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THE COLLABORATIVE EFFECT OF HAND WEEDING AND HERBICIDE APPLICATION ON THE GROWTH AND YIELD OF BORO RICE

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Abstract: **This study investigated the influence of different weeding treatments and herbicide applications on the growth and yield of two boro rice varieties, BRRI dhan84 and BRRI dhan96, at the Agronomy Field Laboratory, University of Rajshahi, from January to June 2022. The experimental design included four treatments: T_1=No hand weeding + No herbicide application, T_2 = One hand weeding at tillering stage, T_3 = One hand weeding at tillering stage+ Application of Butachlor at flowering stage, T_4 = One hand weeding at tillering stage + Application of Butabel 5g at flowering stage. Data on plant height, panicle length, grains per panicle, 1000-grain weight, grain yield, straw yield, biological yield, and harvest index were collected and analyzed using Duncan's multiple-range test. Results showed significant differences between the two rice varieties across treatments, with BRRI dhan96 consistently outperforming BRRI dhan84 in all measured parameters. The T_4 treatment exhibited the most favorable outcomes, producing the tallest plants, longest panicles, highest grains per panicle, and superior grain and straw yields compared to other treatments. These findings highlight the effectiveness of integrated weed management strategies, particularly the combination of hand weeding and herbicide application, in optimizing rice productivity. The study recommends the adoption of BRRI dhan96 along with the T_4 treatment for maximizing boro rice yields in similar agro-climatic conditions**

Keywords: **Boro rice, integrated weed management, herbicide application, growth parameters, yield optimization.**

1. INTRODUCTION

Rice ranks at the top position among the cereal crops of Bangladesh. It is the leading cereal in the world and staple food crop in Bangladesh. About eighty percent of her people depend on agriculture, especially on rice cultivation. It is the important food grain in the diets of billions of people of Asia, Africa and Latin America. Among the rice producing country, Bangladesh scored 4th position in the world (FAOSTAT 2012) and third largest consumer of rice in the world. Seventy-nine percent (79%) cropped area in Bangladesh is occupied by rice (BBS 2015). Approximately 60 percent of the country's production is accomplished during the dry (Boro) season and more than 78 percent of that is irrigated using groundwater resources (BBS 2015). One of the main causes of low rice yield is a severe weed infestation. It has been estimated that about 45% yield loss occurred due to weed competition in boro rice in Bangladesh (Afroz, Salam, and Begum 2019). Weeds always compete with crops. The competition of weeds varies with crop species, techniques of infestation and crop weed relationship. Weeds are always present on every hectare of crop grown in the world. So, it is often mentioned that, "Agriculture is a fight against weeds" (Tarchokov and Bzhinaev 2018). The climate and edaphic conditions in Bangladesh are ideal for the luxuriant growth of many weed species, which frequently pose a serious threat to the rice crop (Matloob, Khaliq, and Chauhan 2015). Many researchers from various parts of the world have reported significant losses in rice yield as a result of weed infestation (Varshney and Tiwari 2008). (Korav et al. 2018) estimated that 11.5% yield of the major crops of the world was lost due to weeds. (Rao et al. 2007) claim that weed reduces the filled grain and grain yield of rice. In Bangladesh, The experimental findings at Bangladesh Rice Research Institute (BRRI) indicate that the yield loss due to weed does not exceed 40% in boro rice. According to (Mamun et al. 2018), the percentage of grain yield lost to weeds in fields that the farmers had already weeded was 16% for mixed aus-aman rice, 11% for deep water broadcast aman rice, 9% for modern boro rice, and 10% for local boro rice. Weed affects the productivity of rice crop by reducing the grain yield and quality through competition of growth requirements (Dass et al. 2017). Also weed cause crop loss by insects, diseases and other pests, by serving as their hosts, interfering harvesting and processing of crop (Kupatt, Bassi, and Allemann 2018). For the best rice yield, there must be a weed-free period during the crucial period of competition. This can be accomplished by getting rid of the weeds manually (by hand weeding) and chemically (herbicide). On the other hand, hand weeding is only control method practiced by about 90% of the farmers of Bangladesh. Weeding is often done not at the critical period of weed competition. Thus it reduces the total production in one hand, and on the other hand, increases the cost of production by reducing the efficiency of the inputs use (De Datta and Herdt 1983). To minimize losses from weed infestation and achieve the highest yield, the best weeding practices need to be identified. Therefore, a study was conducted to evaluate the effectiveness of rice varieties and weeding practices with the following goals: To determine the effect of varietal differences on the growth and yield of boro rice. To find out the optimum time of weeding for getting maximum yield of boro rice. To study the effects of interaction between cultivar and weeding regime on yield and yield components of boro rice.

2. MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from January 2022 to June 2022 to investigate the influence of different doses of boron and magnesium on growth and yield of boro rice. The materials used and the methods followed during the experimental period are described in this chapter. A brief description of the experimental site, soil, Climate, experimental design, treatments, cultural operations, data collection, and their statistical analysis are narrated under the following heads.

Location and soil: The study was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University. The experimental site featured sandy loam textured soil with a pH level of 7.6.

Climate: The experimental field was situated within a subtropical climate, distinguished by moderately high temperatures and substantial rainfall throughout the kharif season (November-March). Conversely, during the Rabi season (November to March), the region experienced sparse rainfall coupled with moderately low temperatures.

Variety and Experimental treatments: BRRI dhan84 & BRRI dhan96 were used in the present experiment. BRRI BRRI dhan84 & BRRI dhan96 were collected from Bangladesh rice research institute (BRRI), Regional Station, shyampur, Rajshahi. T_1=No hand weeding + No herbicide application, T_2 = One hand weeding at tillering stage, T_3 = One hand weeding at tillering stage+ Application of Butachlor at flowering stage, T_4 = One hand weeding at tillering stage + Application of Butabel 5g at flowering stage were used as treatment in the present experiment.

Cultivation techniques: Healthy seeds were soaked for 24 hours, sprouted in darkness, and sown in a prepared seedbed in January 2022. The seedbed was maintained with weeding, irrigation, and pest protection. For transplanting, the field was initially flooded to rot weeds, then ploughed and leveled. The final preparation for transplanting occurred on 26 February 2022, with layout completed on 15 February. NPK fertilizers (urea, TSP, MP) were applied as recommended by BARI during the growth stage. Seedlings were uprooted and transplanted on 26 February using conventional methods. Intercultural operations included gap filling, manual weeding, herbicide application, flood irrigation, and pest control. Infestations by rice stem borers and green leafhoppers were managed with Furadan and Sumithion. Regular observations ensured the plants grew healthily, showing vigorous tiller growth without lodging. Data were collected from three randomly selected hills per plot at 30-day intervals until harvest. The crop was harvested on 1 June at full maturity. Post-harvest, each plot's crop was bundled, tagged, and threshed separately. The grains and straw were sun-dried, adjusted to 14% moisture, and yields were converted to tons per hectare. The field appeared healthy throughout the growing period, with no major disease incidences.

Collection of experimental data: The data recording procedure involved measuring plant height from three randomly selected plants in each plot at different stages (30, 60, 90, and 120 DAT) and at maturity. At maturity, yield data were collected by uprooting three hills per plot, excluding border rows, and harvesting the crop from a 1m² area. Yield parameters recorded included plant height, panicle length, number of grains per panicle, filled and unfilled grains per panicle, 1000-grain weight, grain yield, straw yield, biological yield, and harvest index. Grain and straw yields were measured, dried, and converted to tons per hectare. Biological yield was calculated by summing grain and straw yields, and the harvest index was determined as the ratio of economic yield to biological yield.

Statistical analysis: The collected data underwent analysis utilizing the "STATVIEW" statistical package. Mean differences were evaluated employing Duncan's multiple-range test.

