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Research Article

Effect of Integrated Weed Management on the Yield Performance of Wheat

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ABSTRACT

We conducted our experiment from November 2019 to March 2020 in Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh. The purpose of this investigation was to examine the effects and relative effectiveness of various weed management strategies concerning integrated wheat weed management. The experiment comprised three replication group it was developed up of fourteen weeding regime treatments, namely, unweeded, mulching by rice straw, mulching by water hyacinth , two hand weeding at 25 and 35 DAS, pre-emergence herbicide, pre-emergence herbicide + hand weeding at 35 DAS, pre-emergence herbicide + mulching by water hyacinth, post-emergence herbicide, stale seed bed + post-emergence herbicide, post-emergence herbicide + hand weeding at 35 DAS, post-emergence herbicide + mulching by rice straw, post-emergence herbicide + mulching by water hyacinth, pre-emergence herbicide + post-emergence herbicide, pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS. The experiment was established up using randomized complete block design. Records were kept of data on several aspects. The majority of the yield-contributing characteristics were much greater when rice straw was mulched after emergence along with herbicide. The experiment showed that the longest plant height (82.93 cm), number of effective tillers hill^{-1} (3.70), number of total tillers hill^{-1} (4.13), longest panicle length (9.35 cm), number of total spikelet's spike^{-1} (19.28), number of effective spikelet's spike^{-1} (15.56), number of grains panicle^{-1} (35.52), highest grain yield (6.92 t ha^{-1}), and highest stover yield (13.25 t ha^{-1}) of post-emergence herbicide + mulching by rice straw was revealed among the various weeding regime treatments. This finding suggests that in the BAU Agronomy Field Laboratory, post-emergence herbicide combined with a rice straw mulching regime increased yield.

Introduction

One of the most significant grain crops, wheat (*Triticum spp*.), is produced on around 225 million hectares globally, almost fifty percent of which are in developing countries. It produces 734,045 thousand tons of grain annually (FAO, 2018). Wheat was the most commonly imported and exported product globally in total, with 181,127.6 thousand tons imported and 190,853.6 thousand tons exported. In Bangladesh, 3.73 lakh hectares are cultivated for wheat agriculture, and 1,099 thousand tons were produced annually in 2018 (FAO, 2018). Wheat and mustard farming have moved to unsuitable agricultural land with low yields due to increased competition with different crops such as grains. The population is increasing, which leads to a significant increase in consumption. As a result, it is generally accepted that substantial increases in production are required to meet demand (Halim *et al*., 2023).

One of the primary reasons for yield decline globally, weeds are also known as the silent killer of crops (Priya *et al*., 2017). In addition to decreasing crop production and quality, weeds also consume essential nutrients, environmental resources, light, and soil moisture (Ramalingam *et al*., 2013). Weeds have been reported to decrease wheat yield by as much as 25–30% in Pakistan (Khan *et al*., 2011), 20–40% in India (Mishra, 1997), as high as 50% in Nepal (Ranjit, 2002), and 33% in Bangladesh (Karim, 1992). There are differences in the number of weed species reported in each country: IAAS, Nepal, is host to thirty species (Dangol and Chaudhary, 1993), ninety species in India (Rao, 2000), and Bangladesh is host to seventy-three species (Begum *et al*., 2003). Additionally, weeds harbor plant diseases, insects, and parasitic weeds, making the management

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of these major pests more challenging (Qasem and Foy, 2001). The cost of production and harvesting increases due to weeds. The standard strategy of controlling weeds with hand tools or hoes alone is highly time-consuming, costly, labour-intensive, ineffective, and requires regular repetition (Dhananivetha *et al*., 2017). Herbicides must be used in these conditions to quickly and effectively control weeds. Thus, it is essential to develop a suitable weed-control strategy that includes applying various herbicides (Sanker *et al*., 2015). However, excessive and continuous use of pesticides damages the environment and has a negative impact on the sustainability of agricultural production (Gyani *et al*., 2020). Additionally, effective control cannot be achieved by applying herbicides alone. One option in integrated weed management is chemical weed control, which combines mechanical, cultural, manual, and/or chemical control methods.

