliprole (Recommended dose @75 g ha⁻¹), T₅ = Thiamethoxam + Chlorantraniliprole (Double the recommended dose), T₆ = Tricyclazole 75%WP (Recommended dose @400 g ha⁻¹), T₇ = Tricyclazole 75%WP (Double the recommended dose). Fertilizers were applied (N-P-K-S-Zn @ 120-18-75-40-4 kg ha⁻¹) for all treated plot. All fertilizers were applied as basal during final land preparation except nitrogenous fertilizer. Nitrogen was applied as top dress in three equal splits at 15, 30 and 50 DAT (days after transplanting). Herbicide was sprayed one time after rice transplanting and other pesticides were sprayed 30 DAT and at heading stage. Representative 0.5 kg paddy soil and 250 mL water samples were collected randomly in each plot at 0 (2 h post-treatment), 5, 10, 20, 30, 40, 80 days and pre-harvest interval (PHI) of 7 days after herbicides application. The representative 0.5 kg rice samples were randomly collected at pre-harvest interval (PHI) of 7 days. All the collected paddy soil, water, and rice samples were stored at -20 °C, respectively.

Collection and preparation of standard solutions

Certified pesticide standards (>90%) of bensulfuron methyl + acetachlore, thiamethoxam, chlorantraniliprole, tricyclazole, solvents and reagents including acetonitrile and formic acid of LC-MS- grade were obtained from Sigma Aldrich. Magnesium sulphate and anhydrous sodium chloride, Primary secondary amine (PSA) and graphitized carbon black (GCB) were purchased from Sigma Aldrich. Merck Millipore system was used to collect ultra-pure water. Nylon filters (0.2 µm) from Sigma Aldrich were used to filter the sample extracts.

Preparation of standard solutions

Stock solutions (1000 µg mL⁻¹) of the five pesticide (herbicide, pesticide and fungicide) compounds were prepared individually by dissolving the technical-grade material in acetonitrile (v/v) separately. These were labeled and stored in a freezer at -20°C. From the stock solution, intermediate stock and working standard solutions were prepared as mixes.

Sample preparation

The rice grain, rice straw and soil samples were collected from fields. Rice grains were homogenized into fine powder using grinder. Rice straws were milled into coarse powders using a grinder and were used after passing through 0.1 mm metal sieves.

Instrumentation

The chromatographic separation was carried out in a LC-MS-MS 8050 system using C18, 5 μm (4.8×250 mm) column with a mobile phase of acetonitrile: water acidified with 0.5% formic acid (50:50, v/v) at 0.5 mL min^{-1} flow rate. With these conditions, all the five analytes were detected in 10.0 min. Confirmation was done utilizing Acquity (LC-MS-MS 8050, Shimadzu, Japan). Tandem Quadrupole mass Detector (TQD) with Electrospray ionization (ESI) interface. All the five analytes were ionized in positive polarity.

Extraction and clean up

The QuEChERS method (Anastassiades et al. 2003) with following modifications was employed for extraction and clean-up process. Homogenized rice whole grain powder (10 g) and soil was weighed out into a 50-mL centrifuge tube. After adding 20 ml of acetonitrile, the centrifuge tube was capped and vortex shaken for 1 min. To this, 4 g anhydrous magnesium sulphate and 1 g of sodium chloride was added and again vortex shaken for 1 min to mix the sample thoroughly. The samples were centrifuged for 10 min at 8000 rpm. From this, 9 mL of supernatant was passed through 4 g of anhydrous sodium sulphate to remove moisture and out of this, 6 mL of extract was transferred into centrifuge tube containing 100 mg PSA and 600 mg anhydrous magnesium sulphate. The samples were mixed thoroughly by vortexing for 1 min and centrifuged for 10 min at 4000 rpm. Finally, 4 mL of acetonitrile layer was transferred into a clean glass test tube. The final volume was reconstituted to 1 ml using acetonitrile and transferred into a 1.5 mL glass auto sampler vial for LC/MS-MS analysis after filtering through a $0.2 \mu\text{m}$ filter membrane. For straw sample analysis, additionally 10 mg GCB powder was taken into a 50 mL centrifuge tube.

Results and Discussion

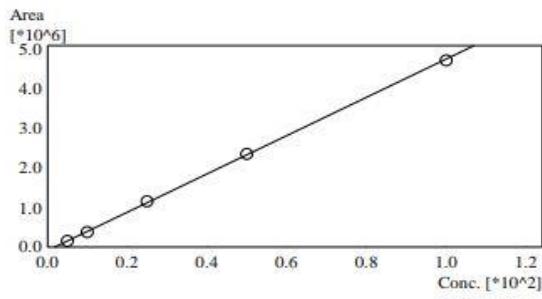
The performance of the developed method was validated with linearity, limit of detection (LOD), and limit of quantitation (LOQ). In order to obtain realistic and accurate results, linearity was evaluated by using the matrix-matched standard calibrations method to eliminate matrix effects. Excellent linearities were acquired with all the determination coefficients (R_2) higher than 0.98 to 0.99 in the range of 0.005-0.5 mg/L with three to five calibration points for bensulfuron-methyl and 0.025-1 mg/L for thiamethoxam, chlorantraniliprole and tricyclazole, respectively. Quantification was calculated using the calibration curve constructed by linear regressing of pesticide concentrations against peak areas (Fig. 14).

Result shows that the retention time of bensulfuron-methyl, thiamethoxam, chlorantraniliprole and tricyclazole were 2.14-2.25, 1.667-1.85, 2.01-2.10 min, individually. Retention time varies from different pesticide detection. Among the 42 samples from different matrix (clean rice, straw and soil), Thiamethoxam (m/z 292.0 > 211.10), and Tricyclazole (m/z 190.0 > 136.0) pesticide residues were found only in 14 soil, grain and straw samples from recommended dose and double dose of pesticides treated plot. No residues were found in soil matrix, clean rice and straw in control treated plot. Bensulfuran methyl (m/z 411.25 > 149.20) only detected in soil at 0-25 DAT but not in clean rice and straw. The residues of pesticides were found to be below MRL fixed by FSSAI for pesticides in rice (FSSAI, 2018) (Table 13).

Table 13. The retention time and concentrations (ppb) of four pesticides in soil, rice grain and rice straw

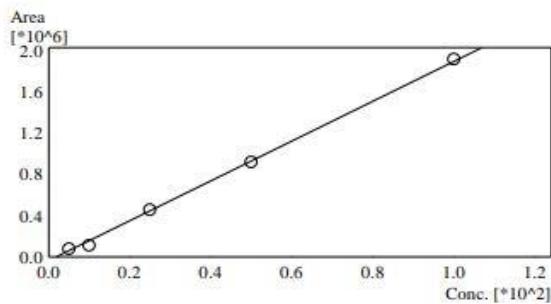
Treatments	Rice grain (clean rice)		Straw		Soil (0 DAT to 25 DAT)	
	Retention time (min)	Concentration (ppb)	Retention time (min)	Concentration (ppb)	Retention time (min)	Concentration (ppb)
T ₁ =Control (Untreated)	-	Not found	-	Not found	-	Not found
T ₂ =Bensulfuron methyl (Recommended dose @ 750 g/ha)	-	Not found	-	Not found	2.32	1.823
T ₃ =Bensulfuron methyl (Double the recommended dose)	-	Not found	-	Not found	2.34	1.801
T ₄ =Thiamethoxam + Chlorantraniliprole (Recommended dose @75 g ha ⁻¹)	1.817	1.153	1.717	1.163	1.716	1.148
T ₅ =Thiamethoxam + Chlorantraniliprole (Double the recommended dose)	1.667	1.153	1.667	1.230	1.815	1.151
T ₆ = Tricyclazole 75% WP (Recommended dose @400 g ha ⁻¹)	2.03	1.685	2.01	1.685	2.054	1.676
T ₇ = Tricyclazole 75% WP (Double the recommended dose)	2.09	1.676	2.10	1.704	2.05	1.713

ID# : 2 m/z : 411.2500>149.2000
 Name : Bensulfuron-methyl
 Quantitative Method : External Standard
 Function : $f(x) = 48502.9 \cdot x - 86631.3$
 Rr1=0.9998251 Rr2=0.9996503
 MeanRF: 4.209215e+004 RF SD: 6.977341e+003 RF %RSD: 16.576347
 FitType : Linear
 ZeroThrough : Not Through
 Weighted Regression : 1/C



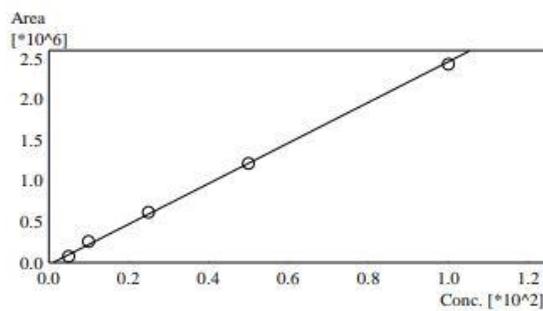
#	Conc.(Ratio)	MeanArea	Area
1	5	158750	158750
2	10	379468	379468
3	25	1156922	1156922
4	50	2361470	2361470
5	100	4725779	4725779

ID# : 4 m/z : 482.0000>283.9500
 Name : Chlorantraniliprole
 Quantitative Method : External Standard
 Function : $f(x) = 19441.5 \cdot x - 36423.4$
 Rr1=0.9969456 Rr2=0.9939006
 MeanRF: 1.674619e+004 RF SD: 3.236842e+003 RF %RSD: 19.328834
 FitType : Linear
 ZeroThrough : Not Through
 Weighted Regression : 1/C



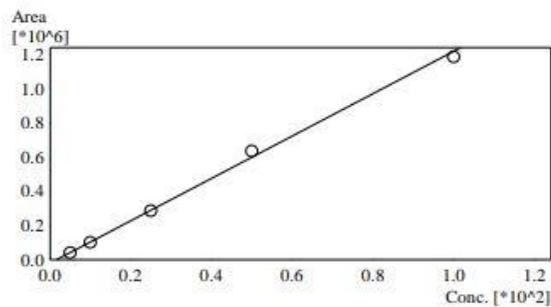
#	Conc.(Ratio)	MeanArea	Area
1	5	80345	80345
2	10	113766	113766
3	25	461374	461374
4	50	926747	926747
5	100	1929539	1929539

ID# : 15 m/z : 292.0000>211.1000
 Name : Thiamethoxam
 Quantitative Method : External Standard
 Function : $f(x) = 24943.4 \cdot x - 28299.7$
 Rr1=0.9983900 Rr2=0.9967826
 MeanRF: 2.284919e+004 RF SD: 4.316026e+003 RF %RSD: 18.889189
 FitType : Linear
 ZeroThrough : Not Through
 Weighted Regression : 1/C



#	Conc.(Ratio)	MeanArea	Area
1	5	76007	76007
2	10	257497	257497
3	25	617114	617114
4	50	1213907	1213907
5	100	2433216	2433216

ID# : 16 m/z : 190.0000>136.0000
 Name : Tricyclazole
 Quantitative Method : External Standard
 Function : $f(x) = 12391.1 \cdot x - 20651.5$
 Rr1=0.9989933 Rr2=0.9979875
 MeanRF: 1.086292e+004 RF SD: 1.795749e+003 RF %RSD: 16.530999
 FitType : Linear
 ZeroThrough : Not Through
 Weighted Regression : 1/C



#	Conc.(Ratio)	MeanArea	Area
1	5	40527	40527
2	10	101592	101592
3	25	286796	286796
4	50	635682	635682
5	100	1186461	1186461

Fig. 14: The calibration curve of the four pesticides

6. GOOD AGRICULTURAL PRACTICES (GAP)

6.1 Yield maximization of Boro rice through good agricultural practice

MKA Bhuiyan, MM Mahbub and Sh Islam

Introduction

Good agricultural practices (GAPs) in rice production comprise a package of technologies, including improved variety, nursery preparation and intensive care, transplanting, weeding and pest management, nutrient management, water management, and timely and proper harvesting (MOAI Myanmar, 2013) which make safe and healthy food while taking into account economic, social and environmental sustainability. Reducing the rice yield gap may be partly achieved through practicing good agricultural practices (GAP) in many countries. The purpose of this work is to spread the basic concepts of Good Agricultural Practices (GAP) in order to: guide the production systems towards sustainable agriculture and ecologically safe, obtain harmless products of higher quality, contribute to food security generate income

Objectives

1. To observe the yield performance by practicing GAPS
2. To compare the economies of GAPs and BRRI-recommended practices

Materials and Methods

There are many components of GAPs. Among them, a few components were evaluated on three varieties. The varieties were BRRI hybrid dhan8, BRRI dhan92, and BRRI dhan104. Here we considered good agricultural practice (GAP) and BRRI recommended management (BRP). Management of GAPs were a. Balance fertilizer application (N,P,K,S, Zn) (soil test based) b. BRRI weeder fb 1 HW at 45 DAT d. Integrated insect and disease management and e. Maintaining planting depth 2-3cm. BRRI recommended practice (BRP) were: a. BRRI recommended fertilizer and cultural practices b. Normal irrigation practice, c. Herbicide fb 1HW d. Insect and disease management by applying pesticides. The experiment followed a factorial RCB design with three replications during the Boro season of 2023-24 at BRRI farm Gazipur.

Results

The results (Table 14) indicate that both variety (V) and management practices (M) significantly influenced yield and yield-related traits of BRRI varieties during the Boro 2023-2024 season at Gazipur. BRRI hybrid dhan8 consistently outperformed the other varieties in all characteristics, with the highest grain yield (GY) of **8.46 t/ha** under good agricultural practices (GAP). It also had the highest number of panicles per square meter (**324**) and grains per panicle (**143**). BRRI dhan92 followed, yielding **7.89 t/ha** under GAP, while BRRI dhan104 had the lowest yield (**6.88 t/ha**) under the same management, likely due to fewer grains per panicle (**98**) and lower 1000-grain weight (GW, **21.49 g**). The effect of management (GAP vs. BRRI recommended practices, CRM) on yield and related traits was not statistically significant, as indicated by non-significant LSD values for management. However, variety and the interaction (V×M) between variety (V) and management (M) significantly influenced all measured traits, suggesting that yield potential was primarily driven by genetic differences among varieties rather than management practices. Overall, GAP slightly improved performance compared to BRP, but its effect varied by variety, highlighting the importance of variety-specific optimization of agronomic practices.

Discussion:

The study demonstrates that yield and yield-related traits in BRRI rice varieties during the Boro 2023-2024 season were primarily influenced by genetic differences, with BRRI hybrid dhan8 outperforming other varieties. It achieved the highest grain yield (8.46 t/ha under GAP) due to its superior panicle density (**324 m²**) and grains per panicle (**143**), combined with a stable 1000-grain weight (**24.16 g**). BRRI dhan92 also performed well, yielding **7.89 t/ha** under GAP, while BRRI dhan104, known for basmati-type long slender aromatic rice, had the lowest yield (**6.88 t/ha**) due to fewer grains per panicle (**98**) and lower grain weight (**21.49 g**). Although management practices (GAP vs. BRP) did not show statistically significant effects, GAP consistently resulted in slightly higher yields, likely due to enhanced agronomic care, such as better nutrient and water management. The important interaction between variety and management practices ($V \times M$) suggests that the management response varies among the varieties, emphasizing the importance of tailoring agronomic practices to specific genotypes.

Conclusion

The study highlights the dominance of genetic factors in determining yield potential, with BRRI hybrid dhan8 being the best-performing variety. Management practices, while not statistically significant, showed potential for yield improvement, particularly under GAP. To enhance productivity, adopting GAP and tailoring practices to specific varieties, such as optimizing nutrients and water is recommended. Further research could explore environmental interactions and resource efficiency under varied agro-ecological conditions to refine management strategies for these rice varieties.

Economic analysis (Partial Budgeting)

Table 15 provides a partial budget analysis comparing Good Agricultural Practices (GAP) to BRRI recommended Practice (BRP) with BRRI hybrid dhan8. The adoption of BRRI hybrid dhan8 in rice farming led to a significant net financial gain of 6,590 Tk. This was achieved through an increased yield of 210 kg of rice, generating an income of 6,300 Tk, along with an additional 180 Tk from 60 kg of straw sales. The changes also reduced costs by 2,910 Tk, primarily through savings on fertilizer (2,110 Tk) and irrigation (800 Tk). However, additional expenses for weeding (2,200 Tk) and perching (600 Tk) totaled 2,800 Tk. When the added income and cost savings were balanced against the increased costs, the overall benefit demonstrated the cost-effectiveness and profitability of adopting BRRI hybrid dhan8.

