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Research Article

Growth and Yield of Wheat as Influenced by Different Moisture Conservation Methods

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Abstract— This study investigates the effects of mulching and wheat variety selection on the growth and yield of wheat (*Triticum aestivum* L.) under rainfed conditions in Bangladesh. The experiment, conducted at the University of Rajshahi, involved three wheat varieties: Prodip, Bijoy, and BARI Gom 27 and four mulching treatments: zero mulching, polyethylene sheet, rice straw, and water hyacinths. The study aimed to assess the impact of these treatments on plant height, total dry matter, crop growth rate, number of effective tillers, spike length, and other yield and yield contributing parameters. Results showed that both variety and mulching significantly influenced wheat growth and yield components. Bijoy consistently outperformed the other varieties in terms of plant height and total dry matter, particularly when mulched with water hyacinths. Water hyacinth mulch also led to the highest crop growth rate and the greatest number of effective tillers and grains per spike. Interaction effects between variety and mulching were significant, with Bijoy mulched with water hyacinths consistently yielding the highest growth and productivity metrics. The findings suggest that selecting the appropriate wheat variety and mulching technique can substantially enhance wheat production in rainfed areas. Specifically, Bijoy variety combined with water hyacinth mulch showed the most promise for improving wheat yield under the conditions tested. These results highlight the importance of tailored agronomic practices for optimizing crop performance in challenging environments.

Keywords—Rainfed conditions, Mulching techniques, Rice straw, Water hyacinths, Polyethylene mulch, Crop growth and yield.

1. Introduction

Wheat (*Triticum aestivum* L.) serves as a vital food source for both the Barind and irrigated regions of Bangladesh, significantly contributing to the dietary needs of both urban and rural communities. However, wheat grain yields in rainfed areas remain low, primarily due to insufficient moisture during sowing, which hinders seed germination and plant establishment. This challenge is compounded by heavy weed infestations, which not only drain soil moisture but also compete with wheat for essential resources like light, nutrients, and space, thereby reducing overall crop performance [1]. Weeds are recognized as one of the most severe pests in wheat cultivation, substantially diminishing both growth and yield [2].

Moisture availability is a critical limiting factor in rainfed areas, directly influencing plant development and grain yield [3]. Wheat's adaptability allows it to be cultivated in a diverse range of environments, from temperate, irrigated regions to areas with high rainfall or dry, cold climates. This adaptability is largely due to the complexity of the wheat genome, which provides significant plasticity to the crop. As a C3 plant, wheat flourishes in cooler environments, and extensive research has provided a solid understanding of its physiology, growth, and development. Nevertheless, approximately one-third of the global wheat cultivation areas in developing countries are situated in marginal environments, characterized by challenges such as drought, heat, and poor soil conditions. These challenging environments are increasingly important for food security, particularly in the developing world, where it is reported that 32% of the 99 million hectares of wheat cultivated face various levels of drought stress [4].

Mulching is a critical practice for conserving soil moisture, particularly in rainfed wheat cultivation, where the success of the crop depends heavily on rainfall before and during the growing season. Mulches help reduce evaporation losses and are widely used in various parts of the world as an effective management tool. They mitigate the effects of environmental factors on the soil by increasing soil temperature and controlling fluctuations in temperature [5]. However, the effectiveness of mulching depends on factors such as soil type, climate, mulch material, and application methods. Surface mulches positively affect the soil moisture regime by reducing evaporation, improving infiltration, enhancing soil water retention, decreasing bulk density, and facilitating soil water condensation at night [6].