Obtaining maximum productivity of high-quality output requires an effective integrated weed management program. The utilization of multiple weed control techniques that produce better outcomes than using just one is known as integrated weed management, which is relatively recent (Das, 2019). Because weed species are distinct, no one weed management strategy has been exhibited as the "magic bullet" for solving weed issues. Perhaps the best choice would be to combine all available weed control strategies with an understanding of biological processes and cropping system design to develop an integrated weed management system. One of the most significant difficulties for growers and researchers in weed science is how to incorporate ecological principles into decision-making for weed management. According to Hussain *et al*. (2021), a combined weed control method mitigates the effects of weeds but fails to completely eradicate them. The experiment aims to compare the effectiveness of various weed control techniques for integrated wheat weed management.

Materials and Methods

Experimental site

The investigation took place at an elevation of 18 meters above sea level, situated geographically at latitude 24° 75' N and longitude 90° 50' E. The area is located within the Argo-ecological Zone (AEZ-9) of the Old Brahmaputra Floodplain (UNDP and FAO, 1988). The medium-high land used for the experiment had a pH of 6.7 and a silty clay loam soil texture. The experimental site is situated in a floodplain with non-calcareous dark-grey soil.

Plant material

The experiment used BARI Gom-28, a high-yielding type of wheat, as the plant material. The Bangladesh Agricultural Research Institute (BARI) created and released the short-duration, heat-tolerant wheat cultivar BARI Gom-28. The cultivar is suitable for late planting conditions and may be grown anywhere in Bangladesh. This type grows to a height of 95–100 cm, requires 102–108 days to complete its life cycle, and is resistant to the diseases Bipolaris leaf blight and leaf rust. It features a broad spike with 45–50 grains per spike, medium bright white grains weighing a thousand grains between 43–48 g, straight tillers in the seedling stage, deep green plants, and thin hairs at the top end of the church. The glume of the spikelet shoulder is medium broad and centered, the flag leaf is straight, the ligule is tall (more than 12.1 mm), and the auricle has a spine. The yield varies between 4.0 to 5.5 t ha^{-1}.

Experimental treatment

There were 14 treatments in this experiment. These are as follows: Unweeded (T_0), mulching by rice straw at 6 t ha^{-1} (T_1), mulching by water hyacinth 6 t ha^{-1} (T_2), two hand weeding at 25 and 35 DAS (T_3), pre-emergence herbicide (Panida) (T_4), pre-emergence herbicide + hand weeding at 35 DAS (T_5), pre-emergence herbicide + mulching by rice straw at 6 t ha^{-1} (T_6), pre-emergence herbicide + mulching by water hyacinth at 6 t ha^{-1} (T_7), post-emergence herbicide (Affinity 50.75 WP) (T_8), post-emergence herbicide + hand weeding at 35 DAS (T_9), post-emergence herbicide + mulching by rice straw (T_{10}), post-emergence herbicide + mulching by water hyacinth (T_{11}), pre-emergence herbicide + post-emergence herbicide (T_{12}), pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS (T_{13}).

Experimental design

To perform the experiment, it was decided to use a randomized full block design with 3 replications. The experiment used a total of 14 x 3 = 42-unit plots. The unit plot with dimensions of 4.0 x 2.5 m. With the area allocated for an irrigation channel, the 0.5 m separation between plots and the distance blocks were separated by 1.0 m. The experiment's plant material was the high-yielding wheat variety BARI Gham-28.

Land preparation

Fifteen days before seeding, a tractor-drawn disc plough was used to prepare the experimental land. To break down clods and level the field, a country plow was used four more times, including cross-ploughing. A wooden hammer was utilized to break up any large visible clods into smaller pieces, and a spade was used to trim the land's corners and levels. All stubble and weeds were cleared from the field. The unit plots were then generated while preserving the desired spacing throughout the entire experimental area.