Table 16 summarizes the financial impact of changes in cultivating BRRI dhan92. Added income includes 6900 Tk from 230 kg of paddy and 630 Tk from 210 kg of straw, along with reduced costs of 2140 Tk for fertilizer and 800 Tk for irrigation, totaling 10,470 Tk. Added costs consist of 2200 Tk for weeding and 600 Tk for perching, totaling 2800 Tk. With no reduction in income reported, the net financial benefit from these changes is 7670 Tk.

Table 17 provides a partial budget analysis comparing Good Agricultural Practices (GAP) to BRRI recommended Practice (BRP) with BRRI dhan104. The added income includes 270 kg of paddy sold at 45 Tk/kg (12,150 Tk) and 140 kg of straw at 3 Tk/kg (420 Tk). Reduced costs amount to 1000 Tk for fertilizer and 800 Tk for irrigation, resulting in a total added benefit of 14,370 Tk.

Additional costs include 2200 Tk for weeding and 600 Tk for perching, totaling 2800 Tk. With no reduction in income reported, the net financial gain from implementing GAP over BRP is 11,570 Tk, showcasing the economic advantage of adopting improved practices.

Conclusion:

The net change in the profit obtained by the GAPs was observed Tk. 6590.00Tk/ ha for BRR hybrid dhan8, Tk. 7670/ha for BRR dhan92 and Tk. 11570/ha for BRR dham104. Hence, it can be concluded that the adoption of GAP practices in rice cultivation is economically viable. Environmentally friendly because of less fertilizer, less insecticide, less water, etc. So, it seems that GAPs produced higher grain yield compared to BRR-recommended practices in different varieties, which is safe, environment-friendly, and cost-effective.

Table 14. Yield and yield characters of BRR varieties as affected by management practices at BRR farm Gazipur during Boro 2023-2024

Variety(V)	Management (M)	Panicle m ⁻²	Grains panicle ⁻¹	1000GW (g)	GY (t ha ⁻¹)
BRR hybrid dhan8	GAP	324	143	24.2	8.46
	BRP	318	138	24.1	8.25
BRR dhan92	GAP	313	136	23.4	7.89
	BRP	307	130	23.3	7.66
BRR dhan104	GAP	297	98	21.5	6.88
	BRP	294	94	21.5	6.61
Lsd (0.05) for V		10.11	8.21	0.16	0.36
Lsd (0.05) for M		ns	ns	ns	ns
Lsd (0.05) for V × M		15.33	12.13	0.25	0.53
CV (%)		3.8	5.5	1.0	3.9

GAP=Good agricultural practices; BRP= BRR recommended Practice

Table 15. Partial budgeting of GAP against BRM with BRR hybrid dhan8

Added income due to change	Added cost due to change
BRR hybrid dhan8 = 210kg @ 30Tk/kg = 6300/-	Weeding= 2200/-
Straw 60kg @3.0/- / kg = 180/-	Perching = 600/-
Reduced cost due to change	Reduce income due to cost= None
Fertilizer = 2110/-	
Irrigation = 800/-	
Sub total = (6300+180+2110+800) = 9390/-	Sub total= 2800/-
Net change= (9390-2800) Tk. = 6590/-	

Table 16. Partial budgeting of GAP against BRM with BRR dhan92

Added income due to change	Added cost due to change
BRR dhan92 (Paddy)= 230 kg @ 30/-/kg = 6900/-	Weeding= 2200/-
Straw 210kg @3.00/- = 630/-	Perching = 600/-
Reduced cost due to change	Reduce income due to cost= None
Fertilizer = 2140/-	
Irrigation = 800/-	
Sub total = (6900+630+2140+800)= 10470/-	Sub total= 2800/-
Net change= (14008-2800) Tk. = 7670/-	

Table 17. Partial budgeting of GAP against CRM with BRR dhan104

Added income due to change	Added cost due to change
BRR dhan89 (Paddy)= 270 kg @ 45/-/kg = 12150/-	Weeding= 2200/-
Straw 140kg @3.00/- / kg = 420/-	Perching = 600/-
Reduced cost due to change	Reduce income due to cost= None
Fertilizer = 1000/-	
Irrigation = 800/-	
Sub total = (12150+420+1000+800) = 14370/-	Sub total = 2800/-
Net change= (11108-2800) = 11570/-	

7. YIELD MAXIMIZATION

7.1 Effect of agronomic factors for maximizing yield of Long Slenderer Premium Quality Fine Rice-BRRI dhan70 (*Katarivog type*) through developing sustainable production management protocol in T Aman season

Dr. A B S Sarker, MS R Aktar, S A Islam and Dr. M M Rana

Introduction

BRRI dhan70 is similar quality like *Katarivog* and which is now becoming popular at Dinajpur region. But yield of this variety is very low due to lack of proper production management protocol. An experiment was conducted at the agronomic research field at BRRI, Gazipur during T Aman season.

Objective: The objective of the experiment:

1. To study contributions of agronomic factors to maximize yield of BRRI dhan70.
2. To find out and recommend the best production management protocol for sustainable higher yield of BRRI dhan70 in T Aman season.

Treatments:

Factor A was two times of crop establishment (T): T₁ = 1 July Seeding and T₂ = 15 July Seeding. Factor B: Two seedling ages (A): A₁ = 15 day and A₂ = 30 day. Factor C: Two Population density or spacing (S): S₁ = 25 x 25 cm (16 hill/m²) and S₂ = 20 x 20 cm (25 hill/m²). Factor D: Two fertilizer management (F): F₁ = BRRI recommended fertilizer Management, F₂ = Soil test based high yield goal targeted fertilizer Management. The experiment was laid down in factorial RCBD with three replications. BRRI recommended other intercultural management like weed, irrigation, insects, diseases and other intercultural management were followed as and when necessary.

Results: There was significant grain yield difference in different agronomic management factor-based treatments. The highest grain yields were obtained from the agronomic-based treatment combination of F₂S₁A₁T₂ (5.89 t/ha) followed by F₂S₁A₂T₁ (5.16 t/ha) than F₂S₁A₂T₂ (4.16 t/ha) (**Table 18**). The lowest grain yield was observed from F₂S₂A₁T₁ (1.52 t/ha) than F₁S₂A₂T₁ (2.08 t/ha).

Table 18. Effect of agronomic factors for maximizing grain yield of Long Slenderer Premium Quality Fine Rice-BRRI dhan70 (*Katarivog type*) in T Aman season

Treatments	Grain yield (t/ha)	Treatments	Grain yield (t/ha)	Treatments	Grain yield (t/ha)
F1 S1 A1 T1	3.70	F1 S2 A2 T1	2.08	F2 S2 A1 T1	1.52
F1 S1 A1 T2	4.01	F1 S2 A2 T2	2.75	F2 S2 A1 T2	2.97
F1 S1 A2 T1	4.06	F2 S1 A1 T1	3.81	F2 S2 A2 T1	2.30
F1 S1 A2 T2	3.36	F2 S1 A1 T2	5.89	F2 S2 A2 T2	2.94
F1 S2 A1 T1	2.42	F2 S1 A2 T1	5.16		
F1 S2 A1 T2	2.26	F2 S1 A2 T2	4.16		
CV (%)	9.23				
Lsd _(0.05)	0.4748				

7.2 Effect of agronomic factors for maximizing yield of medium duration BRRI dhan94 through developing sustainable production management protocol

Dr. M A B S Sarker, Dr M Rana, R Aktar, Dr N Aktar

Introduction

BRRI dhan94 is a newly developed high yielder (>5.0 t/ha) medium duration (134 day) T Aman variety. To optimize its yield potentiality, it is essential to find out the proper Agronomic management. The experiment was conducted at BRRI, Gazipur during T Aman season.

Objective: The objective of the experiment:

1. To study contributions of some agronomic factors to high yield of a medium duration variety (BRRI dhan94) in T Aman season,
2. To find out the best production management protocol for sustainable higher yield of medium duration T Aman BRRI variety (BRRI dhan94).

Treatments:

Factor A: Time of crop establishment (T) was two, T₁ = 1 July Seeding and T₂ = 15 July Seeding.
 Factor B: The age of seedling (A) was two, A₁ = 15 day and A₂ = 30 day. Factor C: Population density or spacing (S) was two, S₁ = 25 x 25 cm (16 hill/m²) and S₂ = 20 x 20 cm (25 hill/m²).
 Factor D: Fertilizer Management (F) was two, F₁ = BRRI recommended fertilizer Management, F₂ = Soil test based high yield goal targeted fertilizer management with additional one-ton vermicompost per hectare was added during transplanting.

The experiment was laid down in factorial RCBD with three replications. BRRI recommended other intercultural management like weed, irrigation, insects, diseases and other intercultural management were followed when was necessary.

Results: There was significant effect of different Agronomic factors on the grain yield production. The highest grain yield was achieved from the treatment F₂A₁S₁T₂ (7.18 t/ha) followed by F₁ A₂ S₁ T₁ (7.06 t/ha) than F₁ A₂ S₂ T₁ (6.45 t/ha) (**Fig. 15**). It also observed that significant higher yield was achieved due to higher contribution of yield components. The lowest grain yield was observed from F₂S₂A₂T₂(3.68 t/ha) than F₂S₁A₂T₂ (4.02 t/ha).

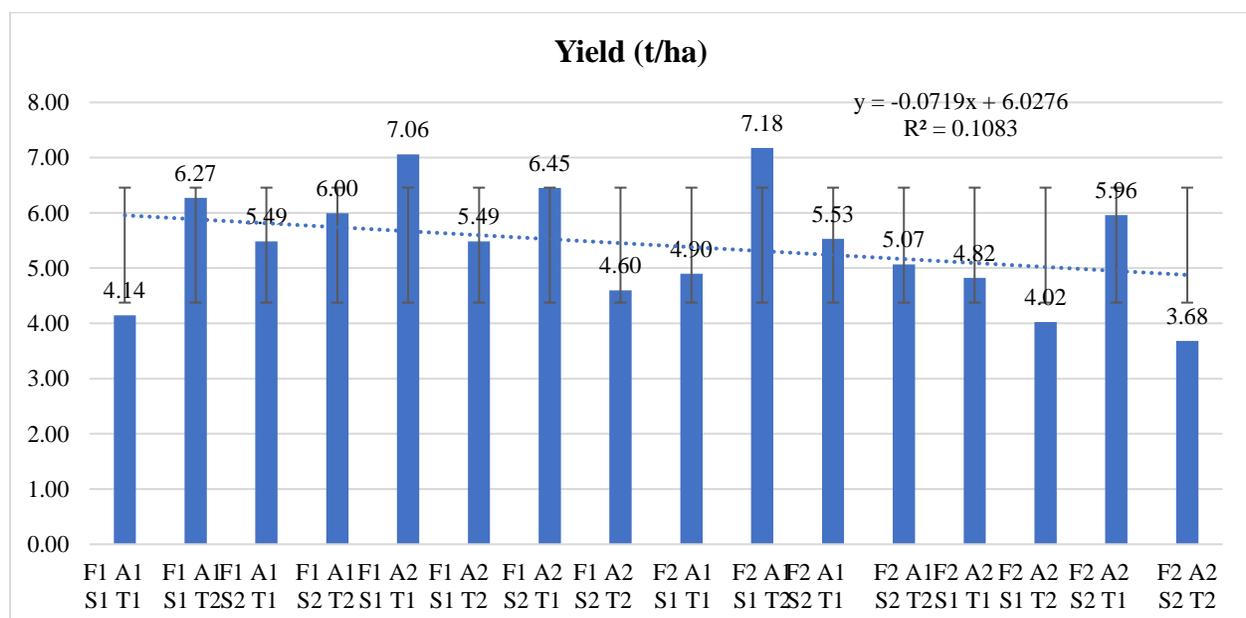


Fig. 15: Effect of agronomic factors for maximizing yield of medium duration BRRI dhan94 during T. Aman season.

It also observed that significant higher yield was achieved due to higher contribution of yield components. For obtaining the highest grain yield, BRRRI dhan94 will be seeding on 15 July and transplanting with 15 days old seedling, maintaining 25 x 25 cm spacing. Soil test-based fertilizer needed to be applied.

7.3 Effect of some agronomic factors for maximizing yield of long duration variety BRRRI dhan92 through developing sustainable production management protocol in Boro season

Dr. M A B S Sarker, R Aktar and Dr. M M Rana

Introduction

BRRRI dhan92 is a newly developed high yielder (>8.0 t/ha) long duration (160 day) Boro variety. The best agronomic management protocol should be found out for obtaining its higher grain yield. The experiment was carried out at BRRRI farm Gazipur during Boro season.

Objective: The objective of the experiment:

1. To study some agronomic factors for high yield contribution of long duration BRRRI variety (BRRRI dhan92) in Boro season and
2. To find out the best production management protocol for sustainable higher yield of the long duration variety.

Treatments:

Factor A was three Age of seedling (A): A₁ = 15 day A₂ = 35 day and A₃ = 55 day. Factor B was Three Population density or spacing (S): S₁ = 30 x 30 cm (11.1 hill/m²), S₂ = 25 x 25 cm (16 hill/m²) and S₃ = 20 x 20 cm (25 hill/m²). Factor C was two Fertilizer Management (F): F₁ = AEZ fertility based high yield goal targeted BRRRI fertilizer recommendation and F₂ = Soil test based high yield goal targeted fertilizer recommendation along with one t/ha vermi compost and 1% Mop solution need to spray at 30 and 45 DAT. Tested Variety was BRRRI dhan92.

Other recommended agronomic management were followed as and when necessary. Factorial Randomized Complete Block design with three replication was followed.

Results: There was significant effect of different treatment on yield and yield contributing factors. The highest grain yield was obtained from the treatment F₂S₂A₁ (8.06 t/ha) followed by F₁S₂A₁ and (7.85 t/ha) than F₁S₃A₂ (7.80 t/ha) (**Fig. 16**).

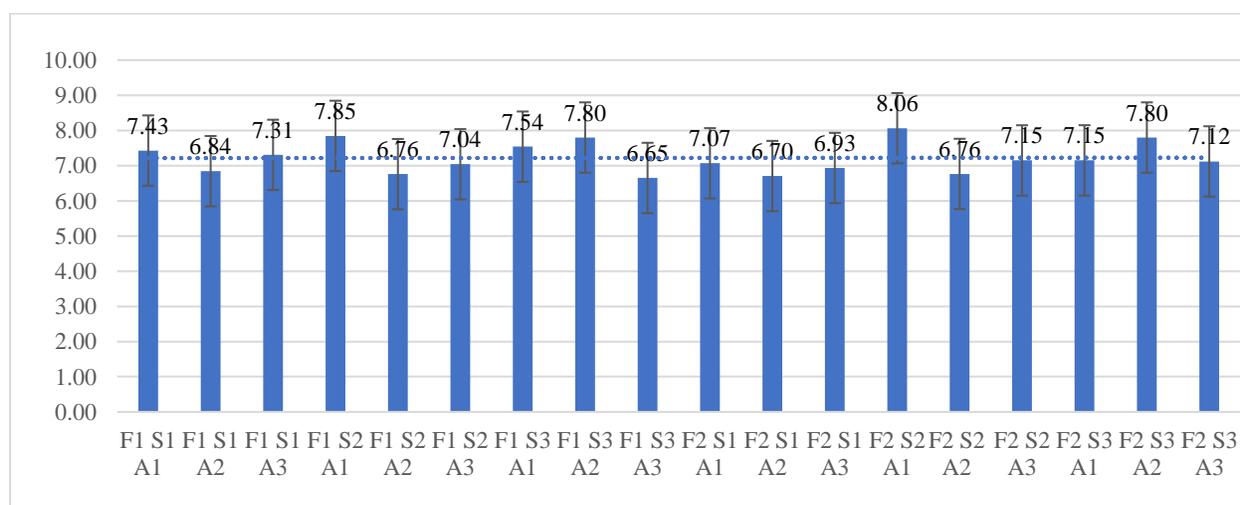


Fig. 16: Effect of some agronomic factors for maximizing grain yield of long duration Boro variety (BRRRI dhan92) for developing sustainable production management

The lowest grain yield was observed from F₁S₃A₃ (6.55 t/ha) than F₂S₁A₂ (6.76 t/ha). The obtained higher yield was contributed by higher number of panicle and fill grain production and lower sterility %. The result means that for obtaining higher yield, STB fertilizer along with 1 t/ha vermi compost need to apply along with 1% MoP solution spray at 30 and 45 DAT. 15-day old seedling maintaining wider spacing should be transplanted (**Fig. 16**).