The changes in soil microclimate caused by mulching promote seedling emergence and root growth while suppressing weed populations [7]. Mulching is also recognized for improving soil quality by increasing soil organic carbon content [8]. Acting as a protective layer, mulch encourages root development and aids in weed control by reducing the rate of evaporation, thereby maintaining higher soil moisture levels and more stable soil temperatures over longer periods. It is well documented that soil cover plays a crucial role in conserving soil moisture and managing weeds without the use of herbicides. For example, mulching can reduce the number of required irrigations by an average of 17% [9], and wheat straw mulch has been shown to cut evaporation by 50% during the winter wheat season, saving approximately 80 mm of water during the growth period [10].
Numerous studies have explored the effects of different mulches on wheat production, consistently demonstrating that mulch application leads to higher grain yields compared to non-mulched crops. The primary reasons for these yield improvements include better soil and water conservation, enhanced physical and chemical properties of the soil, and increased biological activity [11]. Given the importance of mulching and variety selection in boosting wheat yield, this study is both timely and essential. Therefore, this research was conducted with the specific objectives of assessing the performance of different wheat varieties, evaluating the impact of mulching on wheat growth and yield, and examining the interaction between variety and mulching on wheat yield and its components. The main goal of this research was to investigate how various types of mulches affect plant characteristics and grain yield (kg ha^{-1}) of wheat under rainfed conditions.

2. Experimental Materials and Method

Experimental Details: The experiment was carried out at the Agronomy Field Laboratory within the Department of Agronomy and Agricultural Extension at the University of Rajshahi, spanning from November 2013 to March 2014. The experimental site is geographically positioned between 24º17′ and 24º31′ N latitude and 88º28′ and 88º43′ E longitude, at an elevation of 20 meters above sea level. This area is part of Agro-ecological Zone 11, known as the High Ganges River Floodplain. The soil of the experimental plot was well drained with moderately slow permeability. The topsoil, characterized as silty loam, was slightly alkaline with a pH of 8.5. The experiment was conducted under a subtropical climate, which experiences heavy rainfall during the Kharif season (April to September) and lower temperatures with limited rainfall during the Rabi season (October to March).
For this study, three wheat varieties: Prodip, Bijoy, and BARI Gom 27 were used as planting material, obtained from the Regional Wheat Research Station in Shyampur, Rajshahi. The study focused on bread wheat, with all selected varieties being disease and pest tolerant and suitable for late sowing. The experimental design included two factors: Factor A (variety) with three levels (V_1 = Prodip, V_2 = Bijoy, V_3 = BARI Gom 27) and Factor B (mulching) with four levels (M_0 = No mulching, M_1 = Polyethylene sheet, M_2 = Rice straw, M_3 = Water hyacinths). The experiment was arranged in a split-plot design, with no irrigation treatments assigned to the main plots and variety treatments assigned to the sub plots, each with three replications.
Land preparation involved initial ploughing twice using a power tiller, followed by exposing the soil to sunlight for seven days before further ploughing and cross-ploughing. The land was then leveled, and all weeds, stubble, and crop residues were removed. Fertilizers were applied at the final land preparation at the following rates: 220 kg ha^{-1} urea, 180 kg ha^{-1} TSP, 50 kg ha^{-1} MP, and 120 kg ha^{-1} gypsum. Seeds were treated with Vitavax-200 at a rate of 0.25% before planting to protect against seed-borne and soil-borne diseases. Various intercultural operations, along with harvesting and post-harvesting methods, were also carried out as part of the experiment.

Data analysis technique: Data on growth, yield, and yield components were analyzed using ANOVA via MSTAT-C. Mean differences were tested with Duncan's New Multiple Range Test, and simple correlation coefficients were calculated using SPSS program to determine relationships between grain yield and its components.

3. Results and Discussion

Plant height (cm): Variety significantly influenced plant height at 30 and 90 days after sowing (DAS) (Table 1). Initially slow, plant height increased rapidly towards 90 DAS. At 15 DAS, Prodip recorded the highest height (24.958 cm) and Bijoy the lowest (22.575 cm). At 30 DAS, Bijoy had the highest height (35.592 cm), while BARI Gom 27 had the lowest (31.855 cm). By 45 DAS, Bijoy again led with 62.183 cm, and BARI Gom 27 trailed with 44.260 cm. This trend continued, with Bijoy peaking at 98.261 cm by 90 DAS, while BARI Gom 27 remained the shortest at 93.624 cm. Thus, BARI Gom 27 consistently had the lowest heights, while Bijoy had the highest. Mulching levels also significantly impacted plant height (Table 1). At 15 DAS, differences were minimal, with M_0 (no mulch) at 23.856 cm and M_3 (water hyacinth) at 22.889 cm. However, by 30 DAS, M_3 led with 37.188 cm, and the control had the lowest at 30.717 cm. This pattern persisted, with M_3 consistently producing the tallest plants, peaking at 100.707 cm by 90 DAS, while the control was the shortest at 91.134 cm. Water hyacinth mulch yielded the tallest plants, followed by rice straw, with the control being the shortest. Interaction effects between variety and mulching on plant height were not significant (Table 1). At 30 DAS, the highest height (38.467 cm) was in Bijoy with water hyacinth (V_2M_3) and the lowest (28.083 cm) in BARI Gom 27 with no mulch (V_3M_0). By 45 DAS, V_2M_3 reached 66.333 cm, while V_3M_0 had 41.267 cm. This pattern held with V_2M_3 peaking at 105.667 cm by 90 DAS, and V_3M_0 the lowest at 92.333 cm. Overall, the variety named Bijoy with water hyacinth consistently achieved the highest heights across all sampling days.