Fertilizer application

The following suggested doses of zinc (Zn), boron (B), gypsum, triple super phosphate (TSP), and muriate of potash (MoP) were applied to the plots: 200 kg ha^{-1} of urea, 150 kg ha^{-1} of TSP, 75 kg ha^{-1} of MoP, and 100 kg ha^{-1} of gypsum. Just before the final stages of land preparation, thirty percent of the urea, gypsum, MoP, and the complete quantity of TSP was given. At 20 and 40 DAS, the remaining urea was given in two equal doses.

Seed sowing

The wheat seeds were obtained from the Khagdohor, Mymensingh marketing office of the Bangladesh Agriculture Development Corporation (BADC). On November 28, 2019, the seeds were sown in accordance with the recommended treatments. Immediately after seeding, the seeds were covered with soil to a depth of 5 cm. Great care was taken to protect the seeds and seedlings from birds for a maximum of 20 days before emergence.

Harvesting and sampling

During full maturity, on March 26, 2020, the crop was harvested plot-by-plot. Every harvest crop was brought to the floor for threshing in separate bundles with appropriate tags. Five samples were randomly chosen and removed from each plot before harvesting in order to collect data.

Post-harvest operations

The harvested crop was sun-dried in bundles for five days, following which grain cleaning was done, threshed, and dried. After straw and grain were dried under the sun to an average moisture content of 14%. After measurement, the yields were expressed in tons per hectare (t ha^{-1}).

Yield and yield contributing characters of wheat

Plant height (cm), number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, length of spike (cm), number of grains spike^{-1}, weight of 1000-grains (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), and harvest index (%)

*Harvest index **(%)***

The harvest index is a measure of the relationship among biological production and grain production.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Here, Biological yield= Grain yield+ straw yield

Statistical Analysis

The analysis of variance approach was used to gather, tabulate, and scientifically evaluate the yield and yield parameter data. After doing an analysis of variance, the mean differences were determined using a computer package programs (M-STAT) and Duncan's Multiple Range Test (DMRT), according to Gomez and Gomez (1984).

Results and Discussion

Effect of Treatments on Yield and Yield Contributing Parameters of Wheat

Plant height

The various weed control techniques had a notable impact on the height of the plant. At the treatment where post-emergence herbicide + rice straw (T_{10}) mulching was applied, the highest plant height (82.93 cm) was observed. Besides plant height found in the treatments like pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS (T_{13}), two hand weeding at 25 and 35 DAS (T_3), pre-emergence herbicide + post-emergence herbicide (T_{12}), post-emergence herbicide + mulching by water hyacinth (T_{11}), post-emergence herbicide (T_7), pre-emergence herbicide + mulching by water hyacinth (T_6) was statistically similar with the treatment T_{10} (Figure 1A). The treatment with no weeds (T_0) had the lowest plant height, and in terms of statistics, it was comparable to the treatment with water hyacinth (T_2) or rice straw (T_1). The findings agree with Endale (2019) conclusions.

Number of total tillers

Total tillers were significantly impacted by a variety of weed management methods. The treatment using post-emergence herbicide + rice straw mulching (T_{10}) produced the highest total number of tillers (4.13). Pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS (T_{13}) had the second-highest number of total tillers (4.13), but the results are statistically similar to the results of T_3 (two hand weeding at 25 and 35 DAS) and T_9 (post-emergence herbicide + hand weeding at 35 DAS) (Figure 1B). Other treatments, such as pre-emergence herbicide + post-emergence herbicide (T_{12}), pre-emergence herbicide + hand weeding at 35 DAS (T_5), post-emergence herbicide + water hyacinth mulching (T_{11}), pre-emergence herbicide + water hyacinth mulching (T_6), mulching by water hyacinth (T_2), post-emergence herbicide (T_8), post-emergence herbicide (T_7), pre-emergence herbicide (T_4), and mulching with rice straw (T_1) produced higher yields than unweeded (T_0). The unweeded treatment (T_0) had the lowest number of total tillers (2.23). The findings support the results of previous research by Alhammad *et al*. (2023).