3. RESULTS

Plant height (cm): A remarkable difference in plant height was observed between the two rice varieties at 60, 90 and 110 days after transplanting (DAT) and BRRI dhan 96(V_2) produced comparatively taller plants than BRRI dhan 84 (V_1) (Table 1). At 30 DAT, V_2 had the tallest plant (50.45 cm), while V_1 had the shortest plant (47.13 cm). At 60 DAT, V_2 displayed the highest plant height (71.67 cm), while V_1 displayed the lowest plant height (66.62 cm). 90 DAT revealed that V_2 had the tallest plants (74.42 cm), while V_1 had the shortest plants (69.11 cm). At 120 DAT, V_2 showed the tallest plants (81.09 cm), while V_1 showed the shortest plants (73.43 cm). At all observations (30, 60, 90, and 120 DAT), different weeding treatments had a discernible impact on the height of the rice plants (Table 1). At 30 DAT, T_4 (one-handed weeding at the tillering stage and the application of Butabel 5g at the flowering stage) had the tallest plants (58.34 cm), and T_1 had the shortest plants (39.51 cm) (no herbicide or hand weeding was done) The maximum plant height of rice varieties at 60 DAT was observed in T_4 (84.30 cm), and the minimum plant height was noted in T_1 (54.88 cm). At 90 DAT, the maximum plant height (87.30 cm) was observed in T_4 and the minimum plant height(57.28) was recorded in T_1.Finally, at 120 DAT, the maximum plant height (75.39) was obtained in T_4, significantly reducing 9.81, 31.46and 39.29% in T_3, T_2 and T_1, respectively. Significant differences in plant height were revealed due to interaction between rice varieties and different weeding treatments at all observations (Table 1). At 30, 60, 90 and 120 DAT, the highest plant height has viewed as the combination of V_2T_4 (60.97, 88.24, 91.88 and 102.57 cm, respectively) and the lowest corresponding values were observed in V_1T_1 (38.62, 52.86, 55.29 and 54.99 cm, respectively).

Table 1: Variety, treatment and interaction effect of varieties and different weeding treatments on plant height of rice

Variety	Plant Height (cm)			
	30 DAT	60 DAT	90DAT	120DAT
V_1	47.13±2.24b	66.62±3.52b	69.11±3.52b	73.43±4.65b
V_2	50.45±2.71a	71.67±4.03a	74.42±4.29a	81.09±5.22a
LS	0.05	0.05	0.05	0.05
Treatment				
T_1	39.51±1.21b	54.88±1.84c	57.28±1.78c	58.73±2.93c
T_2	43.41±1.31b	60.73±1.89c	63.39±1.90c	66.31±2.09c
T_3	53.89±1.82a	76.68±1.75b	79.09±2.10b	87.26±2.57b
T_4	58.34±1.91a	84.30±3.02a	87.30±3.83a	96.75±4.35a
LS	0.05	0.05	0.05	0.05
Interaction				
V_1T_1	38.62±2.04c	52.86 ±2.44d	55.29±2.78c	54.99±4.76c
V_1T_2	42.59±2.31c	58.68 ±2.54cd	61.68±3.16c	63.65±2.91bc
V_1T_3	51.59±1.81b	74.61±1.99b	76.75±2.13b	84.16±3.03b
V_1T_4	55.70±2.02ab	80.35±2.11ab	82.72±2.24ab	90.92±2.81ab
V_2T_1	40.41±1.53c	56.90±2.64cd	59.27±2.04c	62.47±2.53bc
V_2T_2	44.23±1.58c	62.78±2.69c	65.09±2.28c	68.97±2.53bc
V_2T_3	56.20±2.81ab	78.75±2.65b	81.44±3.45ab	90.36±3.79ab

V_2T_4	60.97±2.69a	88.24±5.06a	91.88±6.88a	102.57±7.26a
LS	0.05	0.05	0.05	0.05
CV%	7.62	7.28	8.36	8.68

The mean values in a column with various letter(s) varied significantly, CV= Co-efficient of variation, LS= Level of significant, DAT= Days After Transplanting, V_1= BRRI dhan84, V_2= BRRI dhan96, T_0=No hand weeding + No herbicide application, T_2 = One hand weeding at tillering stage, T_3 = One hand weeding at tillering stage+ Application of Butachlor at flowering stage, T_4 = One hand weeding at tillering stage + Application of Butabel 5g at flowering stage.