Total dry matter (g $plant^{-1}$): Selected wheat varieties differed significantly in total dry matter (TDM) production at all sampling days (15, 30, 45, 60, 75, and 90 DAS) (Table 2). TDM production increased progressively over time, starting slow but accelerating later. At 15 DAS, the highest TDM (0.072 g/plant) was in V_2 (Bijoy) and the lowest (0.061 g/plant) in V_1 (Prodip). At 30 DAS, Bijoy again had the

Table 1. Varietal effect, effect of mulching and Interaction effect on plant height (cm) of wheat of different days after sowing (DAS).

Variety	Plant height (cm)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
V_1	24.958	33.699	52.467b	80.767a	93.325	97.747
V_2	22.575	35.592	62.183a	83.517a	96.233	98.261
V_3	23.251	31.855	44.260 c	62.150 b	89.651	93.624
LS	NS	NS	0.01	0.05	NS	NS
Treatment						
M_0	23.856	30.717c	48.378b	70.389b	86.022c	91.134c
M_1	23.156	32.768b	51.378b	73.611b	90.444bc	95.556b
M_2	23.478	34.189b	55.267a	76.156ab	95.889ab	97.454b
M_3	22.889	37.188a	56.858a	81.756a	99.922a	100.707a
LS	NS	0.01	0.01	0.01	0.01	0.01
Interaction						
V_1M_0	23.633	31.067	47.133	74.3	83.933	93.133
V_1M_1	23.6	32.533	50.467	79.967	91.2	97.733
V_1M_2	23.033	34.033	54.8	82.2	97.467	99.467
V_1M_3	24.067	37.163	57.467	86.6	100.653	100.7
V_2M_0	21	33	56.733	81.133	88.267	89.937
V_2M_1	22.733	35.3	60.067	81.8	92.933	94.333
V_2M_2	21.933	35.6	65.6	83	100	102.133
V_2M_3	24.533	38.467	66.333	87.333	103.733	105.667
V_3M_0	22.333	28.083	41.267	55.733	85.867	92.333
V_3M_1	23.133	30.47	43.6	59.067	87.2	94.6
V_3M_2	24	32.933	45.4	62.467	90.2	96.763
V_3M_3	23.333	35.933	46.773	71.333	95.333	102.8
LS	NS	NS	NS	NS	NS	NS
CV%	5.63	4.2	5.6	6.8	5.38	2.62

In a column, means followed by a similar letter (s) or without letter (s) or without letter are not significantly different whereas, means followed by a dissimilar letter (s) are significantly different as Duncan's New Multiple Range Test. V_1 = Prodip, V_2 = Bijoy, V_3 = BARI Gom 27 and M_0= Zero mulch, M_1 = Polythene sheet, M_2 = Rice straw, M_3=Water hyacinth, LS = Level of significance, CV = Co-efficient of variation.