7.4 Effect of agronomic critical factors-based managements for different yield goal level on lodging behavior of T. Aman varieties at Middle and Northern parts of Bangladesh.

Dr. M A B S Sarker, R Aktar and Dr. M M Rana

Introduction

Lodging is one of the major constraints in rice production especially for rice yield maximization in many countries as well as in Bangladesh. It is rolling over major production loss of rice in all seasons and all eco-systems in Bangladesh. However, lodging is still a major problem and there is an urgent need to improve lodging resistance agronomic management to increase yield. The Experiment was conducted During T Aman season at BRRRI farm, Gazipur.

Objective: The objective of the experiment:

1. To study the effect of agronomic factors-based managements on varietal lodging behavior at different yield goal level
2. To recommend the judicial management protocol for sustainable yield of different variety.

Treatments:

Factor A = Agronomic Management (3):

M₁ = Management for higher yield goal (> 7 t/ha): DS: 1st week of July, DT: 3rd week of July, Seedling age 15 to 20 days, 1-2 seedling per hill, planting density (20 hill/m²): line to line 25cm and plant to plant 20cm, Uper soil stirring: 20 and 40 DAT, Fertilizer: STB; Urea @ Basal+ 20DAT + 40DAT + PI, 1% MoP solution foliar spray at 30 and 45 DAT. Other recommended agronomic managements will be followed as and when necessary.

M₂ = Management for Medium yield goal (5 t/ha): DS: 1st week of July, DT: 4th week of July, Seedling age 25 days, 1-2 seedling per hill, planting density (27 hill/m²) line to line 25cm and plant to plant 15cm, Fertilizer: 80% of STB where urea 1/3 @ 7 DAT + 1/3 @ 30DAT + 1/3 @ PI, 1% MoP solution foliar spray at 30 and 45 DAT. Other recommended agronomic managements will be followed as and when necessary.

M₃ = Recommended management: DS: 3rd week of June, DT: 4th week of July, Seedling age 30 days, 2-3 seedling per hill, planting density (25 hill/m²): line to line 20cm and plant to plant 20 cm, Fertilizer: RR where 1/3 Urea @ 7 DAT + 1/3 @ 30DAT + 1/3 @ PI, Other recommended agronomic managements will be followed as and when necessary.

Factor B = Variety (4): V₁ = BRRRI dhan71(short duration), V₂ = BRRRI dhan103(medium duration and V₄ = BRRRI dhan94(long duration)

The experiment was carried out by RCBD with three replications at BRRRI HQ and BRRRI RS Rangpur. Other Intercultural management: BRRRI recommended weed, irrigation, insects, diseases and other intercultural management was followed.

Results: The result showed that the highest yield was observed in treatment V₃M₃ (4.53 t/ha) followed by M₁V₁ (4.51 t/ha) than M₃V₁(4.34 t/ha) (**Fig. 17**). The lowest yield was observed by M₂V₂ (2.69 t/ha) than

M₁V₂(2.92 t/ha). The yield maximization result was hampered due to 50 to 70% lodging in all yield maximization treatment plots. The result needs to be confirmed again.

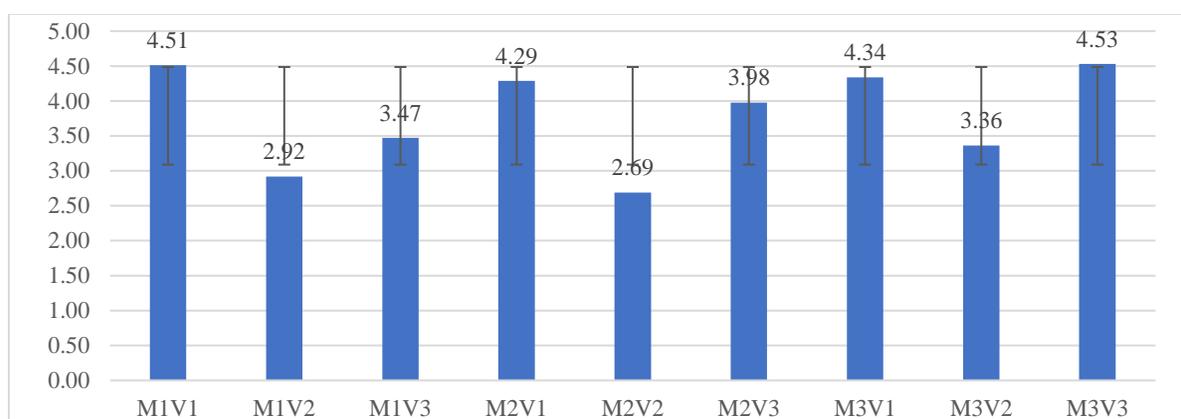


Fig. 17: Effect of agronomic critical factors-based managements for different yield goal level on lodging behavior of T Aman varieties

7.5 Evaluation of improved agronomic management practice for yield maximization of BRRI-developed modern boro rice in the hill ecosystem

M Z Ibne Baki

Introduction

Bangladesh is an agrarian country where 51.9% of the total manpower is involved in agricultural production and agriculture contributes 13.3% of the gross domestic product (GDP) of the country (Bangladesh Bureau of Statistics 2018, 2019). Rice (*Oryza sativa* L.) is the most important cereal food crop that nourishes more than 50% of the total world population (Fairhurst *et al.* 2002). In Bangladesh as well, it contributes 87% of the total cereal production and covers 61% of the total calorie intake of the people (MoA 2009). Currently, Bangladesh is the third most rice-producing country in the world. However, the overall production levels are not sufficient to feed the growing population, which is forecasted to increase by up to 23% by 2050 (United Nations, Population Division 2017).

Chittagong Hill Tracts (Khagrachari, Rangamati, and Bandarban) are considered a low-productive agricultural zone in Bangladesh (Bhuiya and Mohiuddin, 2013). The hilly areas cover about 17,342 km² (about 12% of total Bangladesh) mostly in the Chittagong Hill Tracts districts (Rahman, 2011). Chittagong Hill Tracts districts alone cover about 9% area with low hill areas (about 30%) and high hill ranges (70%). The tribal people practice Jhum (shifting cultivation following the slash-and-burn method). Jhum is customary farming which is very important for the livelihood of the alpine people of Bangladesh. The total productivity of the traditional practice of jhum cultivation is very low. So, it is very important to increase the hill rice production. In this study, we will apply different types of improved agronomic practices to increase hill rice production and develop hill rice production packages.

Materials and Methods

The experiment was conducted at Khagrachori Sadar & Maritanga upazila during the *Boro* seasons, of 2024. Three different agronomic management practices were tested. The treatments were local farmer's practices (T₁), BRRI-recommended management practices (T₂), and researcher-recommended practices (T₃). Local farmer's practices were followed by traditional hilly rice cultivation operations. BRRI recommended managements were followed for seedlings age,

fertilizer doses, time of applications, and other intercultural operations. The researcher recommended practices considered for seedling age, time of planting, growth stage-based fertilizer management, herbicide applications, 1% potash spray, and other intercultural operations. The experiment was laid out in an RCB design with three replications. BRRI dhan102 was used as a test variety for *Boro* seasons. Forty-day-old seedlings were transplanted on 27 January. Two to three seedlings per hill were transplanted maintaining 20- X 20 cm spacing. Observations on yield and yield components *i.e.* plant height (cm), grains panicle⁻¹, 1000 seed weight (g), and grain yield (t ha⁻¹) were recorded at maturity. Plant height, straw yield, and yield attributes were determined by diagonally sampling 12 hills from each plot. The samples were oven dried at 70°C to get constant weight. Yield was determined on a 5 m² area marked in the middle of each plot. The grains were dried in sunlight and winnowed before weighing and yield was adjusted to 14% moisture content and was converted into t ha⁻¹. Data were analyzed by using R. The least significant difference (LSD) at 5% probability was used to compare the means of the treatments (Gomez and Gomez, 1984)

Results and Discussion

The experimental results showed that there is a significant difference in yield and yield contributing characteristics among the management three management practices in Khagrachori sadar and Matiranga upazilla (Table 19). Plant height, panicle numbers, grains in a panicle, and sterility did not differ among the treatments in both locations (Table 18). The highest grain yield was obtained (6.85 and 7.95 t/ha) in T₃ treatment both in Khagrachori and Matirangs compared to local farmer practices, where pre-emergence herbicide and fertilizers were applied based on the growth stage base. Spraying of 1% potash solution had a positive impact on grains per panicle and sterility. The highest straw yields were found (10.73 and 11.16 t/ha) in T₃ treatment both in Khagrachori and Matirangs compared to BRRI recommended and local farmer practices.

Conclusion

Modern agronomic management based on the intercultural operations on rice in hilly ecosystems gave higher grain and straw yields compared to farmers' practices within all the hill regions. So, the researcher recommended practices that might be used in yield maximization of BRRI-developed modern rice varieties in hilly ecosystems.

Table 19: Influence of different agronomic management practices for the yield maximization of hilly *Boro* rice 2023-24

Treatment	Plant ht. (cm)	Panicles (no/m ²)	Grains (no/pan)	Sterility (%)	Grain yield (t/ha)	Straw yield (t/ha)
	Khagrachori Sadar					
Local farmer's practices (T ₁)	100	257	85	46.33	4.26	8.09
BRRI recommended practices (T ₂)	102	266	92	31.67	5.34	9.50
Researcher recommended practices (T ₃)	102	293	107	18.33	6.85	10.73
CV (%)	0.49	10.72	6.81	11.13	8.85	10.11
Lsd(0.05)	0.83	18	7	4.91	0.44	0.55
Matiranga						
Local farmer's practices (T ₁)	100	259	84	38.00	5.09	9.24
BRRI recommended practices (T ₂)	101	294	122	15.33	6.87	10.93

Researcher recommended practices (T ₃)	101	325	131	12.33	7.95	11.16
CV (%)	0.46	8.6	5.15	8.71	6.28	11.23
Lsd(0.05)	0.81	13.86	9	3.64	0.38	0.73

7.6 Evaluation of improved agronomic management practice for yield maximization of BRRI-developed modern aman rice in the hill ecosystem

M Z Ibne Baki

Introduction

Rice (*Oryza sativa* L.) is a crucial cereal crop globally, thriving in diverse climatic zones and serving as a staple food for nearly half of the world's population, predominantly in developing countries. BRRI dhan103 is a high-yielding rice variety developed by the Bangladesh Rice Research Institute (BRRI). This variety is specifically designed to thrive in the agro-climatic conditions of Bangladesh, contributing to increased rice production in the country.

About 90% of rice is cultivated and consumed in Asia. Bangladesh, an agriculture-based nation, grows rice as its main food crop on approximately 11.52 million hectares, covering about 81.79% of the country's cropped area. Rice production accounts for 92% of Bangladesh's total food grain output and more than 50% of the agricultural value, employing around 44% of the total labor force. Rice occupies 78% of the total cropped area of Bangladesh, and the food security of Bangladesh is significantly influenced by the availability and accessibility of rice, as it counts for 70% of the daily calorific requirement and 56% of the protein consumption of the population (BBS, 2019).

The Chittagong Hill Tracts (CHT) comprise 70% of the hilly areas of Bangladesh and cover 13,184 km² (10% of the total country area), of which 90% are sloping lands (Hossain et al., 2017a). More than 35 crop species are cultivated annually in hilly areas (Ahammad and Stacey, 2016). Rice is the major crop component of the jhum field and the average yield is 1.15 t ha⁻¹ (Jamaluddin et al., 2010). So it is very important to increase the hill rice production. In this study, we will apply different types of improved agronomic practices to increase hill rice production and develop hill rice production packages.

Materials and Methods

The experiment was conducted at Khagrachori Sadar and Matiranga upazila during the *Aman* seasons, of 2024. Three different agronomic management practices were tested. The treatments were local farmer's practices (T₁), BRRI-recommended management practices (T₂), and researcher-recommended practices (T₃). Traditional hilly rice cultivation operations followed local farmer's practices. BRRI recommended that management be followed for seedling age, fertilizer doses, time of applications, and other intercultural operations. The researcher recommended practices for seedling age, time of planting, growth stage-based fertilizer management, herbicide applications, 1% potash spray, and other intercultural operations. The experiment was laid out in an RCB design with three replications. BRRI dhan103 was used as a test variety for *Aman* seasons. Thirty-day-old seedlings were transplanted on 14 and 17 August 2024. Two to three seedlings per hill were transplanted maintaining 20 X 20 cm spacing. Observations on yield and yield components *i.e.* plant height (cm), grains panicle⁻¹, 1000 seed weight (g), and grain yield (t ha⁻¹) were recorded at maturity. Plant height, straw yield, and yield attributes were determined by

diagonally sampling 12 hills from each plot. The samples were oven dried at 70°C to get constant weight. Yield was determined on a 5 m² area marked in the middle of each plot. The grains were dried in sunlight and winnowed before weighing and yield was adjusted to 14% moisture content and was converted into t ha⁻¹. Data were analyzed by using R. The least significant difference (LSD) at 5% probability was used to compare the means of the treatments (Gomez and Gomez, 1984).

Results and Discussion

The experimental results showed that there is a significant difference in yield and yield contributing characteristics among the management three management practices in Khagrachori sadar and Matiranga upazilla (Table 20). Plant height, panicle numbers, grains in a panicle, and sterility did not differ among the treatments in both locations (Table 19). The highest grain yield was obtained (6.61 and 7.10 t/ha) in T₃ treatment both in Khagrachori and Matiranga compared to local farmer practices, where pre-emergence herbicide and fertilizers were applied based on the growth stage base. Spraying of 1% potash solution had a positive impact on grains per panicle and sterility. The highest straw yields were found (11.43 and 13.45 t/ha) in T₃ treatment both in Khagrachori and Matirangs compared to BRRI recommended and local farmer practices.

Conclusion

Modern agronomic management based on the intercultural operations on rice in hilly ecosystems gave higher grain and straw yields compared to farmers' practices within all the hill regions. So, the researcher recommended practices that might be used in yield maximization of BRRI-developed modern rice varieties in hilly ecosystems.

Table 20: Influence of different agronomic management practices for the yield maximization of hilly Aman rice 2024

Treatment	Plant ht. (cm)	Panicles (no/m ²)	Grains (no/pan)	Sterility (%)	GY (t/ha)	Straw yield (t/ha)
	Khagrachori Sadar					
Local farmer's practices (T ₁)	119	186	81	35.51	4.06	7.88
BRRI management practices (T ₂)	122	193	87	23.71	5.39	10.11
Researcher recommended practices (T ₃)	125	224	97	17.25	6.61	11.43
CV (%)	2.1	12.26	7.21	10.13	2.71	8.25
Lsd(0.05)	0.87	21	8	5.68	0.56	0.46
Matiranga						
Local farmer's practices (T ₁)	118	196	91	31.00	4.88	8.73
BRRI management practices (T ₂)	125	271	135	19.43	6.31	11.31
Researcher recommended practices (T ₃)	122	288	153	11.27	7.10	12.32
CV (%)	0.38	9.3	5.15	7.52	7.42	13.45
Lsd(0.05)	0.88	15.71	9	4.81	0.73	0.87

8. SOIL HEALTH MANAGEMET

8.1 Isolation and characterization of salt-tolerant PGPR isolated from coastal saline soil in Bangladesh

R Shultana, M M Rana, U A Naher

Introduction:

About 53% of the coastal areas in Bangladesh are affected by salinity (Rasel *et al.*, 2013; Shatil *et al.*, 2021). Salt-tolerant rice varieties often fail to produce a satisfactory yield in actual saline soil due to the lack of proper soil management. Physical removal of salts or chemical amendments is not only expensive but also has an adverse ecological impact and it is not possible to cover large areas for soil renovation purposes (Shultana *et al.*, 2020). Indigenous PGPR strains available in saline soil could be an alternative for saline soil management (Pan *et al.*, 2019). To date, available research findings are inadequate on the simultaneous application of region-specific salt-tolerant PGPR with different salt-responsive rice varieties under saline soil conditions. Therefore, the experiment was conducted to screen out potential salt-tolerant bacterial strains isolated from coastal saline soil.