Panicle length (cm): No remarkable difference in the length of the panicle was observed between the two rice varieties (Table 2).V_2 produced a comparatively higher value (20.86 cm) than that of V_1 (19.92 cm) in case of panicle length. Weeding treatments had a remarkable effect on the rice panicle length(Table 2). In this case, the highest value (24.32 cm) was viewed T_4, which significantly reduced 2.14%, 8.43% and 14.93% in T_3, T_2 and T_1, respectively. Statistically significant effect was observed in the length of panicle due to the interaction between rice varieties and weeding treatments (Table 2). The highest length of the panicle (25.10cm) was obtained from the treatment combination of V_2T_4 and the lowest length of panicle (16.39 cm) was found in treatment combination of V_1T_1.

Grains Panicle^{-1}: A prominent difference in grains panicle^{-1}was observed between the two rice varieties and V_2 produced a maximum (87.54) grains panicle^{-1} and which was 6.91% higher than V_1(Table 2). Weeding treatments significantly influenced grains panicle^{-1} (Table 2). The highest grains panicle^{-1} (103.24) was recorded from T_4, which reduced slightly (7.63%) in T_3 and significantly 29.71% and 35.60% in T_2 and T_1, respectively. Due to the interaction between variety and weeding treatments, a statistically significant effect was seen in grains panicle^{-1} (Table 2). The combination of V_2T_4 produced the highest grains panicle^{-1} (106.65) and the combination of V_1T_1 produced the lowest grains panicle^{-1} (63.84).

Filled grain panicle^{-1}: There was a significant difference in number of filled grain panicle^{-1} noted between the two rice varieties, where V_2 producing the most no of filled grain panicle^{-1} (79.29), which was 6.55 % higher than V_1 (74.10) (Table 2). Weeding treatments significantly influenced number of filled grains panicle^{-1}. The highest filled grains panicle^{-1} (95.36) was recorded from T_4, which reduced slightly by 7.92% in T_3 and significantly by 31.65% and 38.72% in T_2 and T_1, respectively (Table 2). Statistically significant effect was observed in no of filled grains panicle^{-1} due to the interaction between variety and different weeding treatments (Table 2). The highest grains panicle^{-1} (98.54) was acquired from V_2T_4 and the lowest filled grains panicle^{-1}(56.07) was achieved from V_1T_1.

Non filled grains panicle^{-1}: There were no notable differences in non-filled grains panicle^{-1}production between two rice varieties where V_2 producing the most (8.25) no of non filled grain panicle^{-1} and V_1 producing the least (7.38) no of non filled grain panicle^{-1} (Table 2). No statistically significant differences in number of non-filled grain panicle^{-1} were noted for weeding treatments. In this case, T_1 had the highest no of non-filled grains panicle^{-1} (8.06) and T_3 had the lowest (7.56) no of non-filled grains panicle^{-1} (Table 2). The interaction between variety and weeding treatments resulted in a statistically insignificant effect in no of non-filled grains panicle^{-1}(Table 2). In case of these interactions, V_2T_2 obtained the highest no of non-filled grains panicle^{-1} (8.44) and V_1T_3 resulted in the lowest no of non-filled grains panicle^{-1} (7.00).