highest TDM (0.353 g/plant), while BARI Gom 27 (V3) had the lowest (0.335 g/plant). By 45 DAS, Bijoy maintained the highest TDM (1.547 g/plant), with BARI Gom 27 the lowest (1.528 g/plant). At 60 DAS, Bijoy reached 4.032 g/plant, and Prodip was lowest at 3.772 g/plant. At 75 DAS, Bijoy had the highest TDM (7.119 g/plant), with BARI Gom 27 the lowest (7.101 g/plant). By 90 DAS, Bijoy again led with 9.895 g/plant, while Prodip had 9.885 g/plant. Thus, Bijoy consistently produced the highest TDM, while Prodip and BARI Gom 27 produced the lowest at different stages. Mulching significantly influenced TDM production (Table 2). At 15 DAS, TDM was similar across treatments, with the highest (0.066 g/plant) in both M_0 (Zero mulch) and M_2 (Rice straw), and the lowest (0.064 g/plant) in M_1 (Polythene sheet). By 30 DAS, M_3 (Water hyacinth) had the highest TDM (0.370 g/plant), and M_0 the lowest (0.315 g/plant). At 45 DAS, M_3 led with 1.565 g/plant, and M_0 was lowest at 1.508 g/plant. At 60 DAS, M_3 again had the highest TDM (4.050 g/plant), while M_0 had the lowest (3.995 g/plant). By 75 DAS, M_3 recorded 7.127 g/plant, and M_0 had 7.082 g/plant. At 90 DAS, M_3 had the highest TDM (9.911 g/plant), while M0 had the lowest (9.856 g/plant). The interaction effect of variety and mulching on TDM production was significant (Table 2). At 15 DAS, the highest TDM (24.533 g) was in V_2M_3 (Bijoy × Water hyacinth), and the lowest (21.000 g) in V_2M_0 (Bijoy × Zero mulch). At 30 DAS, V_2M_3 again had the highest TDM (0.378 g), and the lowest was in V_3M_0 (BARI Gom 27 × Zero mulch). At 45 DAS, V_2M_3 reached 1.572 g, while V_3M_0 had 1.501 g. By 60 DAS, V_2M_3 had the highest TDM (4.059g), and V_3M_0 the lowest (3.989 g). At 75 DAS, V_2M_3 recorded 7.145 g, while V_3M_0 had 7.075 g. At 90 DAS, V_2M_3 had the highest TDM (9.921g), and V_3M_0 the lowest (9.843 g). Thus, V_2M_3 consistently produced the highest TDM at all sampling days.

Crop growth rate (g m^{-2} day^{-1}): Variety significantly influenced crop growth rate at 45-60 DAS and 60-75 DAS intervals (Table 2). The highest crop growth rate (1.871 g

Table 2. Varietal effect, effect of mulching and Interaction effect on Total Dry Matter (TDM), and Crop Growth Rate (CGR) of wheat of different days after sowing (DAS).

Variety	Total Dry Matter (TDM)						Crop Growth Rate (CGR)				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS
V_1	0.061b	0.341b	1.535	3.772	7.109	9.885	1.866	7.963	16.569b	20.574b	18.512
V_2	0.072a	0.353a	1.547	4.032	7.119	9.895	1.871	7.963	16.583a	20.586a	18.525
V_3	0.062b	0.335b	1.528	4.015	7.101	9.878	1.815	7.955	16.580a	20.573b	18.5
LS	0.05	0.01	0.01	NS	0.01	0.05	NS	NS	0.05	0.05	NS
Treatment											
M_0	0.066	0.315d	1.508d	3.995	7.082d	9.856d	0.066	0.315d	1.508d	3.995	7.082d
M_1	0.064	0.336c	1.530c	3.683	7.103c	9.878c	0.064	0.336c	1.530c	3.683	7.103c
M_2	0.066	0.351b	1.545b	4.031	7.118b	9.897b	0.066	0.351b	1.545b	4.031	7.118b
M_3	0.065	0.370a	1.565a	4.05	7.127a	9.911a	0.065	0.370a	1.565a	4.05	7.127a
LS	NS	0.01	0.01	NS	0.01	0.01	NS	0.01	0.01	NS	0.01
Interaction											
V_1M_0	0.062	0.308 e	1.501e	3.011f	7.076e	9.849	1.64ef	7.956	16.58	20.578	18.489
V_1M_1	0.058	0.329de	1.524d	3.989e	7.099d	9.877	1.780 d	7.96	16.582	20.58	18.491
V_1M_2	0.062	0.354 bc	1.548bc	4.035bc	7.123bc	9.902	1.973b	7.961	16.584	20.584	18.518
V_1M_3	0.072	0.371 ab	1.565ab	4.052ab	7.139ab	9.913	2.071a	7.962	16.59	20.585	18.524
V_2M_0	0.067	0.328de	1.522de	4.009de	7.096de	9.87	1.706e	7.958	16.558	20.571	18.496
V_2M_1	0.076	0.348 cd	1.541cd	4.025cd	7.113cd	9.888	1.869c	7.959	16.568	20.576	18.507
V_2M_2	0.074	0.358abc	1.553abc	4.037abc	7.123bc	9.9	1.884c	7.96	16.561	20.581	18.505
V_2M_3	0.063	0.378a	1.572a	4.059a	7.145a	9.921	2.026ab	7.967	16.58	20.586	18.516
V_3M_0	0.063	0.308e	1.501e	3.989e	7.075e	9.843	1.631f	7.953	16.575	20.556	18.491
V_3M_1	0.062	0.331d	1.526d	4.013d	7.096de	9.87	1.795d	7.956	16.578	20.576	18.495
V_3M_2	0.063	0.340cd	1.534cd	4.021cd	7.107cd	9.89	1.845cd	7.958	16.58	20.578	18.496
V_3M_3	0.061	0.359 abc	1.552abc	4.039abc	7.127abc	9.901	1.988b	7.964	16.584	20.584	18.553
LS	NS	0.01	0.01	0.05	0.01	NS	0.01	NS	NS	NS	NS
CV(%)	3.14	1.03	5	12.7	4	5	1.35	4.5	2.4	0.19	2.5