Materials and Methods:

The experiment was conducted at the soil microbiology laboratory, Agronomy division during the season of T. Aman, 2023. The soil was collected from six locations in the Khulna district viz. Basurabad, Batiaghata (N 22043.316'; E 22043.316'), Baronpara, Batiaghata (N 22038.002'; E 089030.879'), Kholisha, Dacope (N 22036.899'; E 089030.737'), Khatail, Dacope (N 22035.881'; E 089028.863'), Raipara, Khatail, Dacope (N 22036.156'; E 089028.485'), Channirchar, Dacope (N 22036.789'; E 089028.694') (Fig. 18). The soil chemical properties are stated in Table 21. Thirty bacteria strains were isolated from the collected soil. The strains of different shapes, sizes, and colors were identified and separated. The distinct strains were preserved in slant agar media and kept at 4°C. The strains were tested at various NaCl concentrations (0, 0.5, 1, 1.5 and 2M). The potential strains that survived at NaCl concentrations of 1.5M onwards were further considered for screening various salt-tolerant and plant growth-promoting traits like floc yield production, exopolysaccharide production (EPS) and sodium uptake. Besides, plant growth-promoting traits included nitrogen fixation, phosphate solubilization and indole acetic acid production. Initially, nine bacterial strains were screened through a preliminary test on salinity tolerance and plant growth-promoting characteristics. The nine potential strains were inoculated to BRRI dhan99 (Salt-tolerant) and BRRI dhan88 (Salt-susceptible) under laboratory conditions. The generated data were analyzed following Analysis of Variance (ANOVA) using R-4.1.1 software. The treatment means were compared by Least Significant difference (LSD) at a probability level of 0.05.

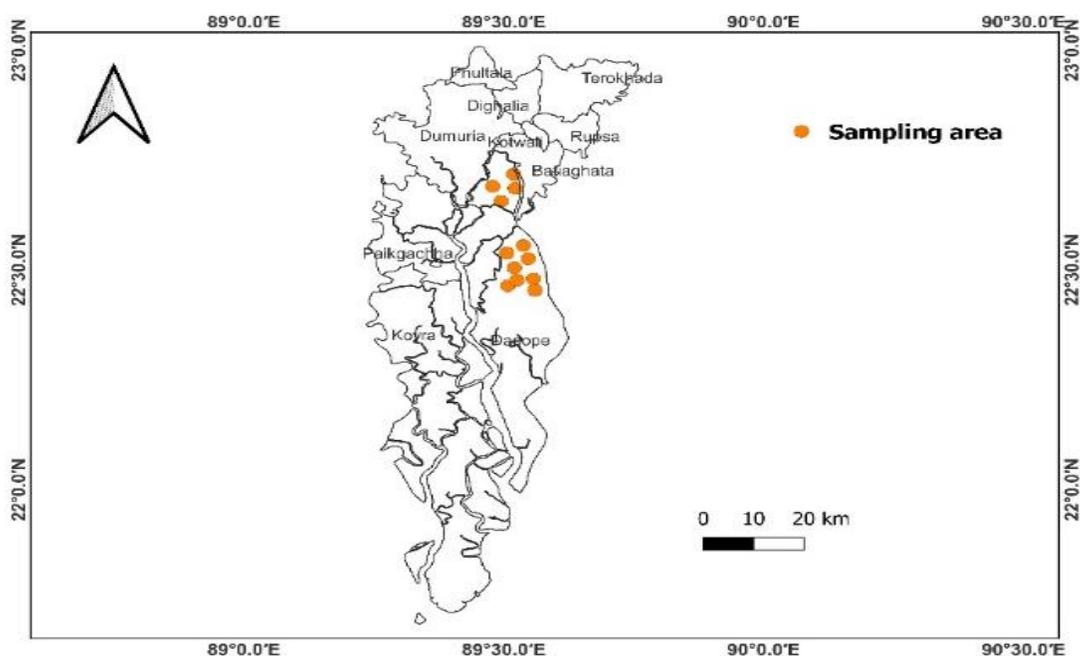


Fig. 18: The soil sampling areas of Batiaghata and Dacope Upazilas under Khulna district

Table 21: The characteristics of soil collected from different salt-affected areas under Khulna district

SL	Location	pH	EC (dSm ⁻¹)	OM%	Total N (%)	Available P (mg/L)	K (meq/100g soil)
1	Basurabad, Batiaghata	7.20	10.23	2.87	0.17	1.95	0.43
2	Baronpara, Batiaghata	7.30	22.03	3.18	0.18	1.13	0.60
3	Kholisha, Dacope	8.05	24.03	3.13	0.19	1.84	0.80
4	Khatail, Dacope	8.03	21.95	3.04	0.16	1.65	0.73
5	Raipara, Khatail, Dacope	8.02	13.65	2.30	0.14	1.79	0.66
6	Channirchar, Dacope	7.25	15.60	2.60	0.14	1.86	0.70

Results:

The salt-tolerant and plant growth-promoting traits:

Thirty bacterial strains were isolated from six different locations. Then the strains were allowed to grow at various levels of NaCl (0, 0.5, 1, 1.5 and 2M). The fourteen bacterial strains measured the maximum tolerance of NaCl concentration (1M). The fourteen selected salt-tolerant strains were further tested for their salinity tolerance and plant growth-promoting traits.

Floc yield production: Among the fourteen bacterial strains highest amount of floc yield was produced by the strain KB1 (18.36 gL⁻¹) (Fig. 19).

Exopolysaccharide production: The highest EPS was produced by the strains KB9 (49.16 gL⁻¹) and KB1 (49.11 gL⁻¹) followed by KB7 (42.23 gL⁻¹) and KB5 (40.33 gL⁻¹) (Fig. 20).

Sodium uptake: The highest amount of Na uptake was measured by the strain KB5 (74 ppm) (Fig. 21).

Indole acetic acid production: The highest indole acetic acid (IAA) was produced by the strains KB11(23.98 ppm) followed by KB5 (21.74 ppm) (Fig. 22).

Nitrogen fixation: The qualitative screening showed the ability to fix atmospheric nitrogen by the selected ST-PGPR strains KB1, KB5, KB9, KB11, and KB13.

Phosphate solubilization: The qualitative screening for phosphate solubilization showed by the strains KB1, KB3, KB6, KB7, KB9, KB11, KB13 and KB14 (Table 22).

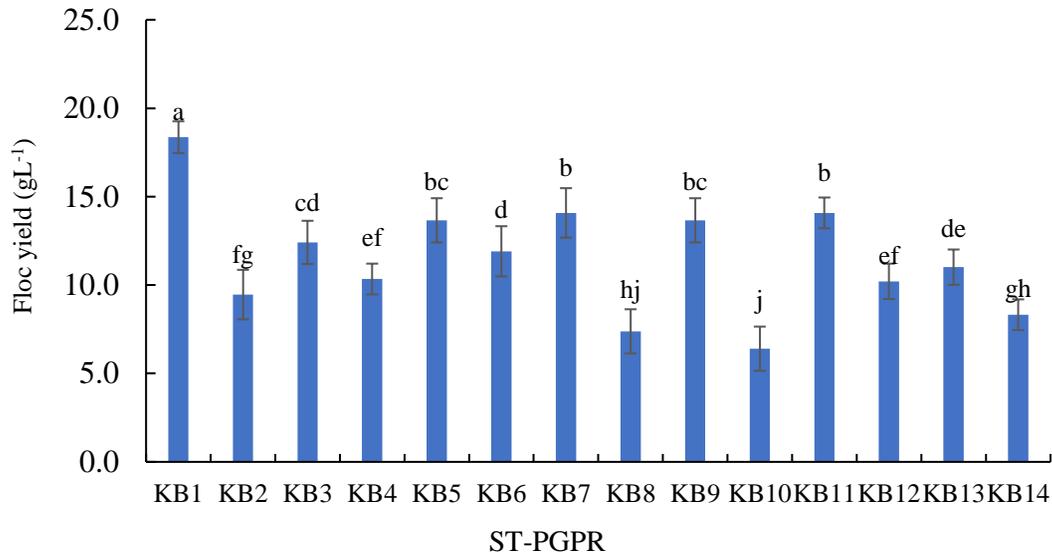


Fig. 19: The floc yield production of the selected ST-PGPR strains at 1M of NaCl

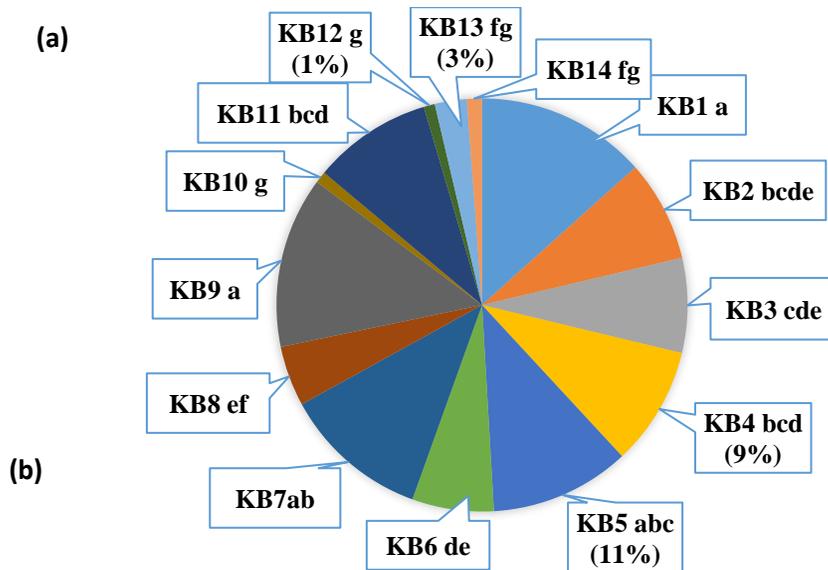
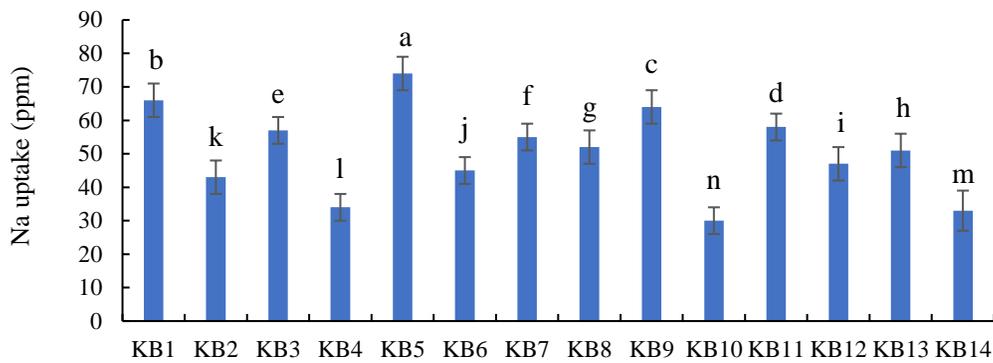
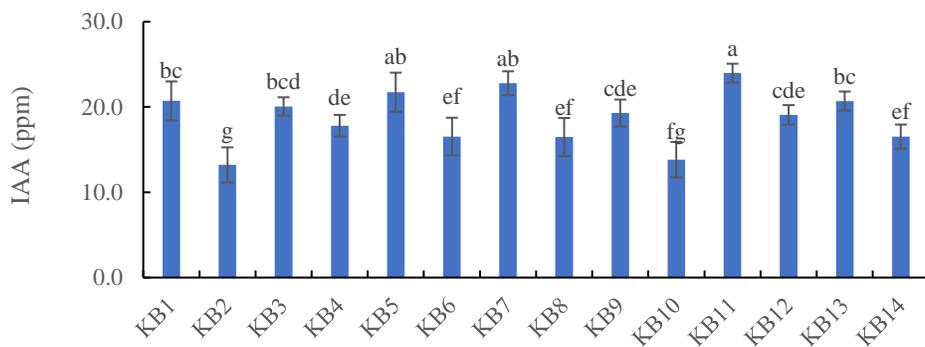


Fig. 20 a & b: EPS production of the selected ST-PGPR strain at 1M of NaCl



ST-PGPR

Fig. 21: The uptake of sodium of the selected ST-PGPR strains at 1M of NaCl



ST-PGPR

Fig. 22: The indole acetic acid production of the selected ST-PGPR strains at 1M of NaCl

Table 22: The nitrogen fixing and phosphate solubilizing ability of the selected ST-PGPR strains

Bacteria strains	Nitrogen fixation	Phosphate solubilization
KB1	+++	+++
KB2	-	-
KB3	-	+++
KB4	-	-
KB5	++	-
KB6	-	+++
KB7	-	+++
KB8	-	-
KB9	+	+++
KB10	-	-
KB11	++	+++
KB12	-	-
KB13	+++	+++
KB14	-	+++

Note: '+' positive; '-' Negative

Discussion:

The reported bacterial strains can survive in salt-stressed environments since they can form floc yield or aggregate as a response to salinity which increased with the higher concentration of NaCl. Moreover, bacterial flocculation or aggregate formation positively correlated with EPS production.

Similarly, Hong *et al.* (2017) identified *B. iodinum* RS16 as a higher flocculation yield producer at 1.5 M of NaCl concentration which further protects the host plant against various stresses. The above-mentioned attributes for salinity tolerance of the reported strains have a direct effect on sodium (Na) uptake from the saline media at 1.5M of NaCl concentrations. The sodium (Na⁺) binding capacity of bacterial EPS was earlier stated by Arora *et al.*, (2010) who reported that bacteria can bind the Na⁺ ion under salinity stress through the excretion of EPS, which consequently reduces its toxicity in the soil.

Conclusion:

Based on their salt-tolerance and plant growth-promoting traits, potential strains KB1, KB3, KB5, KB6, KB7, KB9, KB11, KB13, and KB14 could be identified as salt-tolerant PGPR strains. However, further plant inoculation studies are needed before confirmation.

8.2 Effect of salt-tolerant PGPR (ST-PGPR) inoculation on the growth of rice seedlings under salt-stress condition

R Shultana, M M Rana, U A Naher

Introduction:

In the current agricultural systems, developing an eco-friendly approach to enhance plant growth under abiotic stresses has received more attention (Viscardi *et al.*, 2016). Taking into consideration this scenario, attention should be given to enhancing the yield of salt-affected rice cultivation areas by taking advantage of the salt-tolerant plant growth-promoting rhizobacteria (PGPR). A clear understanding of PGPR mechanisms could help efficiently utilize beneficial microorganisms to enhance plant growth under saline soil conditions (Pan *et al.*, 2019). To date, insufficient research findings are available on the combined application of region-specific salt-tolerant PGPR with different salt-responsive rice varieties under saline conditions. Several salt-resistant rice varieties already have been commercialized in Bangladesh but in many cases, the field performance of these varieties in actual saline areas has failed to reach a satisfactory level. Therefore, along with the cultivation of salt-tolerant rice plants, the adoption of different salt-tolerant PGPR as an organic source of fertilizer could be a promising alternative for rice cultivation in the saline ecosystem. Hence, the experiment will be conducted to observe the effect of different PGPR strains on the growth of rice seedlings at various salinity stresses.

Materials and methods:

The experiment was conducted at the laboratory, Agronomy division during the season of Boro, 2023-24. The treatments were comprised of nine bacterial inoculums (No inoculum, KB1, KB3, KB5, KB6, KB7, KB9, KB11, KB13 and KB14). The rice varieties BRRI dhan99 and BRRI dhan88 were considered as a test plant. The two levels of salinity (0 (control), and 7 dSm⁻¹) were maintained throughout the growing period. The seeds were seeded in a perforated plastic tray that originally had multiple compartments. The trays were submerged in plastic trays containing the desired level of saline water. The seedlings were allowed to grow up to 45 days. The trays were arranged in a Randomized Complete Block Design following three replications. The data on seedling height, number of leaves, shoot length, root length, shoot dry weight and root dry weight were measured. All the data generated were analyzed following Analysis of Variance (ANOVA) using R-4.1.3 software. The treatment means were compared by Least Significant difference (LSD) at a probability level of 0.05.