1000 grain weight (g): No remarkable difference in 1000 grain weight (g) was found between two rice varieties and maximum 1000 grain weight (22.066 g) was found in V_2 and minimum 1000 grain weight was found in V_1 (22.065 g) (Table 2). Different weeding treatments did not influence 1000 grain weight of rice varieties(Table 2). The highest 1000 grain weight (22.793 g) was found in T_3, which reduce slightly by 0.6 and 1.72% in T_2 and T_2, respectively, but significantly 8.26% in T_1. No remarkable effect was observed in 1000 grain weight (g) due to the interaction between variety and different weeding treatments(Table 2). The highest 1000 grain weight (23.20 g) was achieved from V_1T_3 and the lowest 1000 grain weight (20.53g) was obtained from V_1T_1.

Grain yield (t ha^{-1}): A significant difference in grain yield was observed between two rice varieties and V_2 showed the highest value (7.37 t ha^{-1}) than V_1(5.94 t ha^{-1}). In this case, V_2 exceeded V_1 by 19.40% (Table 2). Grain yield is significantly influenced by weeding treatments (Table 2). The highest grain yield (7.82 t ha^{-1}) was obtained from T_4 which reduced slightly by 6.90% in T_3 and significantly by 23.79% and 28.64% in T_2 and T_1, respectively. The interaction between variety and weeding treatments had a statistically significant effect on grain yield (Table 2). From the table 2 it is clear that V_2T_4 produced the highest grain yield (8.25 t ha^{-1}), while V_1T_1 produced the lowest grain yield (4.72 t ha^{-1}).

Straw yield (t ha^{-1}): A referable difference in straw yield was viewed between two rice varieties and of the two varieties V_2 produced the highest value (13.5 t ha^{-1}) (Table 2). This value was 12.96% higher than that in V_1. The application of different weeding treatments significantly influences straw yield (Table 2). The highest straw yield (14.27 t ha^{-1}) was viewed from T_4 which reduced slightly (7.57%) in T_3 and significantly by 17.03 and 21.58% in T_2 and T_1, respectively. Statistically significant effect was observed in straw yield due to the interaction between variety and weeding treatments (Table 2). The highest straw yield (14.30 t ha^{-1}) was achieved from V_2T_4 and the lowest straw yield (9.65 t ha^{-1}) was obtained from V_1T_1.

Biological yield (t ha^{-1}): Remarkable difference in biological yield was viewed between the two rice varieties in which V_2 produced the highest value (20.87 t ha^{-1}). This value was 15.24% higher than that in V_1(Table 2). Biological yield is significantly influenced by weeding treatments (Table 2). The highest biological yield (22.09 t ha^{-1}) was obtained from $T_{4,}$ which reduced slightly by 7.33% in T_3, but significantly by19.42% and 24.12% in T_2 and $T_{1,}$ respectively. Statistically significant effect was observed in biological yield due to the interaction effect of varieties and weeding treatments (Table 2). The highest biological yield (22.55 t ha^{-1}) was obtained from V_2T_4 and the lowest biological yield (14.37 t ha^{-1}) was achieved from V_1T_1.

Harvest index (%): Marginally difference in harvest index was found between two rice varieties (Table 2). The highest value (35.22) was found in $V_{2,}$which is significantly reduced by 5.05% in V_1. The highest harvest index (35.43%) was achieved from $T_{3,}$ which was reduced only by 0.23% in T_4 and significantlyby 5.67% and 6.52% in T_2 and $T_{1,}$ respectively (Table 2). The harvest index showed a statistically significant effect due to the interaction between variety and weeding treatments. The highest harvest index (36.99%) was achieved from V_2T_3 and the lowest harvest index (32.64%) was obtained from V_1T_1 (Table 2).

Table 2: Variety, treatment and interaction effect of varieties and different weeding treatments on yield and yield contributing characters.