In a column, means followed by a similar letter (s) or without letter (s) or without letter are not significantly different whereas, means followed by a dissimilar letter (s) are significantly different as Duncan's New Multiple Range Test. V_1 = Prodip, V_2 = Bijoy, V_3 = BARI Gom 27 and M_0= Zero mulch, M_1 = Polythene sheet, M_2 = Rice straw, M_3=Water hyacinth, LS = Level of significance, CV = Co-efficient of variation.

m²/day) was observed in Bijoy (V_2), and the lowest (1.815 g m²/day) in BARI Gom 27 (V3) during 15-30 DAS. During 30-45 DAS, Prodip (V_1) and Bijoy (V_2) both had the highest growth rate (7.963 g m²/day), while BARI Gom 27 had the lowest (7.955 g m²/day). At 45-60 DAS, Bijoy and BARI Gom 27 recorded the highest growth rates (16.583 g m²/day and 16.580 g m²/day, respectively), with Prodip the lowest (16.569 g m²/day). During 60-75 DAS, Bijoy had the highest rate (20.586 g m²/day) and both Prodip and BARI Gom 27 had the lowest (20.573 g m²/day). Finally, at 75-90 DAS, Bijoy again had the highest rate (18.525 g m²/day), while BARI Gom 27 had the lowest (18.500 g m²/day). Using of mulches also significantly influenced crop growth rate (Table 2). At 15-30 DAS, the highest rate (0.066 g m²/day) was observed in zero mulch (M_0) and rice straw (M_2), and the lowest (0.064 g m²/day) in polyethylene sheet (M_1). During 30-45 DAS, water hyacinth (M_3) had the highest rate (0.370 g m²/day), while zero mulch had the lowest (0.315 g m²/day). At 45-60 DAS, water hyacinth again led (1.565 g m²/day), with zero mulch lowest (1.508 g m²/day). During 60-75 DAS, water hyacinth recorded the highest rate (4.050 g m²/day) and zero mulch the lowest (3.995 g m²/day). At 75-90 DAS, water hyacinth had the highest rate (7.127 g m²/day), and zero mulch the lowest (7.082 g m²/day). The interaction effects of variety and mulching also significantly influenced crop growth rate (Table 2). At 15-30 DAS, Prodip × water hyacinth (V_1M_3) had the highest rate (2.071 g m²/day) and BARI Gom 27 × zero mulch (V_3M_0) the lowest (1.631 g m²/day). During 30-45 DAS, Bijoy × water hyacinth (V_2M_3) led (7.967 g m²/day), while BARI Gom 27 × zero mulch was lowest (7.953 g m²/day). At 45-60 DAS, Prodip × water hyacinth had the highest rate (16.590 g m²/day), and Bijoy × zero mulch the lowest (16.558 g m²/day). During 60-75 DAS, Bijoy × water hyacinth recorded the highest rate (20.586 g m²/day), and BARI Gom 27 × zero mulch the lowest (20.556 g m²/day). Finally, at 75-90 DAS, BARI Gom 27 × water hyacinth had the highest rate (18.553 g m²/day), while Prodip × zero mulch had the lowest (18.489 g m²/day).