Results:

Effect of Salt-tolerant PGPR inoculations on seedling growth of BRR I dhan99 and BRR I dhan88 under non-stress condition

Under non-salinated conditions, the highest shoot length of BRR I dhan99 was measured by the inoculation of KB1(43.43 cm) followed by KB9 (41.90 cm), KB11(42cm) and KB13 (43.03). Besides, the highest root length was observed by the inoculation with KB14 (13.2 cm) followed by KB7 (12 cm), KB9 (12.93 cm), KB11 (12.83 cm), KB13 (11.43 cm) and KB14 (13.20 cm). The highest shoot weight was produced by the strains KB1 (0.21 g), KB9 (0.20 g) and KB13 (0.19 g) followed by KB5 (0.17 g) and KB11(0.18 g). The highest root weight was produced by the strain KB9 (0.13 g) followed by KB1(0.11 g), KB5 (0.12 g) and KB6 (0.10 g) (Fig. 23). Likewise, the highest shoot length of BRR I dhan88 was measured by the strains KB9 (50.67 cm) followed by KB1(48.37 cm), KB5 (47.40 cm), and KB14 (46.40 cm). Besides, the highest root length was produced by the inoculation of KB9 (48.37 cm) followed by KB7 (9.60 cm), KB11 (9.83 cm) KB13 (9.40 cm) and KB14 (11.33 cm). The highest shoot weight was produced by the strain KB9 (0.23g cm) and KB1 (0.22g cm). Besides, the highest root weight was produced by the strain KB5 (0.08g) and KB9 (0.08g) followed by KB1(0.06g), KB7 (0.06g), KB13 (0.06) and KB11 (0.05g) (Fig. 24).

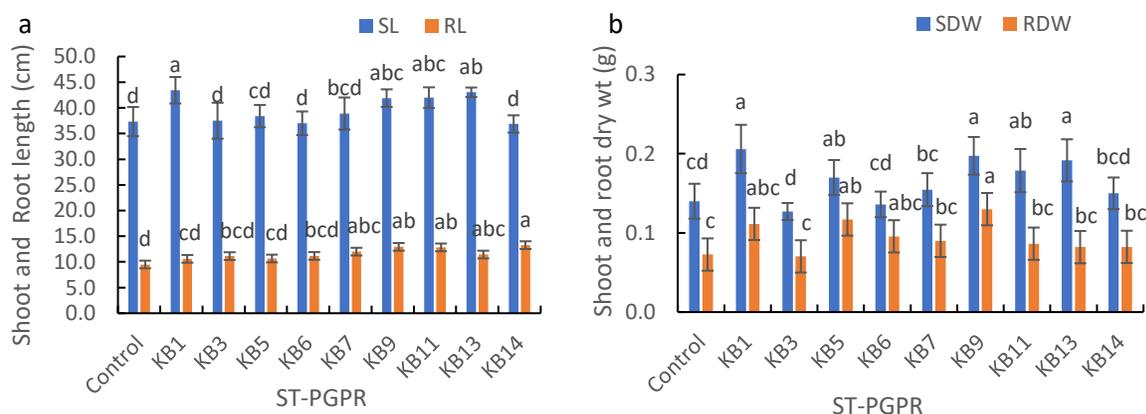


Fig. 23: Effect of ST-PGPR inoculations on (a) shoot length and root length and (b) shoot weight and root weight of BRR I dhan99 under non-saline conditions. SL: Shoot length; RL: Root length; SDW: Shoot Dry Weight; RDW: Root dry weight.

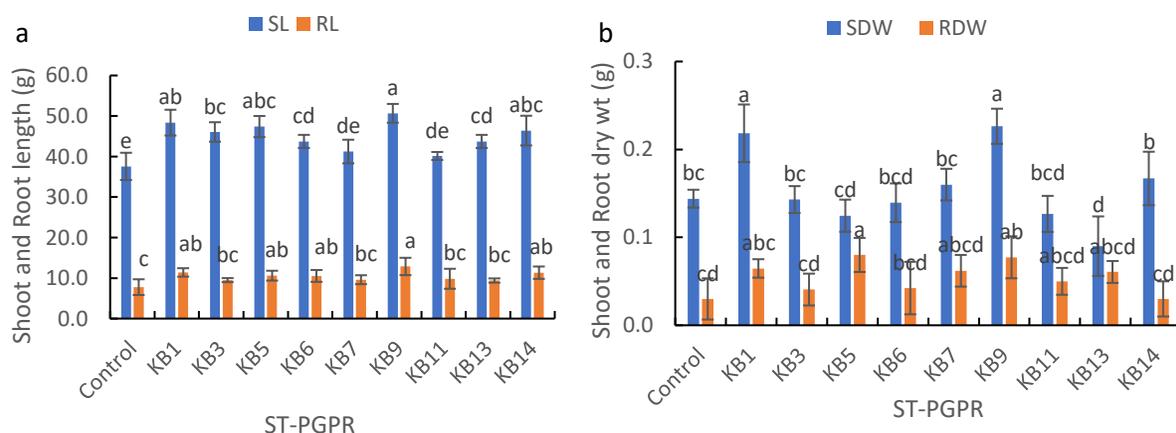


Fig. 24: Effect of ST-PGPR inoculations on (a) shoot length and root length and (b) shoot weight and root weight of BRR I dhan88 under non-saline conditions. SL: Shoot length; RL: Root length; SDW: Shoot Dry Weight; RDW: Root dry weight.

Effect of Salt-tolerant PGPR inoculations on seedling growth of BRR1 dhan99 and BRR1 dhan88 under salt-stress condition

Under salt-stress conditions, the highest shoot length of BRR1 dhan99 was measured by the inoculation of KB1(46.33 cm) and KB7 (45.57) followed by KB3 (40.90cm), KB6(42.47cm), KB11 (41.43cm) and KB14 (40.50cm). Besides, the highest root length was observed by the inoculation of KB1 (13.30cm), KB3 (13cm) and KB13 (13cm) followed by KB7 (12.9 cm), KB11 (12.3 cm) and KB14 (12.10 cm). The highest shoot weight was produced by the strains KB1 (0.21 g) followed by KB7 (0.20 g). The highest root weight was produced by the strain KB5 (0.08) and KB9 (0.08 g) followed by KB1(0.07g) and KB7 (0.06 g) (Fig. 25). Likewise, the highest shoot length of BRR1 dhan88 was measured by the strains KB7 (44.30 cm) followed by KB1(44 cm), KB3 (44.23 cm), and KB5 (44.17 cm), KB9 (41.63 cm), KB11 (43.03 cm), KB13 (42.40 cm), and KB14 (43.30 cm), Besides, the root length did not vary significantly. The highest shoot weight was produced by the inoculation of strain KB1 (0.27g cm) KB5 (0.26g cm), KB7 (0.27) followed by KB14 (0.25) Besides, the highest root weight was produced by strain KB1 (0.11g) (Fig. 26).

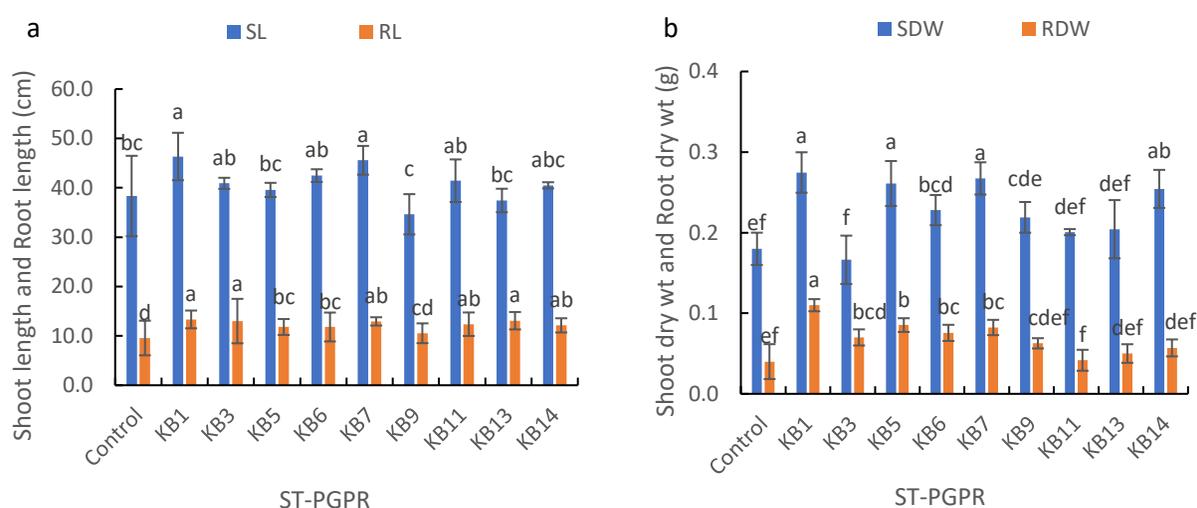


Fig. 25: Effect of ST-PGPR inoculations on (a) shoot length and root length and (b) shoot weight and root weight of BRR1 dhan99 under saline conditions. SL: Shoot length; RL: Root length; SDW: Shoot Dry Weight; RDW: Root dry weight.

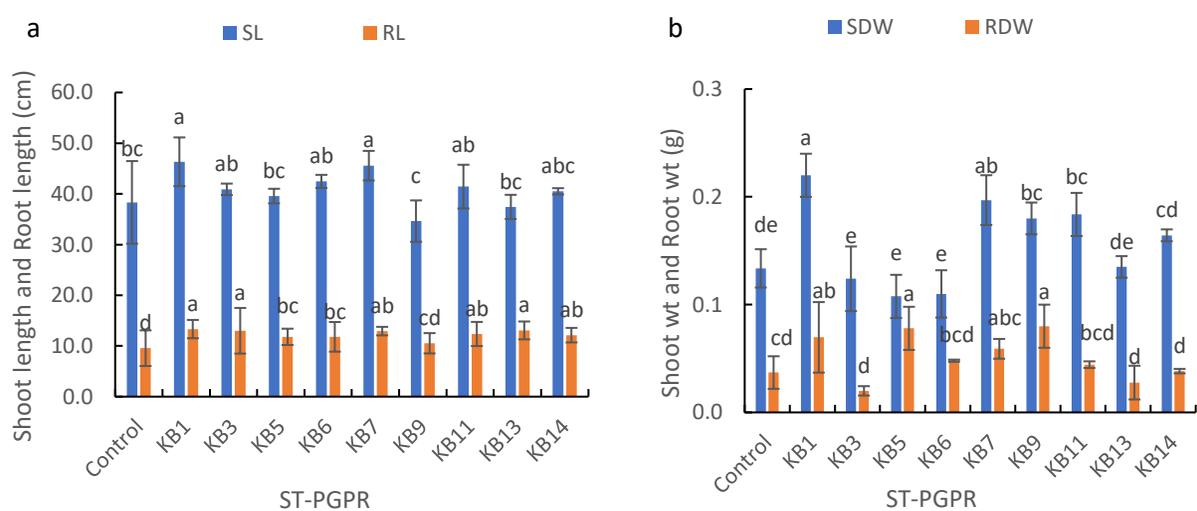


Fig. 26: Effect of ST-PGPR inoculations on (a) shoot length and root length and (b) shoot weight and root weight of BRR1 dhan88 under saline conditions. SL: Shoot length; RL: Root length; SDW: Shoot Dry Weight; RDW: Root dry weight.



Discussion

The highest shoot and root length and shoot and root dry matter of BRRI dhan99 and BRRI dhan88 were produced by the inoculation of KB1, KB5, KB7, KB9 and KB11 since these strains are capable of reducing the salt-stress effect of rice seedlings. This is because of the highest exopolysaccharide production by the reported strains. Thus, they can bind sodium ions in soil therefore sodium ions become less available to plants. Besides, the strains showed their ability to produce higher indole acetic acid, nitrogen fixation and phosphate solubilization which stabilizes normal plant growth even in salt-stress conditions. Likewise, Shultana *et al.*, (2020) confirmed the highest growth of rice plants inoculated with a salt-tolerant strain, UPMRB9.

Conclusion:

Among the nine tested bacterial strains KB1, KB5, KB7, KB9 and KB11 were identified as potential salt-tolerant strains. Hence, this bacterial strain could be considered as a salt-tolerant strain which can significantly contribute to reducing the salinity stress of rice at the seedling stage. However, further confirmation is needed before the final recommendation.

9. WEED MANAGEMENT

9.1 Evaluation of candidate herbicide for weed control efficiency

MKA Bhuiyan and md Shahidul Islam

Introduction

Weed control efficiency (WCE) is vital in rice cultivation to prevent yield loss caused by weeds. New molecule herbicides offer effective solutions by targeting various weed species through different application methods. Evaluating WCE helps identify the best herbicides for specific weeds and growing conditions, improving productivity and reducing environmental impact in rice farming.

Materials and methods

A study was conducted to evaluate the performance of 56 candidate herbicides for weed control efficiency during the T. Aman 2023 and Boro 2023-24 seasons. The rice varieties used were BRRI dhan87 in the T. Aman season and BRRI dhan88 in the Boro season. Seedlings aged 25 days were transplanted on 12 August for the T. Aman season, while 35-day-old seedlings were transplanted on 10 January for the Boro season. To assess weed control efficiency, weed data were collected from randomly selected 1 m² sampling areas in both seasons. Weed sampling was conducted at 40 days after transplanting (DAT) for T. Aman and 45 DAT for Boro. Weed control efficiency was calculated based on the dry weight of weed biomass, providing a quantitative measure of herbicide effectiveness in reducing weed populations. This study provides critical insights into the efficacy of herbicide candidates under diverse seasonal conditions and agronomic practices, contributing to improved weed management strategies for rice cultivation.

Results

Field trials were conducted at the Bangladesh Rice Research Institute, Gazipur from T. Aman 2023 and boro 2023-24, seasons. Most of the herbicides performed more than 80% weed control efficiency in different weed populations observed in the field (Table 22). Only *cynodon dactylon* cannot be controlled >80% by some herbicides in most cases. Among the herbicides, six herbicides

did not control weed effectively and their weed control efficiency was less than 80%. Table 23 shows that post-emergence herbicide is dominant and most of the herbicides contain more effective combination chemicals. The table summarizes the herbicide chemical names, doses per hectare, weed control efficiency (WCE) against five weed species, application timing, and overall effectiveness. Herbicides like Penoxulam + Butachlor, Quinclorac + Bispyribac sodium, and Pretilachlor + Bensulfuron methyl show high WCE across both seasons, particularly effective against *Cynodon dactylon*, *Monochoria vaginalis*, and *Cyperus difformis*. Late post-emergence herbicides, such as Flumioxazim and Bispyribac sodium + Pyrazosulfuron Ethyl, also exhibit high efficiency in the Boro season. However, 2,4-D Amine, applied late post-emergence, demonstrates lower WCE and is marked as unsatisfactory. The table highlights the importance of choosing herbicides based on timing and targeted weed species for effective management.

Discussion

The evaluation of 56 herbicides during the T. Aman 2023 and Boro 2023-24 seasons at BIRRI farm, Gazipur, revealed varying weed control efficiencies (WCE) across herbicide formulations and application timings. Herbicides like Quinclorac + Bispyribac sodium and Pretilachlor + Bensulfuron methyl demonstrated consistently high WCE, with values exceeding 80% for most weed species in both seasons, indicating broad-spectrum effectiveness. Post-emergence applications, such as Haloxyfop-R-methyl + Clethodim, were generally more effective in the Boro season, showing higher WCE than in T. Aman. Penoxulam + Butachlor applied during the early post-emergence stage, also performed well, achieving uniform weed control. Conversely, herbicides like 2,4-D Amine, particularly in the late post-emergence stage, showed lower efficacy, especially for grass weeds, highlighting the importance of timely application. Overall, herbicides like Quinclorac + Bispyribac sodium and Pretilachlor + Bensulfuron methyl are recommended for effective and consistent weed control, improving weed management strategies in rice cultivation.