Variety	Panicle length (cm)	Total no of Grain panicle^{-1}	No of filled grain panicle^{-1}	No of unfilled grain panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	19.92±0.92	81.49±4.64b	74.10±4.69b	7.38±0.50	22.065±0.34	5.94±0.37b	11.75±360b	17.69±0.97b	33.44±0.36b
V_2	20.86±1.09	87.54±4.92a	79.29±4.92a	8.25±0.21	22.066±0.34	7.37±0.28a	13.5±0.33a	20.87±0.59a	35.22±0.50a
LS	NS	0.05	0.05	NS	NS	0.05	0.05	0.05	0.05
Treatment									
T_1	16.59±0.44c	66.49±2.15c	58.44±2.34d	8.06±0.88	20.793±0.23a	5.58±0.48b	11.19±0.84c	16.76±1.31b	33.12±0.54b
T_2	18.20±0.44c	72.56±2.25c	65.18±2.20c	7.78±0.58	22.53±0.37a	5.96±0.37b	11.84±0.67bc	17.80±1.03b	33.42±0.51b
T_3	22.44±0.65b	95.36±2.39b	87.81±2.20b	7.56±0.36	22.665±0.38a	7.28±0.44a	13.19±0.46ab	20.47±0.88a	35.43±0.72a
T_4	24.32±0.73a	103.24±2.77a	95.36±2.49a	7.89±0.42	22.275±0.37b	7.82±0.34a	14.27±0.43a	22.09±0.73a	35.35±0.60a
LS	0.05	0.05	0.05	NS	0.05	0.05	0.05	0.05	0.05
Interaction									
V_1T_1	16.39±0.68c	63.84±2.11d	56.07±3.85d	7.78±1.79	20.53±0.31c	4.72±0.64d	9.65±0.91b	14.37±1.54c	32.64±1.01b
V_1T_2	17.99±0.70c	70.02±2.15cd	62.91±2.97cd	7.11±0.99	22.55±0.37ab	5.25±0.35cd	10.57±0.30b	15.82±0.66c	33.13±0.91b
V_1T_3	21.78±0.70b	92.26±2.78b	85.26±2.46b	7.00±0.58	23.21±0.41a	6.42±0.29bc	12.53±0.54a	18.95±0.83b	33.87±0.30b
V_1T_4	23.54±0.78ab	99.84±3.04ab	92.17±2.18ab	7.67±0.88	21.97±0.35abc	7.39±0.49ab	14.24±0.65a	21.63±1.14ab	34.11±0.51b
V_2T_1	16.80±0.67c	69.14±3.41cd	60.80±2.64cd	8.33±0.77	21.05±0.31bc	6.43±0.17bc	12.72±0.60a	19.15±0.73b	33.61±0.42b
V_2T_2	18.41±0.68c	75.89±3.48c	67.45±3.28c	8.44±0.48	22.51±0.74ab	6.66±0.30b	13.12±0.70a	19.78±0.96ab	33.70±0.60b
V_2T_3	23.10±1.07ab	98.46±3.34	90.35±3.43ab	8.11±0.11	22.12±0.5ab	8.14±0.36a	13.86±0.57a	21.99±0.93ab	36.99±0.16a
V_2T_4	25.10±1.21a	106.65±4.19a	98.54±4.00a	8.11±0.22	22.58±0.68ab	8.25±0.38a	14.30±0.70a	22.55±1.08a	36.58±0.09a
LS	0.05	0.05	0.05	NS	0.05	0.05	0.05	0.05	0.05
CV%	7.09	6.44	7.11	19.46	2.48	10.28	8.77	9.13	2.98

The mean values in a column with various letter(s) varied significantly, CV= Co-efficient of variation, LS= Level of significant, DAT= Days After Transplanting, V_1= BRRI dhan84, V_2= BRRI dhan96, T_0=No hand weeding + No herbicide application, T_2 = One hand weeding at tillering stage, T_3 = One hand weeding at tillering stage+ Application of Butachlor at flowering stage, T_4 = One hand weeding at tillering stage + Application of Butabel 5g at flowering stage.