Number of effective tillers plant^{-1}: The data on number of effective tillers as influenced by the selected varieties are presented in Table 3. Number of effective tillers was significantly influenced by the selected varieties. Significantly higher number of effective tiller (5.125) was recorded in the V_2 (Bijoy). Significantly lower number of effective tiller (4.750) was recorded in the V_1 (Prodip). The data on number of effective tillers as influenced by the use of different mulching are presented in Table 3. Number of effective tillers was significantly influenced by the use of different mulches. Significantly higher number of effective tiller (5.310) was recorded with the application of M_3 (water hyacinth). Significantly lower number of effective tiller (4.612) was recorded with the application of M_0 (zero mulch). The number of effective tillers was significantly influenced by the interaction of variety and mulching in Table 3. The Number of effective tillers was higher (5.601) with the interaction effect of V_3 (BARI Gom 27) × M_3 (water hyacinth). The lower number of effective tiller (4.303) was observed in V_3 (BARI Gom 27) × M_0 (zero mulching).

Spike length (cm): The data on Spike length as influenced by the selected varieties are presented in Table 3. Number of Spike length was significantly influenced by the selected varieties. Significantly highest spike length (16.033 cm) was found in V_1 (Prodip). Significantly lowest spike length (14.350 cm) was found in V_3 (BARI Gom 27). The data on Spike length was influenced by the different mulches are presented in Table 3. The Spike length was influenced by the use of different mulching. Significantly highest Spike length (15.661 cm) was found in M_3 (water hyacinths). Significantly lowest Spike length (15.040 cm) was found in M_0 (zero mulching). The Spike length was influenced by the interaction of variety and mulching in Table 3. The Spike length was highest (16.133 cm) with the interaction effect of V1 (Prodip) × M_2 (Rice straw). The lowest spike length (13.460 cm) was observed in V_3 (BARI Gom 27) × M_2 (Rice straw).

Spikelet's spike^{-1}: The data on spikelet's spike^{-1} as influenced by the selected varieties are presented in Table 3. The spikelet's spike^{-1} did not differ significantly influenced by the selected varieties. The highest number spikelet's spike^{-1} (20.617) was recorded in V_1 (Prodip). The lower number of spikelet's spike^{-1} (14.350) was recorded in V_3 (BARI Gom 27). The data on number of spikelet's spike^{-1} as influenced by the different mulching are presented in Table 3. Number of spikelet's spike^{-1} differs significantly influenced by the use of mulches. The higher number of spikelet's spike^{-1} (19.386) was recorded in M_3 (water hyacinths). The lower number of spikelet's spike^{-1} (18.330) was recorded in M_0 (zero mulching). Number of spikelet's spike^{-1} did not differ significantly influenced by the interaction of variety and mulching in Table 3. Number of spikelet's spike^{-1} was highest (21.002) with the interaction effect of V_1 (Prodip) × M_1 (Polyethylene sheet) The lower number of spikelet's spike (17.276) was observed with V_3 (BARI Gom 27) × M_1 (Polyethylene sheet) .

Number of grains spike^{-1}: The data on number of grains spike^{-1} as influenced by the selected varieties are presented in Table 3. Number of grains spike^{-1} was influenced by the selected varieties. The higher number of grains spike^{-1} (43.633) was found in V_3 (BARI Gom 27). The lower number of grains spike^{-1} (42.862) was recorded in V_2 (Bijoy). The data on number of grains spike^{-1} as influenced by mulching are presented in Table 3. Number of grains spike^{-1} was significantly influenced by the use of different mulches. Significantly the higher number of grains spike^{-1} (46.315) was recorded in M_3 (water hyacinth). Significantly the lower number of grains spike^{-1} (41.400) was recorded in M_0 (zero mulch). Number of grains spike^{-1} was influenced by the interaction of selected varieties and mulching in Table 3. Number of grains spike^{-1} was higher (47.133) with the interaction effect of V_2 (Bijoy) × M_3 (water hyachinth). The lower number of grains spike^{-1} (40.536) was observed in V_2 (Bijoy) × M_0 (zero mulch) and in V_3 (BARI Gom 27) × M_1 (Polyethylene sheet).