Conclusion:

In conclusion, herbicides like Quinclorac + Bispyribac sodium and Pretilachlor + Bensulfuron methyl showed the highest and most consistent weed control efficiency across both T. Aman 2023 and Boro 2023-24 seasons. Post-emergence applications were generally more effective in the Boro season, while timely application was crucial for maximizing efficacy. Herbicides such as 2,4-D Amine showed lower efficiency, especially for grass weeds, emphasizing the importance of selecting the right herbicide and application timing for optimal weed control.

Among the herbicide groups, some new molecule herbicides and their efficacy were given below.

Table 23. Herbicide chemical name, dose and weed control efficiency of different herbicides evaluated during T. Aman 20223 and Boro 2023-24 at BIRRI farm Gazipur

Chemical name	Dose ha ⁻¹	Season	Weed Control Efficiency (%)					Remarks
			<i>Cynodon dactylon</i>	<i>Echinochloa crus-galli</i>	<i>Monochoria vaginalis</i>	<i>Scirpus maritimus</i>	<i>Cyperus difformis</i>	
Haloxyfop-R-methyl 7.5% + Clethodim 15%	150 ml	Aman	58.50	82.50	84.50	80.30	81.40	Postemergence satisfactory
		Boro	74.54	86.60	86.32	81.40	83.50	
Pretilachlor 38.5% + Penoxsulam 1.5%	1200ml	Aman	59.00	85.60	82.65	80.90	83.00	Post-emergence Satisfactory
		Boro	77.80	83.00	80.60	82.00	80.75	
Penoxulam + Butachlor	2000ml	Aman	60.50	82.50	81.00	83.20	81.50	post-emergence (1-3 leaves stage); very effective.
		Boro	77.50	83.00	83.00	81.40	82.84	

Quinclorac 30% + Bispyribac sodium 5%	600g	Aman	80.00	81.00	83.00	80.25	80.00	Post-emergence Satisfactory
		Boro	81.20	82.00	87.00	80.00	82.00	
Pretilachlor 36% + Bensulfuron metyl 4%	1000 g	Aman	80.80	81.00	82.00	80.00	80.00	Pre-emergence. Satisfactory
		Boro	77.20	82.00	84.60	80.80	84.50	
Flumioxazim 50 WP	500g	Aman	70.00	81.00	83.00	83.70	87.00	Late Post-emergence (3-4 leaf) Satisfactory
		Boro	76200	85.00	80.50	88.00	86.00	
Bentazone 400% + MCPA 60% SL	1.8L	Aman	70.00	80.00	80.00	82.80	80.00	Post emergence Satisfactory
		Boro	76.00	81.50	81.00	90.80	80.00	
2,4-D Amine	2.0L	Aman	70.80	65.00	62.00	73.00	70.00	Late post emergence. Not satisfactory.
		Boro	76.0	63.00	72.00	74.00	71.00	
Bispyribac sodium 20% + Pyrazosulfuron Ethyl 10%	150g	Aman	70.00	81.00	83.00	83.70	87.00	Post-emergence Satisfactory.
		Boro	76200	85.00	80.50	88.00	86.00	

9.2 Effect of adding urea with Herbicides for controlling weeds and the growth and yield of transplanted Rice in T Aman season

MKA Bhuiyan and MM Mahbub

Introduction

The effect of adding urea with herbicides for controlling weeds in transplanted rice is an important area of study in crop management. Combining urea, a nitrogen fertilizer, with herbicides can enhance weed control while simultaneously promoting the growth of rice plants. This practice aims to improve nutrient availability, leading to better crop establishment and higher yields. The synergistic effect of urea and herbicides may result in more effective weed suppression and improved rice productivity, offering a cost-effective solution for managing both weeds and fertilizer needs in rice cultivation.

Objective

The study aims to determine whether integrating urea with herbicides enhances weed suppression, improves rice growth, and ultimately increases grain yield.

Materials and methods

The experiment was conducted to evaluate the effect of adding urea with herbicides on weed control and the growth and yield of transplanted rice during the T. Aman 2023 season. The treatments consisted of nine herbicide-based treatments, each with a different method of urea application, as well as control treatments. The treatments were as follows.

Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ fb 1HW(T₁), Penoxsulam@ 93.7ml ha⁻¹fb 1HW(T₂), Bispyribac sodiumSC @ 150 ml ha⁻¹ fb 1HW(T₃), Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ with 1% urea tank mix fb 1HW(T₄), Penoxsulam@ 93.7ml ha⁻¹ with 1% urea tank mix fb 1HW(T₅), Bispyribac sodiumSC @ 150 ml ha⁻¹ with 1% urea tank mix fb 1HW(T₆), Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ broadcast with urea(5kg urea /33 decimal) fb 1HW(T₇), Penoxsulam@ 93.7ml ha⁻¹ broadcast with urea(5kg urea /33 decimal) fb 1HW(T₈), Bispyribac sodium SC @ 150 ml ha⁻¹ broadcast with urea(5kg urea /33 decimal) fb 1HW(T₉), Unweeded(T₁₀) and Weed free by three hand weeding(T₁₁).The experiment followed RCBD design with three

replications. Thirty days old seedlings were transplanted on 7 August 2023. BRRI dhan103 was used as a variety during T Aman season.

Results

The results from Table 24 indicate that weed management treatments significantly reduced weed pressure and yield loss compared to the unweeded control. Treatments such as **T₇** (Bensulfuron methyl + Acetachlor with urea broadcast) showed the best performance, with the lowest weed number (**16/m²**), weed dry weight (**5.86 g/m²**), and a yield loss of only **1%**, demonstrating its high effectiveness. Other treatments, like **T₂** (Penoxsulam) and **T₃** (Bispyribac sodium SC), also provided good control, with WCE of **79%** and **80%**, respectively, and moderate yield losses of **11-12%**. The weed-free control (**T₁₁**) exhibited **83%** WCE and **3%** yield loss, further supporting the importance of effective weed control. In contrast, the unweeded control (**T₁₀**) had the highest weed number (**90/m²**) and weed dry weight (**32.91 g/m²**), resulting in a **51%** yield loss. Overall, the treatments with herbicide and urea combinations were the most effective in controlling weeds and minimizing yield loss, highlighting the importance of timely and integrated weed management in rice cultivation. Fig. 27 illustrates a clear inverse relationship between weed dry matter and **grain yield** across different weed management treatments. Treatments that combined herbicides with urea, such as **T₄** (Bensulfuron methyl + Acetachlor with 1% urea tank mix) and **T₅** (Penoxsulam with 1% urea tank mix), effectively reduced weed dry matter and resulted in higher grain yields, indicating the positive impact of integrated weed management. The weed-free control (**T₁₁**), achieved through three hand weedings, also showed low weed dry matter and high grain yield, further supporting the importance of efficient weed control. Conversely, the **unweeded** control (**T₁₀**), with the highest weed dry matter, showed the lowest yield, emphasizing the detrimental effect of uncontrolled weed growth on rice productivity. Overall, treatments with herbicide-urea combinations were the most effective in controlling weeds and promoting higher grain yields, highlighting the importance of integrated weed management strategies. (Fig. 25). The treatment combining urea with herbicides resulted in a significant increase in yield components such as the number of panicles m⁻², and the number of grains per panicle. The overall grain yield of rice was notably higher in the urea + herbicide treated plots compared to those treated with herbicides alone. The results from **Table 25** demonstrate that different weed management treatments significantly influenced the yield and yield-contributing characters. The highest panicle number and grains per panicle were observed in treatments **T₈** (310 panicles/m², 100 grains) and **T₇** (299 panicles/m², 99 grains), indicating these treatments' superior performance in promoting panicle and grain development. Grain yield was highest in **T₈** (**7.19 t/ha**), followed by **T₇** (**7.12 t/ha**) and **T₉** (**7.04 t/ha**), while the unweeded control (**T₁₀**) had the lowest yield (**3.51 t/ha**) due to the detrimental impact of uncontrolled weeds. The 1000 grain weight remained relatively consistent across treatments, with only minor differences. Statistical analysis revealed significant differences among treatments, particularly for panicle number and grain yield, with **LSD** values of **30.87** and **0.55**, respectively. Overall, treatments with integrated weed management, especially **T₇**, **T₈**, and **T₉**, showed significant improvements in rice productivity compared to the unweeded control.

Discussion

The results from **Table 24 and 25** highlight the importance of effective weed management in rice production. **Table 23** demonstrates that treatments combining herbicides with urea (e.g., **T7, T8,** and **T9**) effectively controlled weeds, resulting in higher **weed control efficiency (WCE)** and lower **yield loss** compared to the unweeded control (**T10**), which showed the highest weed pressure and the greatest yield loss. **Table 25** further underscores the impact of weed control on rice yield, with treatments **T7** and **T8** achieving the highest **grain yield (7.12 t/ha and 7.19 t/ha, respectively)** due to their superior weed management. The unweeded control (**T10**) resulted in a significantly lower yield (**3.51 t/ha**), emphasizing the negative impact of uncontrolled weed growth. Overall, integrated weed management treatments, particularly those with herbicides and urea, led to higher yields and better growth parameters, highlighting their effectiveness in enhancing rice productivity.

This approach can be particularly useful in regions where weed pressure is high and nutrient availability is a limiting factor for rice production. Further studies could explore the long-term effects of this combination with different chemical groups of herbicides on soil health and sustainability in rice ecosystems.

conclusion

For improved rice yield, it is recommended to broadcast Penoxsulam at 93.7 ml/ha along with urea (5 kg/bigha) during the post-emergence stage, as this combination effectively controls weeds and boosts nutrient availability, leading to better crop growth and higher grain yield.

Table 24. Weed number, weight weed control efficiency (%) and yield loss (%) of different weed management treatments during T aman season 2023.

Treatment	Weed no./m ²	weed dry-weight (g m ⁻²)	WCE (%)	yield loss%
T ₁	18	6.89	79	15
T ₂	18	6.81	79	11
T ₃	19	6.74	80	12
T ₄	18	6.67	80	11
T ₅	19	6.59	80	8
T ₆	17	6.62	80	7
T ₇	16	5.86	82	1
T ₈	10	4.55	86	-
T ₉	12	5.25	84	2
T ₁₀	90	32.91		51
T ₁₁	13	5.51	83	3
Lsd(.05)	7.33	1.99	-	-
CV (%)	19.0	16.1	-	-

Table 25. Yield and yield contributing character of different weed management treatments during T aman season 2023.

Treatment	Panicle/m ²	Grains/panicle	1000GW	GY(t/ha)
T ₁	264	79	23.22	6.13
T ₂	277	81	23.21	6.41
T ₃	273	82	23.23	6.32
T ₄	280	86	23.31	6.43
T ₅	282	88	23.47	6.58
T ₆	285	90	23.30	6.65
T ₇	299	99	23.52	7.12
T ₈	310	100	23.65	7.19

T ₉	303	96	23.34	7.04
T ₁₀	181	70	23.03	3.51
T ₁₁	298	93	23.13	7.00
Lsd(0.05)	30.87	13.62	0.43	0.55
CV (%)	6.5	9.1	1.20	5.10

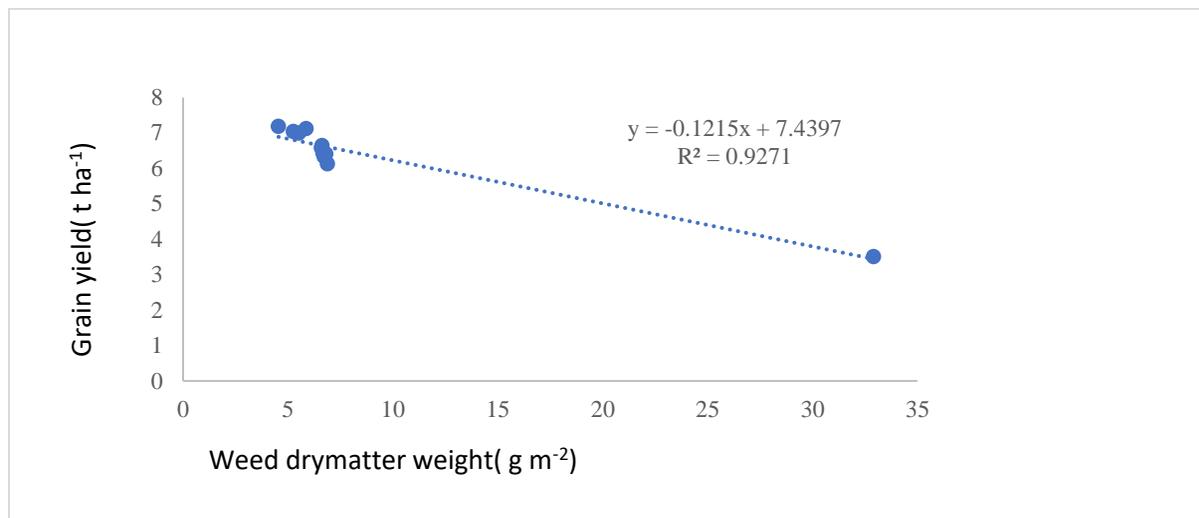


Fig. 27: Relationship of grain yield and weed dry matter of different weed management treatments

9.3 Effect of adding urea with Herbicides for controlling weeds and the growth and yield of transplanted Boro rice

MKA Bhuiyan, MM Mahbub

Introduction

The combined application of herbicides and urea has been suggested as an effective strategy for enhancing weed control and improving rice growth, as nitrogen may increase herbicide uptake and improve the crop's ability to compete with weeds (Mao *et al.*, 2020). Some farmers of different corners of Bangladesh are practicing herbicide with urea application to get better weed suppression and yield. The effect of adding urea to herbicide treatments on the control of weeds should be explored and the subsequent growth and yield of transplanted boro rice will be evaluated. By integrating urea with herbicide applications, this research aims to provide insights into optimizing weed management strategies, potentially improving both weed control efficiency and rice productivity in rice systems.

Objectives

The primary objective of this study is to evaluate the impact of combining urea with new molecule herbicides on the grain yield and yield components and weed control efficiency of transplanted Boro rice.

Materials and methods

The treatments of the experiment were Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ fb 1HW(T₁), Penoxsulam@ 93.7ml ha⁻¹fb 1HW(T₂), Bispyribac sodiumSC @ 150 ml ha⁻¹ fb 1HW(T₃), Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ with 1% urea tank mix fb 1HW(T₄), Penoxsulam@ 93.7ml ha⁻¹ with 1% urea tank mix fb 1HW(T₅), Bispyribac sodiumSC @ 150 ml ha⁻¹ with 1% urea tank mix fb 1HW(T₆), Bensulfuron methyl+ acetachlor @ 750g ha⁻¹ broadcast with urea (5kg

urea /33 decimal) fb 1HW(T₇), Penoxsulam@ 93.7ml ha⁻¹ broadcast with urea(5kg urea /33 decimal) fb 1HW(T₈), Bispyribac sodium SC @ 150 ml ha⁻¹ broadcast with urea(5kg urea /33 decimal) fb 1HW(T₉),Unweeded(T₁₀) and Weed free by three hand weeding(T₁₁).The experiment followed RCBD design with three replications. BRRI dhan89 was used as a variety.

Results

The findings reveal substantial differences in the efficacy of weed management treatments during the Boro season 2023–24. Treatments T₉ and T₈ demonstrated the highest effectiveness, with significantly reduced weed densities (12 and 13 weeds/m²) and dry weights (6.22 g/m² and 7.4 g/m²), achieving the highest weed control efficiencies (84% and 83%) and the lowest yield losses (0% and 3%). In contrast, the unweeded control (T₁₀) exhibited the highest weed density (93 weeds/m²) and dry weight (45.66 g/m²), resulting in a substantial yield loss of 58%, emphasizing the detrimental impact of uncontrolled weed growth (**Table 26**). Other treatments displayed moderate weed control efficiencies (77%–82%) and yield losses ranging from 4% to 11%, highlighting varying levels of effectiveness. Statistical analysis revealed significant differences among treatments for weed density and dry weight (LSD = 7.00 and 2.67, respectively), with coefficients of variation (CV) of 16.8% and 14.3%, ensuring experimental reliability. These results underscore the superior performance of T₉ and T₈ in optimizing weed control and minimizing yield losses in transplanted Boro rice, demonstrating their potential for improving productivity in rice cultivation systems.