Number of effective tillers

Different weed control techniques had a significant collective impact on the quantity of effective tillers. Treatment T_{10} (post-emergence herbicide + mulching by rice straw) produced the greatest number of effective tillers (3.7), which was followed by treatments T_9 (post-emergence herbicide + hand weeding at 35 DAS) and T_{13} (pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS). However, T_{12} (pre-emergence + post-emergence herbicide), T_{11} (post-emergence herbicide + water hyacinth mulching), T_5 (pre-emergence herbicide + manual weeding at 35 DAS), and T_6 (pre-emergence herbicide + water hyacinth mulching) produced results that were statistically comparable. In addition, treatments T_7 and T_8 (post-emergence herbicides) were similar, T_2 (water hyacinth mulching), T_3 (two-hand weeding at 25 and 35 DAS), T_4 (pre-emergence herbicide), and T_1 (rice straw mulching) had a statistically significant impact on the quantity of effective tillers and produced superior results than T_0 (unweeded). In T_0, the least number of efficient tillers (2.23) were discovered in the unweeded area. (Figure 1C).

The findings of Parihar et al. (2019) agree with the above results.

Panicle length (cm)

Different weed control strategies had significant effects on panicle length. The treatment T_{10} (post-emergence herbicide + rice straw mulching) had the longest panicles (9.35 cm), which were followed by T_{13} (pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS), T_5 (pre-emergence herbicide + hand weeding at 35 DAS), and T_7 (post-emergence herbicide) (Figure 1D). On the contrary, compared to T_0 (unweeded), the treatments T_1 (mulching by rice straw), T_2 (mulching by water hyacinth), T_3 (two hand weeding at 25 and 35 DAS), T_4 (pre-emergence herbicide), T_6 (pre-emergence herbicide + mulching by water hyacinth), T_8 (post-emergence herbicide), T_9 (post-emergence herbicide + hand weeding at 35 DAS), T_{11} (post-emergence herbicide + mulching by water hyacinth), and T_{12} (pre-emergence herbicide + post-emergence herbicide) produced longer plants than T_0 (unweeded). T_0 (unweeded) had the lowest panicle length. The findings support those of previous research conducted by Kumar *et al*. (2018).