1000 grain weight (g): The 1000 gm seed weight was significantly influenced by recommended dose of fertilizer in Table 3. The highest 1000 gm seed weight (56.630cm) was found with V_1 (Prodip) whereas the lowest (40.667 cm) was in V_3 (BARI Gom 27). The result clearly showed that 1000 gm seed weight increased with variety Prodip. The 1000 gm seed weight varied significantly due to different mulches in Table 3. The highest 1000 gm seed weight (52.314 gm) was found in M_3 (water hyachinth) and the lowest (448.014 gm) at M_0 (zero mulch). The 1000 gm seed weight was respectively increased with different mulching (Table 3). The 1000 gm seed weight was influenced by the interaction effect of selected varieties and mulching in Table 3. The 1000 gm seed weight was highest (61.437gm) with the interaction effect of V_3 (BARI Gom - 27) × M_3 (water hyachinths). The lowest 1000 gm seed weight (38.40 m) was observed with V_3 (BARI Gom - 27) × M_0 (Zero mulch).

Grain yield (t ha^{-1}): The data on grain yield as influenced by the selected varieties are presented in Table 3. Number of grain yield was significantly influenced by the selected varieties. Significantly highest grain yield (5.225) was recorded with the V_3 (BARI Gom 27). Significantly lowest grain yield (4.536) was recorded with the V_2 (Bijoy). Islam (2008) was conducted a field experiment to study the effect of sowing date and boron application on the performance of wheat varieties. Significant variation was found due to different varieties in respect of all the parameters studied. Prodip produced the highest grain yield (4.32 t ha^{-1}) followed by Gourab (3.95 t ha^{-1}), Sourav (3.81 t ha^{-1}) and Shotabdi (3.68 t ha^{-1}). The data on grain yield as significantly influenced by the different mulches are presented in Table 3. Grain yield was significantly influenced by the use of mulching. Significantly highest grain yield (5.408) was recorded in M_2 (Rice straw). Significantly lowest grain yield (3.810) was recorded in M_0 (zero mulch). Grain yield was significantly influenced by the interaction of selected varieties and mulching (Table 3). Grain yield was highest (5.960) with the interaction effect of V_3 (BARI Gom- 27) × M_2 (Rice straw). The lowest grain yield (3.305) was observed with V_1 (Prodip) × M_0 (zero mulch).

Straw yield (t ha^{-1}): The data on straw yield as influenced by the selected varieties are presented in Table 3. The straw yield was significantly influenced by the varieties. Significantly highest straw yield (6.108) was recorded in variety V_1 (Prodip). Significantly lowest straw yield (5.350) was recorded in variety V_2 (Bijoy). The data on straw yield as influenced by the mulching are presented in Table 3. Straw yield was significantly influenced by the use of different mulches. Significantly highest (6.332) was recorded in M_3

Table 3. Varietal effect, effect of mulching and Interaction effect on yield and yield contributing characters of wheat.