The regression model shown in **Fig. 28** illustrates the relationship between grain yield and weed dry matter weight across various weed management treatments. The data reveal a significant negative correlation, indicating that as weed dry matter weight increases, grain yield decreases. This inverse relationship underscores the competitive impact of weeds on rice growth, where higher weed biomass likely leads to reduced resource availability for the crop, such as light, nutrients, and water. The regression line provides a quantitative framework for understanding this relationship, suggesting that effective weed management, which minimizes weed biomass, is critical for achieving optimal grain yields. Treatments with lower weed dry matter weights are associated with higher grain yields, demonstrating the importance of selecting efficient weed control strategies to mitigate yield losses. The model emphasizes the role of integrated weed management approaches in sustaining productivity in rice cultivation.

The data in **Table 27** reveal the significant impact of weed management treatments on the yield and yield-contributing traits of transplanted **Boro rice** during the 2023–24 season. Treatment T₉ achieved the highest performance, with **326 panicles/m², 106 grains per panicle**, and a grain yield of **7.92 t/ha**, followed closely by T₈, which recorded **310 panicles/m², 102 grains per panicle**, and a yield of **7.67 t/ha**. These results highlight the superior weed control and resource optimization provided by these treatments. In contrast, the unweeded control (T₁₀) exhibited the lowest values across all parameters, with **188 panicles/m², 74 grains per panicle**, and a drastically reduced yield of **3.32 t/ha**, underscoring the detrimental effects of uncontrolled weed competition. Other treatments, such as T₃, T₇, and T₁₁, also demonstrated robust yields ranging from **7.21 t/ha to 7.63 t/ha**, attributed to effective weed suppression. Statistical analysis confirmed significant

differences in panicle density and grains per panicle, while 1000-grain weight differences were non-significant. Overall, treatments **T₉** and **T₈** emerged as the most effective strategies for enhancing rice productivity under weed management practices. The study indicates that integrating urea with herbicides offers a dual advantage of improved weed management and enhanced rice growth, leading to higher yields. Urea not only acts as a fertilizer but also appears to boost the efficacy of herbicides by increasing the susceptibility of weeds to chemical treatments.

Discussion

The analysis of the relationship between grain yield and weed dry matter weight, along with the data from the two tables, underscores the critical role of effective weed management in optimizing rice productivity. The regression analysis revealed a significant inverse relationship between grain yield and weed dry matter, highlighting the adverse effects of weed competition. Treatments such as **T₉** and **T₈** consistently demonstrated superior performance across multiple parameters, including higher weed control efficiency (WCE), reduced weed dry weight, and minimal yield losses, achieving grain yields of **7.92 t/ha** and **7.67 t/ha**, respectively. These treatments were characterized by greater panicle density, more grains per panicle, and efficient resource utilization. Conversely, the unweeded control (**T₁₀**) experienced the highest weed pressure, reflected in drastically lower yields (**3.32 t/ha**) and significant yield losses (**58%**). Statistical analyses confirmed substantial differences among treatments for weed suppression, yield components, and grain yield, with high-performing treatments ensuring sustainable productivity.

This approach can be particularly useful in regions where weed pressure is high and nutrient availability is a limiting factor for rice production. Further studies could explore the long-term effects of this combination with different chemical groups of herbicides on soil health and sustainability in rice ecosystems.

Findings:

For achieving the highest grain yield of 7.92 t/ha in rice, it is recommended to broadcast Bispyribac sodium SC at 150 ml/ha along with urea (5 kg urea per 33 decimals), followed by one hand weeding (HW) for effective weed control and optimal crop growth.

Table 26. Weed number, weight weed control efficiency (%), and yield loss (%) of different weed management treatments during Boro season 2023-24

Treatment	Weed no./m ²	weed dry-weight (g m ⁻²)	WCE (%)	yield loss (%)
T ₁	21	10.06	77	10
T ₂	22	9.6	78	11
T ₃	15	7.22	82	4
T ₄	21	9.4	78	10
T ₅	20	9.5	78	9
T ₆	19	8.36	78	10
T ₇	18	7.94	80	9
T ₈	13	7.4	83	3
T ₉	12	6.22	84	0
T ₁₀	93	45.66	-	58
T ₁₁	16	7.61	81	5
Lsd _(.05)	7.00	2.67	-	-
CV (%)	16.8	14.3	-	-

Table 27. Yield and yield contributing character of different weed management treatments during Boro season 2023-24

Treatment	Panicle/m ²	Grains/panicle	1000 GW (g)	GY (t/ha)
T ₁	280	88	24.29	7.10
T ₂	277	84	24.28	7.03
T ₃	318	99	24.47	7.63
T ₄	280	86	24.38	7.09
T ₅	302	91	24.54	7.22
T ₆	288	90	24.37	7.11
T ₇	296	93	24.59	7.21
T ₈	310	102	24.61	7.67
T ₉	326	106	24.66	7.92
T ₁₀	188	74	24.10	3.32
T ₁₁	307	97	24.34	7.55
Lsd _(.05)	30.53	16.19	ns	0.56
CV (%)	6.2	10.3	1.12	4.70

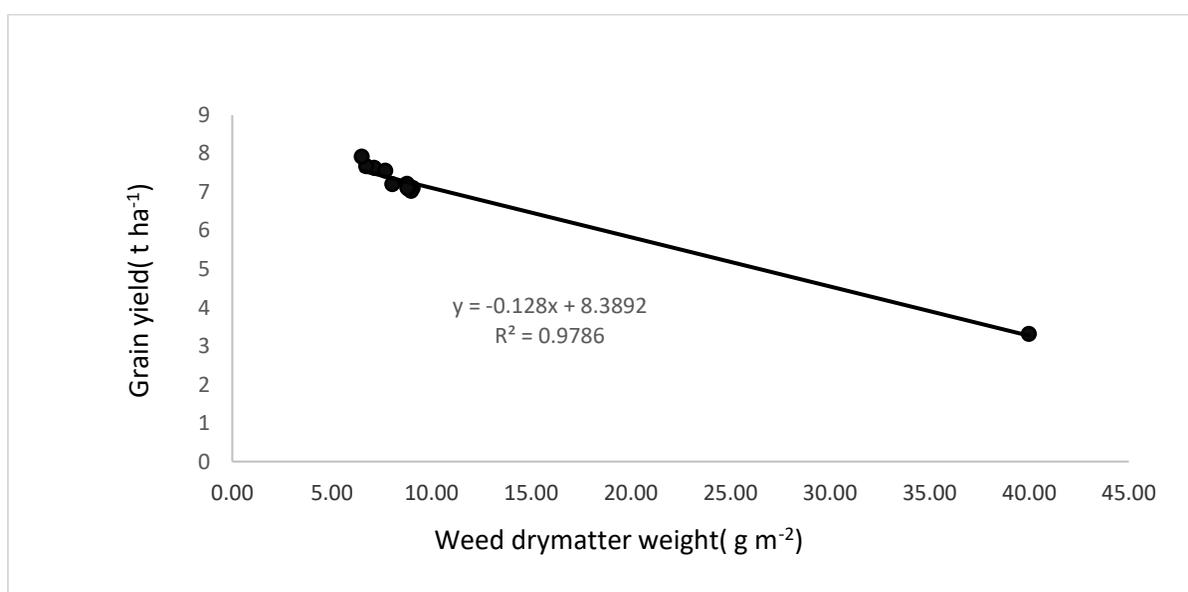


Fig. 28. Relationship of grain yield and weed dry matter weight of different weed management treatments

9.4 Reduce weed seed in weed Seed Bank of soil in long-term fallow management and herbicide uses in Rice- rice Cropping System

MKA Bhuiyan, MM Mahbub and R Shultana

Introduction:

The weed seed bank in the soil is the major source of weeds in rice fields. The size of the weed seed bank in rice fields is highly variable depending on the climate, soil moisture content, depth of sampling, history of the areas, and management practices used by farmers (kamoshita *et al.*, 2010). Therefore, information on the ecological aspects of weeds occurring in rice, including their potential seed production, is crucial for weed management. Weed management in rice fields focuses on methods suitable to decrease the weed population in the soil seed bank.

Objectives

1. To assess the total number of weed seeds reserve, species composition, and dominant weed species present to compare the floristic diversity of soil weed seed bank and
2. To reduce weed seed reservoir through fallow management in different soil depths.

Materials and methods

Two-factor treatments were considered to evaluate the study. Weed management before soil sampling considered factor A (Weed management in the field)

1. Kill weed seedlings by tillage or herbicide (Stale seedbed technique/tillage before the flowering of weeds) (W_1), 2. Tillage after flowering of weeds (W_2), 3. Weed management by herbicide fb 1HW (W_3), 4. Weed management by HW (W_4) and 5. Control (No weeding) (W_5)

After imposed weed management treatment before transplanting soil sample were collected before land preparation (Factor B). A soil auger was used to take soil samples to a depth up to 15 cm from three depths i.e. 0-5 cm, 05-10 cm and 10-15 cm. Soil samples were taken by using a PVC probe of 2.5 cm diameter for each method from each replication. The soil cores of same depth were bulked and mixed to make composite soil samples. These composite soil samples were divided into three working sub-samples, each with a 600gm weight for soil weed seed bank study in pot. Samples of each plot were placed in an individual plastic pot (31 cm diameter \times 07 cm depth) in the net house. The soils were sprinkled with water as needed to keep them moist. Weed seedlings that emerged were identified, counted, and removed at 30-day intervals throughout the four months (August, September, October, and November of T Aman 2023) and in Boro season (February, March, April, and May 2024) emergence period. After each batch of seedlings was removed, soils were thoroughly mixed to expose the weed seeds to the upper level of the soil and re-wetted to permit further emergence. This process was repeated four times. Seedling emergence counts were converted to numbers per m^2 by calculating volume to area. The dominant weed species was determined by the calculation of Importance Value (I.V.) which was expressed as:

$$IV (\%) = 100 \times \frac{\text{No. of each species in a community}}{\text{Total no. of all species in a community}}$$

Based on natural logarithms, floristic diversity/weed seed diversity was calculated using Shannon and Weiner's diversity index (Magurran, 1988; Kobayashi et al., 2003). Higher values of H' indicate greater floristic diversity (Shannon and Weaver, 1949). The Shannon index was computed by the following formula: $H = -\sum p_i \ln p_i$; Where \ln is the natural logarithm $p_i = n_i / N$, n_i is the number of sampled individuals of species i N is the total number of sampled individuals.

The texture of the collected soil is clay loam and the bulk density was 1.34 g/ cm^3 .

Results and discussion

Diversity index of weed species

The diversity index of weed species in a rice-rice cropping system provides a measure of the variety and distribution of weed species within a given area. Diversity indices help quantify not only how many different species of weeds are present (species richness) but also how evenly the individuals are distributed among those species (species evenness). Understanding weed diversity in a rice cropping system is essential for developing effective weed management strategies, particularly in the context of sustainability and long-term productivity

The two tables present Shannon's Index of Diversity (H') values for weed species under various soil depths and weed management treatments over different months, one for T. Aman 2023 (Table 28) and the other for Boro 2024 (Table 29). Both tables assess weed diversity across different treatments (W_1 to W_5) at three soil depths (0-5 cm, 5-10 cm, and 10-15 cm) over different months.

In T. Aman 2023 (Table 28), the diversity of weed species generally fluctuates across the months of August to November. The highest diversity was observed under W₅, with values peaking in September (1.43 at 0-5 cm), and the lowest under W₄, particularly in August and November. For most treatments, diversity was higher at the 0-5 cm depth in comparison to deeper soil layers, suggesting greater weed variety closer to the surface.

In Boro 2024 (Table 29), similar trends were observed, but with generally higher diversity values than those recorded during T. Aman 2023. For instance, W₅ showed the highest diversity throughout all months, peaking in March (1.42 at 5-10 cm), while W₁ typically showed lower diversity. Across all treatments, the 0-5 cm depth exhibited consistently higher diversity, similar to the T. Aman season.

In summary, both seasons show that the 0-5 cm depth tends to have higher weed species diversity across most treatments. W₅ consistently showed the highest diversity in both seasons, indicating it may be the most conducive to weed growth. The data also highlight seasonal differences, with higher overall diversity in Boro 2024 compared to T. Aman 2023, possibly due to varying environmental factors and weed management practices between the two seasons.

The diversity index of weed species in a rice-rice cropping system is influenced by a range of factors, including water management, herbicide application, tillage, crop rotation, and season. Higher diversity can be beneficial for reducing the risk of herbicide resistance but may also lead to more intense competition with rice if not properly managed. By applying integrated weed management strategies, farmers can maintain a balance between controlling dominant weed species and preserving overall weed diversity, ensuring sustainable rice production over the long term.

The graphs (Fig. 29 and Fig. 30) present data on the number of weed seeds in the weed seed bank per square meter, categorized by different weed management treatments (W₁ to W₅) and sampling periods over two growing seasons—T. Aman 2023 and Boro 2024. Each graph compares weed seed numbers in the soil at different months, namely August, September, October, and November for T. Aman 2023 (Fig. 30), and February, March, April, and May for Boro 2024. In T. Aman 2023 (**Stale seedbed technique/tillage before flowering of weeds**(W₁) shows relatively low weed seed numbers in August and September but slightly higher counts in October and November, indicating that early tillage before flowering can reduce weed seed accumulation, although some seeds may still be present due to late-emerging weeds. W₂ (**Tillage after flowering of weeds**) shows a significant increase in weed seed numbers, especially in September and November, reflecting that tillage after flowering allows seeds to mature and accumulate in the soil, leading to higher seed bank levels. W₃ (**Herbicide followed by one hand weeding fb 1HW**) shows moderate seed bank numbers throughout the months, with a noticeable drop in October and November, indicating that the combination of herbicides and manual weeding can help reduce seed production and accumulation. W₄ (**Hand weeding only**) shows similar patterns to W₃, with moderate seed numbers that decrease over time, but still higher than W₁ or W₃, indicating that manual weeding alone does not always prevent some weed seed accumulation. W₅ (**No weeding**) has the highest weed seed numbers across all months, particularly in September and November, highlighting the significant impact of the absence of weed control on seed bank buildup.

In Boro 2024, **W₁** shows a steady increase in weed seed numbers from February to May, with a moderate rise in March and May. This suggests that while the stale seedbed technique reduces initial seed accumulation, it might not entirely prevent weed seed banks from increasing over time. **W₂** shows the highest seed bank numbers, particularly in March and May, indicating that tillage after flowering allows for significant seed accumulation in the soil. **W₃** shows consistent seed numbers, but with a gradual decrease from February to May, reflecting the effectiveness of herbicide application followed by manual weeding in controlling weed seeds. **W₄** shows a moderate increase in seed numbers from February to May, but the numbers are lower than in **W₂**, demonstrating that hand weeding helps reduce weed seed accumulation compared to no weed control. **W₅** shows the highest seed accumulation, especially in May, emphasizing the impact of not implementing any weed management strategy on the weed seed bank.

Discussion: Stale seedbed (**W₁**) and **W₃** (Herbicide + HW) typically have lower weed seed numbers, indicating that proactive and combined weed management approaches are effective in controlling weed seed banks. **W₂** (Tillage after flowering) and **W₅** (No weeding) show higher weed seed counts, with **W₅** consistently having the highest accumulation, confirming the crucial role of weed management in controlling seed banks. In both seasons, **W₄** (Hand weeding) provides moderate control, but it is not as effective as the combined herbicide and weeding approach (**W₃**) or early tillage (**W₁**).