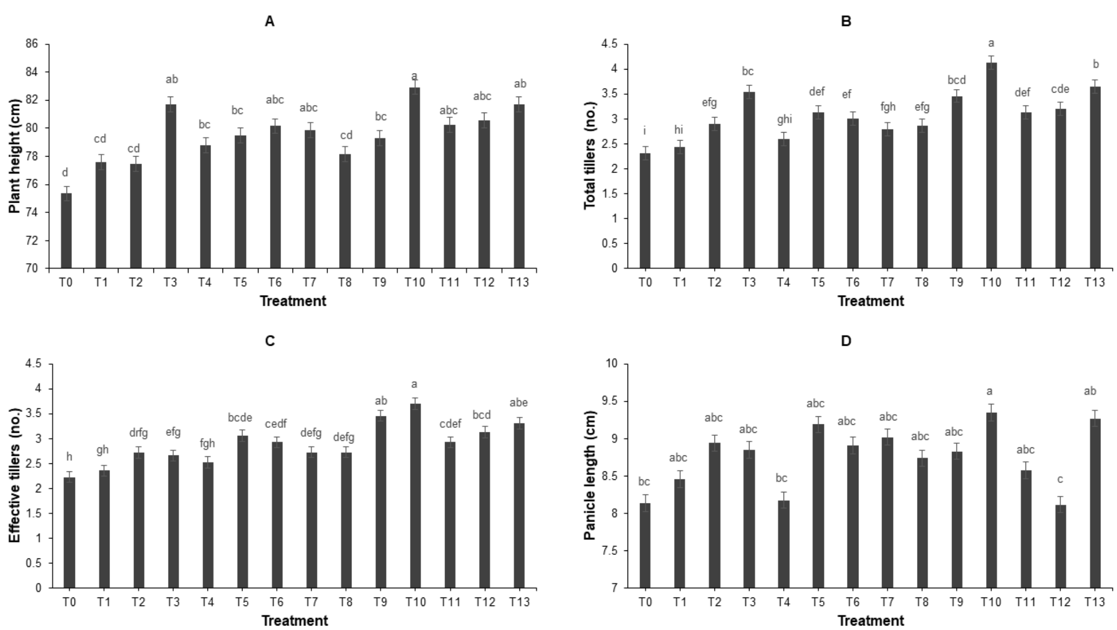

Figure. 1 Effect of treatment on plant height, number of total tillers, number of effective tillers and panicle length
While figures with different letters exhibit significant variations, means with the same letter do not.
Here, unweeded (T_0); Mulching by rice straw at 6 t ha^{-1} (T_1); mulching by water hyacinth 6 t ha^{-1} (T_2); two hand weeding at 25 and 35 DAS (T_3); pre-emergence herbicide (Panida 33 EC) (T_4); pre-emergence herbicide (Panida 33 EC) + hand weeding at 35 DAS (T_5); pre-emergence herbicide (Panida 33 EC) + mulching by rice straw at 6 t ha^{-1} (T_6); pre-emergence herbicide (Panida 33 EC) + mulching by water hyacinth at 6 t ha^{-1} (T_7); post-emergence herbicide (Affinity 50.75 WP) (T_8); post-emergence herbicide + hand weeding at 35 DAS (T_9); post-emergence herbicide (Affinity 50.75 WP) + mulching by rice straw (T_{10}); post-emergence herbicide (Affinity 50.75 WP) + mulching by water hyacinth (T_{11}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) (T_{12}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) + hand weeding at 35 DAS (T_{13}).

Number of total spikelets spike^{-1}

Treatment regimen had a significant impact on the overall number of spikelets spike^{-1}. Total spike panicle^{-1} (19.28) was highest in T_{10} (post-emergence herbicide + rice straw mulching), T_{11} (post-emergence herbicide + water hyacinth mulching), T_{12} (pre-emergence herbicide

+ post-emergence herbicide), and T_{13} (pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS). Unweeded treatment was found the lowest amount of total spike panicle^{-1} (13.81) (Figure 2A). The findings agree with the conclusions stated by Sarwar *et al.* (2013).

Number of effective spikelets spike^{-1}

The treatment regimen had a major impact on the effective spikelets spike^{-1}. The T_{10} (post-emergence herbicide + rice straw mulching) had the highest number of effective spikelets spike^{-1} (15.65), followed by the T_{11} (post-emergence herbicide + water hyacinth mulching) and T_3 (two hand weeding at 25 and 35 DAS). The unweeded sample had the lowest value (10.68) (Figure 2B). The findings support the conclusions of previous research investigated by Akter *et al.* (2018).

Number of grains panicle^{-1}

The weeding schedule significantly impacted panicle^{-1} in the grains. The treatments that resulted in the highest amount of grains panicle^{-1} (34.52) were T_{10} (post-emergence herbicide + mulching by rice straw), which was followed by T_3 (two hand weeding at 25 and 35 DAS) and T_{13} (pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS). The treatments that produced the lowest grains panicle^{-1} (26.36) were unweeded (Table 1). The findings agree with the conclusions reported by Kumari *et al*. (2023).

1000-grain weight (g)

The weeding regimen had a significant effect on 1000-grain weights. The treatment T_3 (two hand weeding at 25 and 35 DAS) produced the maximum weight of 1000-grains (48.66), while the treatment T_{11} (post-emergence herbicide (Affinity 50.75 WP) + water hyacinth mulching) produced the lowest weight of 1000-grains (Table 1). Islam (1987); Singh and Singh (1996); Mamun and Salim (1989) additionally reported decreases of 7.22, 29.44, and 5.00%, respectively, in the wheat's 1000-grain weight as a result of weed competition.