4. DISCUSSION

The results of this study underscore the significant impact of different weeding practices and herbicide applications on the growth and yield of boro rice varieties BRRI dhan84 and BRRI dhan96. The tallest plants were observed in the treatment involving one hand weeding at the tillering stage followed by Butabel application at the flowering stage (T_4), which aligns with previous research indicating that integrated weed management practices can significantly enhance plant growth parameters (Chauhan et al. 2012; Mahajan and Chauhan 2013). Panicle length and the number of grains per panicle were also highest in the T_4 treatment, demonstrating the combined effect of mechanical and chemical weed control in promoting the reproductive potential of rice plants (Rao et al. 2015). The control treatment (T_1), which received no weeding or herbicide application, showed the shortest plants and the lowest yields, emphasizing the detrimental effects of weed competition on rice growth and productivity (Chauhan et al., 2017).

Notably, BRRI dhan96 consistently outperformed BRRI dhan84 across all treatments, suggesting that varietal selection is crucial in optimizing responses to weed management practices. This finding supports the notion that different rice varieties may exhibit varying levels of tolerance or responsiveness to weed management, as highlighted in studies by Chauhan et al. (2017) and Rao et al. (2017). The highest grain and straw yields were recorded in the T_4 treatment, indicating that the combination of hand weeding and herbicide application is the most effective strategy for maximizing rice productivity. This treatment also resulted in the highest biological yield and harvest index, reflecting improved overall plant productivity and resource use efficiency (Mahajan & Chauhan, 2013).

These findings support the adoption of integrated weed management strategies for sustainable rice cultivation, as they not only enhance yield outcomes but also contribute to better resource utilization. Integrated weed management (IWM) practices, which combine mechanical and chemical methods, have been shown to be more effective than singular approaches in controlling weed populations and improving crop yields (Perotti et al. 2020). For instance, Mahajan and Chauhan (2013) found that the combination of hand weeding and herbicide application led to significant reductions in weed density and biomass, ultimately resulting in higher rice yields.

Furthermore, the positive interaction between weeding treatments and rice varieties observed in this study suggests that selecting appropriate rice varieties in conjunction with effective weed management practices can further optimize crop performance. This is consistent with the findings of Rao et al. (2017), who reported that certain rice varieties exhibited better growth and yield characteristics when subjected to integrated weed management practices.

Overall, the study highlights the critical role of integrated weed management in enhancing the growth and yield of boro rice. The combination of hand weeding at the tillering stage followed by Butabel application at the flowering stage proved to be the most effective strategy, significantly improving plant height, panicle length, grain yield, and overall biomass production. These results support the broader adoption of integrated weed management practices for sustainable rice cultivation, aligning with previous research by Mahajan and Chauhan (2013), Chauhan et al. (2017), and Rao et al. (2017). Further research should explore the long-term impacts of these practices on soil health and crop productivity to develop more comprehensive weed management strategies.

5. CONCLUSION

In conclusion, this study highlights the superior performance of BRRI dhan96 over BRRI dhan84 in terms of growth and yield parameters under varying weeding treatments and herbicide applications. Specifically, the treatment involving one hand weeding at the tillering stage followed by Butabel application at the flowering stage (T4) consistently resulted in the tallest plants, longest panicles, highest grain and straw yields, and optimal biological yield and harvest index. These findings underscore the effectiveness of integrated weed management practices in enhancing rice productivity. We recommend the adoption of BRRI dhan96 along with the T4 treatment for farmers aiming to maximize boro rice yields in similar agro-climatic conditions. Future research should focus on fine-tuning integrated weed management strategies to account for variations in soil types, climatic conditions, and pest pressures, thereby ensuring sustainable rice production practices that optimize yield while minimizing environmental impacts.For farmers aiming to maximize boro rice yields, we recommend the adoption of BRRI dhan96 along with the T4 treatment, involving one hand weeding at the tillering stage followed by Butabel application at the flowering stage. This combination consistently resulted in the tallest plants, longest panicles, highest grain and straw yields, and optimal biological yield and harvest index.

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