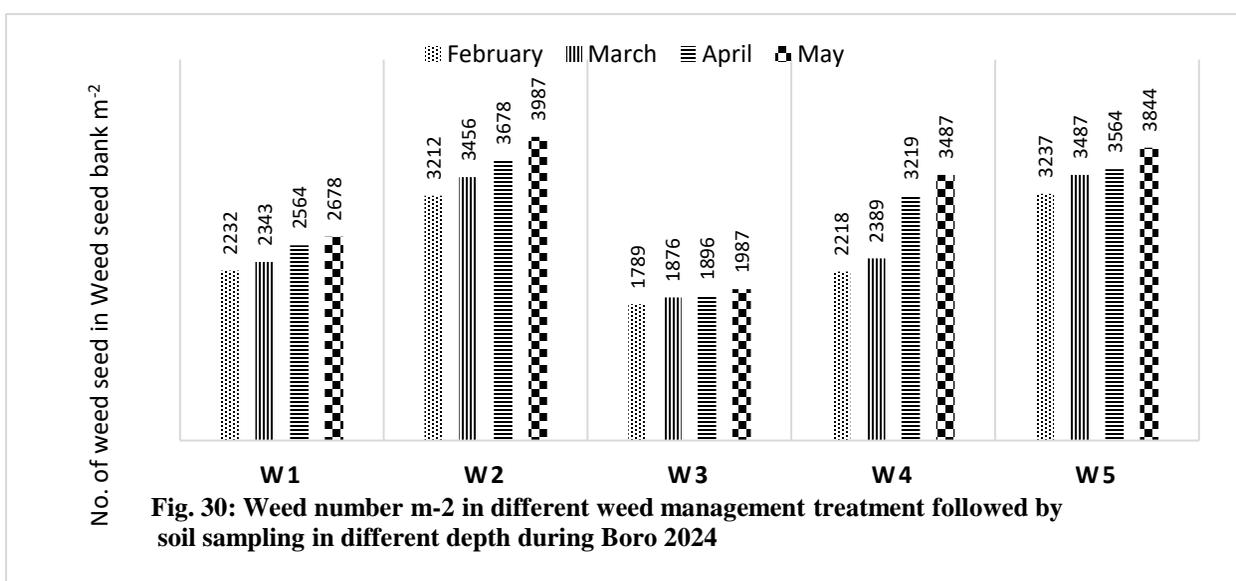
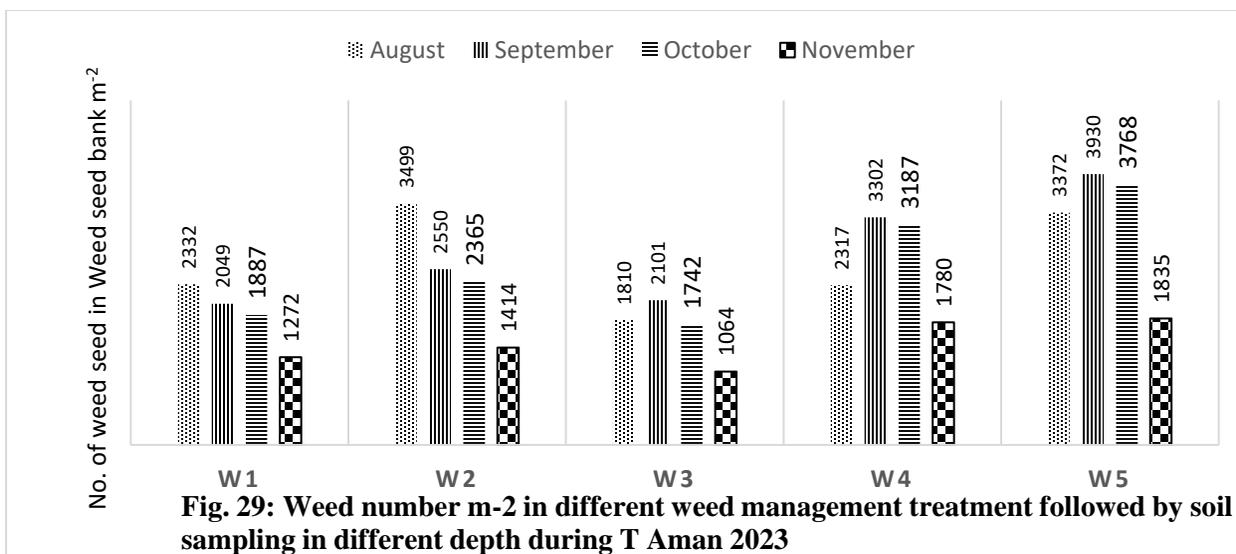
Conclusion: The results from both T. Aman 2023 and Boro 2024 highlight that integrated weed management strategies, such as **W₁** (stale seedbed technique) and **W₃** (herbicide followed by hand weeding), are most effective in reducing weed seed banks. These approaches control weeds early and consistently, leading to lower seed accumulation. In contrast, **W₂** (tillage after flowering of weeds) and **W₅** (no weeding) result in higher weed seed numbers, with **W₅** having the most significant buildup. Hand weeding (**W₄**) offers moderate control but is less effective than combined methods. Effective and timely weed management is crucial for reducing long-term weed seed bank buildup.

Table 28. Shannon’s index of diversity value of weed species over different months during T aman 2023

Aug.	Soil depth(cm)			Sept.	Soil depth (cm)			Octo.	Soil depth (cm)			Nov.	Soil depth (cm)		
WM	0-5	5-10	10-15	WM	0-5	5-10	10-15	WM	0-5	5-10	10-15	WM	0-5	5-10	10-15
W ₁	0.85	0.83	0.54	W ₁	1.23	1.28	0.86	W ₁	1.18	1.17	0.92	W ₁	1.26	1.13	0.87
W ₂	0.97	0.84	0.75	W ₂	1.20	1.37	0.75	W ₂	1.19	1.20	0.94	W ₂	1.43	0.97	0.79
W ₃	0.77	0.68	0.49	W ₃	1.27	0.86	0.68	W ₃	0.99	0.98	0.80	W ₃	1.12	0.96	0.80
W ₄	0.72	0.65	0.47	W ₄	1.13	1.23	0.69	W ₄	0.96	0.82	0.76	W ₄	0.80	0.75	0.75
W ₅	0.90	1.25	0.75	W ₅	1.43	1.35	1.20	W ₅	1.33	1.35	0.90	W ₅	0.98	0.88	0.77

Table 29. Shannon’s index of diversity value of weed species over different months during Boro, 2024

Feb	Soil depth (cm)			March	Soil depth (cm)			April	Soil depth (cm)			May	Soil depth (cm)		
WM	0-5	5-10	10-15												
W ₁	0.84	0.99	0.64	W ₁	1.16	1.23	0.82	W ₁	1.18	1.26	0.92	W ₁	1.10	1.17	0.79
W ₂	0.76	0.95	0.70	W ₂	1.19	1.38	0.77	W ₂	1.27	1.38	0.97	W ₂	1.20	1.27	0.96
W ₃	0.80	0.78	0.53	W ₃	1.10	0.90	0.78	W ₃	0.95	0.99	0.78	W ₃	0.96	1.08	0.73
W ₄	0.76	0.75	0.52	W ₄	1.14	1.25	0.84	W ₄	0.96	0.87	0.73	W ₄	0.98	0.90	0.80
W ₅	0.90	1.28	0.60	W ₅	1.39	1.42	1.14	W ₅	1.38	1.44	0.79	W ₅	1.20	1.38	0.79



W₁= Kill weed seedlings by tillage or herbicide (Stale seedbed technique/tillage before flowering of weeds, W₂=Tillage after flowering of weeds, W₃= Weed management by herbicide fb 1HW, W₄= Weed management by HW, W₅= No weeding

9.5 Degradation pattern of herbicide in rice field soil under irrigated ecosystem

S A Islam, A Sultana, H B Shozib, M K A Bhuiyan and N Akter

Introduction:

The application of herbicides is experiencing a rapid increase in Bangladesh and globally. This trend is driven by factors such as rising labour costs and the need for swift and efficient weed control in rice and non-rice cultivation areas. Despite their effectiveness, herbicides, being chemical agents, present certain challenges. Some groups of herbicides exhibit phytotoxicity to crops, leading to potential yield losses and quality degradation. Furthermore, the persistence of herbicide residues in soil and rice grains raises significant health concerns for consumers. Consequently, it is imperative to investigate the degradation patterns of herbicides in rice fields and the extent of their residues in rice grains to address these health safety issues. In the T. Aman season of 2022, the experiment was initially conducted under field conditions. However, due to a substantial amount of rainfall during this period, the experimental conditions were heavily

affected. Consequently, the decision was made to experiment during the dry season to ensure controlled and consistent conditions.

Objectives

To analyze the degradation of herbicide residue levels in soil and rice grain samples.

Materials and methods

The experiment was conducted at BIRRI farm, Gazipur in Boro, 2023-24. The experiment was followed by an RCB design with three replications. Thirty-five-day-old seedlings of BIRRI dhan89 were transplanted on 25 January 2024 having 20 × 20 cm spacing with two seedlings per hill. The treatments were: T₁ = Control (Untreated), T₂ = Bensulfuron methyl + Acetachlore; T₃ = Ethoxy sulfuron ethyl and T₄ = Pendimethalin. Fertilizers were applied (N-P-K-S-Zn @ 150-12-80-5-2 kg ha⁻¹) for all treated plots. All fertilizers were applied as basal during final land preparation except nitrogenous fertilizer. Nitrogen was applied as top dress in three equal splits at 15, 30 and 50 DAT (days after transplanting). Herbicide was sprayed one time after rice transplanting and other pesticides were sprayed 30 DAT and at heading stage. Representative 100 g paddy soil composite samples were collected randomly in each plot at 3, 7, 14, 28, and 42 days. All the collected paddy soil and rice samples were stored at -20 °C, respectively.

Extraction and evaluation in LCMS-MS

Analytical standards (Purity by HPLC ≥ 98.0 %) of bensulfuron methyl, acetachlore, ethoxy sulfuron ethyl and pendimethalin were used to prepare stock solutions (1000 µg mL⁻¹) and QuEChERS method (Bożena Łozowicka *et al.*, 2017) were followed with some optimization for extraction from soil and grain. Linearities were acquired with all the determination coefficients (R²) higher than 0.99 in the range of 0.005-0.5 mg/L with three to five calibration points of all herbicides. Quantification was calculated using the calibration curve constructed by linear regressing of pesticide against peak areas (Fig. 31).

Results

The retention times of Bensulfuron methyl, Ethoxy sulfuron ethyl, and Pendimethalin were found to be 2.23, 2.43, and 35.55 minutes, respectively. In the soil samples, Bensulfuron methyl and Ethoxy sulfuron ethyl were detected up to 28 days after herbicide application (DAHA), while Pendimethalin was detectable up to 42 DAHA (Table 30). Acetachlore was not detected in any samples, which may be attributed to its volatility and the need to standardize the protocol for GC-MS/MS analysis.

No residues were found in the soil and rice grain matrix after the harvest of rice samples from the field. The pesticide residues were below the Maximum Residue Limits (MRL) set by FSSAI for pesticides in rice (FSSAI, 2018). According to Sondhia (2014), all these tested herbicides are categorized as unlikely to cause any harmful effects, with LD50 values greater than 5000 mg/kg. Further repetition of the experiment is necessary for additional confirmation.

Conclusion

The study concluded that herbicide residues of Bensulfuron methyl, Ethoxy sulfuron ethyl, and Pendimethalin degraded in the soil and became non-detectable (ND) within 28 days. Additionally, no herbicide residues were detected in rice grain samples after harvesting during the T. Aman season. These findings suggest that the herbicides used in this study degrade relatively quickly under the given field conditions, thereby mitigating potential health risks associated with herbicide residue in rice grains.

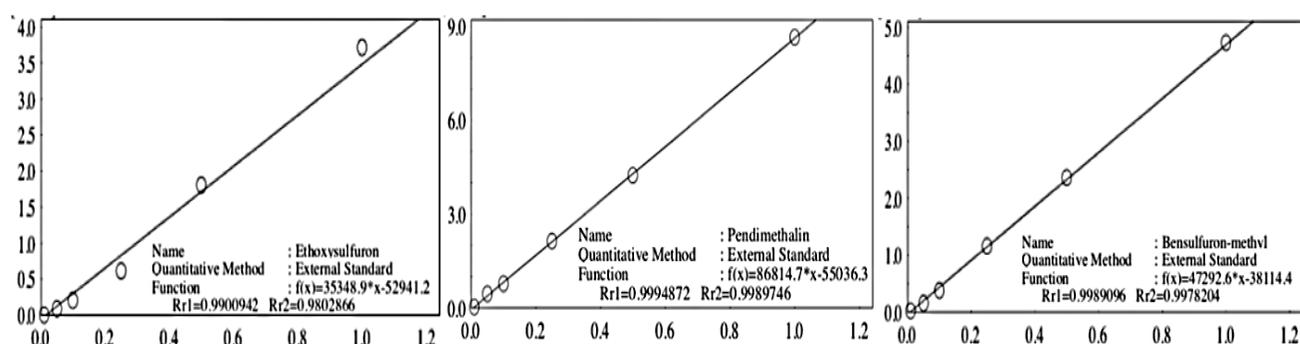


Fig. 31: The slandered calibration curve of the three herbicides

Table 30. The retention time and concentrations (ppb) of four pesticides in soil and rice grain

Treatment	Herbicide	Oral LD ₅₀	Soil sample at 03 DAT	Soil sample at 07 DAT	Soil sample at 14 DAT	Soil sample at 28 DAT	Soil sample at 42 DAT
T1	Control (No herbicide)	-	ND	ND	ND	ND	ND
T2	Bensulfuron methyl	>5000 ppm	54.09 ppb	18.02 ppb	8.12 ppb	3.04 ppb	ND
T3	Ethoxy sulfuron ethyl	3270 ppm	63.45 ppb	30.08 ppb	10.41 ppb	4.03 ppb	ND
T4	Pendimethalin	4050 ppm	95.74 ppb	41.58 ppb	19.88 ppb	8.02 ppb	3.98 ppb

10. TECHNOLOGY TRANSFER

10.1 Ecosystem based integrated production technology development in haor areas

MM Mahbub

Introduction

Haor area is located in a wide area of Sylhet, Sunamganj, Moulvibazar, Habiganj, Brahmanbaria, Netrokona and Kishoreganj districts in the north-eastern part of Bangladesh. Haor is present in 43% of these seven districts, covering an area of about 8.6 lakh hectares. Haor area is of immense importance to ensure food security of Bangladesh. Through appropriate agronomic management, on one hand, the yield of paddy in the Haor area will increase and the socio-economic status of the farmers will improve. On the other hand, food security of the country will also be ensured.

Objective:

To disseminate rice production technologies to the haor farmers.

Materials and methods:

Demonstrations of different rice varieties are established at Dekhar haor, Shantiganj, Sunamganj during Boro, 2023-24 at farmers' field. Varieties were: BRRRI dhan29, BRRRI dhan89, BRRRI dhan92 and hybrid varieties. Agronomy, Pathology, Entomology, Soil Science and Irrigation and Water management division of BRRRI work together at farmers field to disseminate the rice production technologies in the farmers. Different activities of different divisions-

Agronomy Division:

- Proper seedling age (30-35 day-old-seedling)
- 20-x-20 cm spacing
- 2 seedlings per hill
- Use of herbicide for weed management

Soil science Division:

- Ensure the basal and top dress of fertilizers with present in the field
- Monitoring the field for finding any type of deficiency symptoms in the plants

Pathology Division:

- Seedlings treatment for bakane disease by Autostin
- Visiting field and gave necessary advice to the farmers

Entomology Division:

- Use of perching
- Control of Stem borer by insecticide

Irrigation and Water Management Division:

- Advised to irrigation by LLP from near the Canal of farmers' field.

Result and discussion:

BRRRI dhan89 gave the highest grain yield of 7.2 t/ha and BRRRI dhan92 produced 7.1 t/ha yield. BRRRI dhan29 of Abdul motin and BRRRI dhan89 of Arfan and Abdul mojid were infested by neck blast because they did not take proper management in appropriate time (Table 31). Farmers are very much interested to know about the rice production technologies to increase their yield and get information from the farmers training.

Table 31: Grain yield of the demonstration at Dekhar haor

Farmers Name	Variety	Grain yield (t/ ha)
Abdul motin	BRRRI dhan92	7.1
	BRRRI dhan29	6.1*
	Krishibid	7.1
Benu Mojumder	Ispahani	6.9
Arfan	BRRRI dhan89	4.9*
Abdul Mojid	BRRRI dhan29	5.2
	Bau	7.0
	BRRRI dhan89	6.2*
Promoth Babu	BRRRI dhan89	7.2
	Bau	6.5

*At maturity stage neck blast infested the field and reduced grain yield.