Grain yield (t ha^{-1})

The weeding regime has a considerable impact on grain yield. The results showed that the T_{10} treatment (post-emergence herbicide + rice straw mulching) produced the highest grain yield (5.92 t ha^{-1}), followed by the T_{13} treatment (pre-emergence herbicide + post-emergence herbicide + hand weeding at 35 DAS), which produced the lowest grain yield (2.21 t ha^{-1}) (Figure 2C). The grain yield was discovered to be higher within the weed-free and farmer-weeded treatments than in the unweeded treatment by 47.74 and 0.97%, respectively (Kabir *et al.,* 2014).

Stover yield (t ha^{-1})

The weeding practice had a considerable impact on the amount of spoilage. The T_{10} treatment (post-emergence herbicide + rice straw mulching) produced the maximum stover yield (13.25 t ha^{-1}), while T_0 treatment produced the minimum stover yield (3.91 t ha^{-1}) (Figure 2D). Mishra *et al.* (2012) reported a similar phenomenon as well.

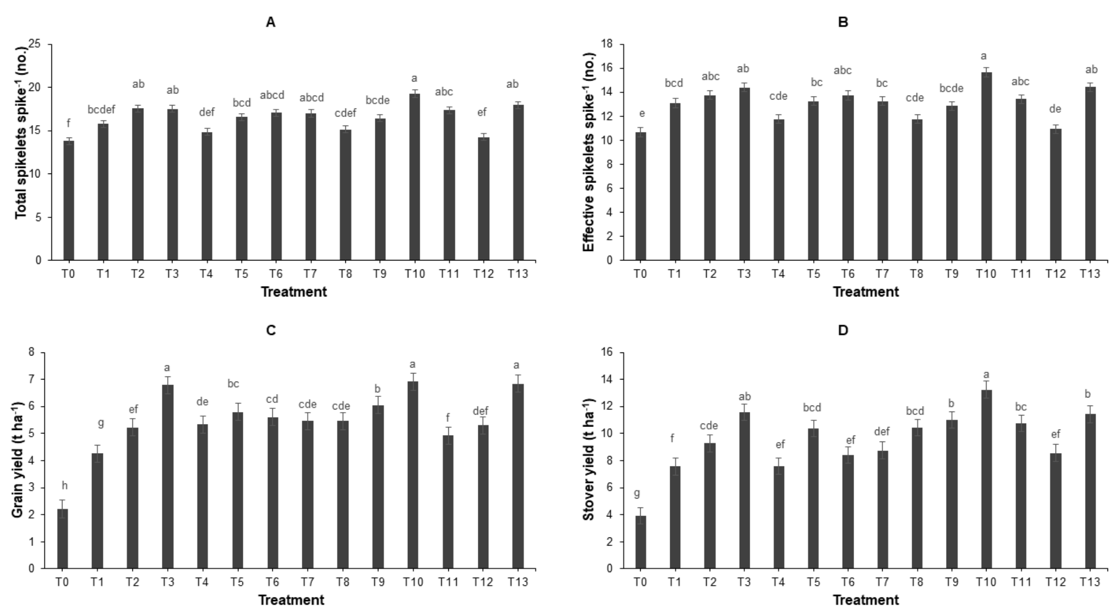

Figure. 2 Effect of treatment on number of total spikelets spike^{-1}, number of effective spikelets spike^{-1}, grain yield (t ha^{-1}), stover yield (t ha^{-1})
While figures with different letters exhibit significant variations, means with the same letter do not.
Here, unweeded (T_0); Mulching by rice straw at 6 t ha^{-1} (T_1); mulching by water hyacinth 6 t ha^{-1} (T_2); two hand weeding at 25 and 35 DAS (T_3); pre-emergence herbicide (Panida 33 EC) (T_4); pre-emergence herbicide (Panida 33 EC) + hand weeding at 35 DAS (T_5); pre-emergence herbicide (Panida 33 EC) + mulching by rice straw at 6 t ha^{-1} (T_6); pre-emergence herbicide (Panida 33 EC) + mulching by water hyacinth at 6 t ha^{-1} (T_7); post-emergence herbicide (Affinity 50.75 WP) (T_8); post-emergence herbicide + hand weeding at 35 DAS (T_9); post-emergence herbicide

(Affinity 50.75 WP) + mulching by rice straw (T_{10}); post-emergence herbicide (Affinity 50.75 WP) + mulching by water hyacinth (T_{11}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) (T_{12}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) + hand weeding at 35 DAS (T_{13})

Biological yield (t ha^{-1})

Treatment T_{10} (post-emergence herbicide + rice straw mulching) produced the maximum biological yield (20.17 t ha^{-1}), while unweeded produced the lowest yield (6.13 t ha^{-1}) (Table 1). The findings agree with the research conducted by Goswami *et al*. (2018).

Harvest index (%)

The weeding regimen has a significant effect on the harvest index. Among of all treatments, T_4 (41.47) had the highest harvest index (41.47%), while T_{11} (31.44%) had the lowest. (Table 1). The results confirm the conclusions of previous research carried out by Farhat *et al*. (2023).

Table 1. Effect of treatment on Plant Yield related parameters

Treatment	Grains panicle^{-1} (no.)	1000-grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
T_0	26.36e	48.14ab	6.13i	36.58abcd
T_1	27.81cde	47.66ab	11.83h	36.26abcd
T_2	33.01ab	48.23ab	14.51defg	36.09abcd
T_3	33.54ab	48.66a	18.37b	37.06abc
T_4	31.13abc	48.22ab	12.91gh	41.47a
T_5	30.4bcd	48.49ab	16.16cd	35.96bcd
T_6	28.94cde	48.22ab	14.04fg	40.14ab
T_7	30.33bcd	48.04ab	14.22efg	38.46abc
T_8	28.22cde	48.11ab	15.92cde	34.37cd
T_9	29.10cde	48.47ab	17.05bc	35.64bcd
T_{10}	34.52a	48.14ab	20.17a	34.31cd
T_{11}	28.25cde	47.53b	15.69cdef	31.44d
T_{12}	27.32de	48.33ab	13.86g	38.40abc
T_{13}	33.50ab	48.23ab	18.27b	37.56abc
LSD $_{(0.05)}$	3.72	1.07	1.69	5.48
Level of sig.	**	*	**	*
CV (%)	7.35	2.33	6.77	8.91

Means in a column that have the identical letter do not differ significantly from figures that have different letters. * = 5% probability level of significance, ** = 1% probability level of significance.

Here, unweeded (T_0); Mulching by rice straw at 6 t ha^{-1} (T_1); mulching by water hyacinth 6 t ha^{-1} (T_2); two hand weeding at 25 and 35 DAS (T_3); pre-emergence herbicide (Panida 33 EC) (T_4); pre-emergence herbicide (Panida 33 EC) + hand weeding at 35 DAS (T_5); pre-emergence herbicide (Panida 33 EC) + mulching by rice straw at 6 t ha^{-1} (T_6); pre-emergence herbicide (Panida 33 EC) + mulching by water hyacinth at 6 t ha^{-1} (T_7); post-emergence herbicide (Affinity 50.75 WP) (T_8); post-emergence herbicide + hand weeding at 35 DAS (T_9); post-emergence herbicide (Affinity 50.75 WP) + mulching by rice straw (T_{10}); post-emergence herbicide (Affinity 50.75 WP) + mulching by water hyacinth (T_{11}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) (T_{12}); pre-emergence herbicide (Panida 33 EC) + post-emergence herbicide (Affinity 50.75 WP) + hand weeding at 35 DAS (T_{13})

Summary and Conclusion

The weed management treatment produced a significant effect on every crop characteristic. Wheat growth and yield performed effectively under the T_{10} treatment (post-emergence herbicide with rice straw mulching). The results of this study suggest that the most effective integrated weed management strategy for wheat would be to use a post-emergence herbicide and mulch with rice straw. However, additional research in several Bangladeshi AEZs is required for conformation.

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