Variety	Effective tiller	Spike length (cm)	Spikelets spike^{-1}	Grains spike^{-1}	1000 seed weight (g)	Grain yield (t ha-1)	Straw yield (t ha-1)	Biological yield	Harvest index (%)
V_1	4.750 b	16.033 a	20.617 a	43.485	56.630a	4.850 b	6.108 a	10.951 a	44.221
V_2	5.125 a	15.567 a	18.150 b	42.862	51.385b	4.536c	5.350 b	9.882b	45.678
V_3	4.992 a	14.350 b	17.967 b	43.633	40.66 7c	5.225 a	6.200 a	11.400 a	48.02
LS	0.05	0.05	NS	NS	0.01	0.05	0.01	0.01	NS
Treatment									
M_0	4.612 c	15.04	18.330 c	41.692 b	48.014 b	3.810 b	5.036 b	8.822 c	43.215
M_1	4.866 bc	15.355	18.642 bc	41.400 b	48.890 b	5.100 a	5.850 b	10.950 b	49.442
M_2	5.033 ab	15.2	19.296 ab	43.913 ab	49.016 b	5.408 a	6.321 a	11.725 a	46.33
M_3	5.310 a	15.661	19.386 a	46.315 a	52.314 a	5.176 a	6.332 a	11.504 ab	44.918
LS	0.01	NS	0.05	0.01	0.05	0.01	0.01	0.01	NS
Interaction									
V_1M_0	4.608 de	15.861	19.934	43.078	43.439	3.305 e	4.279 c	7.568 e	43.56
V_1M_1	4.470 e	15.065	18.67	42.002	55.561	5.001 bc	5.673 b	10.671 bcd	46.671
$V1M_2$	4.931cd	14.862	20.661	42.865	53.56	5.005 bc	5.801 b	12.936 a	45.200
V_1M_3	5.004 bcd	16.064	20.86	46.004	56.033	5.270 ab	7.105 a	12.679 a	41.532
$V2M_0$	4.935 bcd	15.131	17.539	40.536	49.6	4.105 d	5.302 b	9.402 d	43.6
V_2M_1	4.961 bcd	15.06	17.676	41.667	52.005	4.406 cd	5.204 b	9.605 cd	45.501
V_2M_2	5.265 abc	16.008	18.603	42.134	51.834	4.401 cd	5.100 bc	9.500 cd	46.27
V_2M_3	5.330 ab	16.067	18.805	45.800	52.061	5.234 ab	5.806 b	12.603 a	47.332
V_3M_0	4.303 e	14.135	17.532	41.465	38.405	4.033 de	5.533 b	9.503 cd	42.461
V_3M_1	5.171 bc	14.932	17.276	40.531	39.102	5.905 a	6.705 a	11.031 b	45.862
V_3M_2	4.902 cd	13.46	18.402	46.736	41.78	5.960 a	6.763 a	10.807 bc	47.533
V_3M_3	5.601 a	16.133	21.002 .	47.133	61.437	5.830 a	7.402 a	12.730 a	56.237
LS	0.05	NS	NS	NS	NS	0.01	0.01	0.01	NS
CV%	4.95	5.88	3.65	6.87	5.76	6.89	6.66	5.84	11.37

In a column, means followed by a similar letter (s) or without letter (s) or without letter are not significantly different whereas, means followed by a dissimilar letter (s) are significantly different as Duncan's New Multiple Range Test. V_1 = Prodip, V_2 = Bijoy, V_3 = BARI Gom 27 and M_0= Zero mulch, M_1 = Polythene sheet, M_2 = Rice straw, M_3=Water hyacinth, LS = Level of significance, CV = Co-efficient of variation.

(Water hyachinth). Significantly lowest straw yield (5.036) was recorded in M_0 (zero mulch). The straw yield was significantly influenced by the interaction of selected varieties and mulching in Table 3. The straw yield was highest (7.402) with the interaction effect of V_1 (Prodip) × M_3 (water hyachinth). The lowest straw yield (4.279) was observed with V_1 (Prodip) × M_0 (zero mulch).

Biological yield (t ha^{-1}): The data on biological yield as significantly influenced by the selected varieties are presented in Table 3. The biological yield differs significantly influenced by the selected varieties. The highest biological yield (11.400) was recorded in varietyV_3 (BARI Gom-27). The lowest biological yield (9.882) was found in variety V_2 (Bijoy). The data on as influenced by the mulching are presented in Table 3. The biological yield differs significantly influenced by the use of different levels of mulching. The highest biological yield (11.725) was recorded in M_3 (water hyachinth). The lowest biological yield (8.822) was found in variety M_0 (Zero mulch). The biological yield differs significantly influenced by the interaction of selected varieties and mulching in Table 3. The biological yield was highest (12.936) with the interaction effect of V_1 (Prodip) × M_2 (Rice straw). The lowest biological yield (7.568) was observed with V_1 (Prodip) × M_0 (zero mulch).

Harvest index (%): The data on Harvest index as influenced by the selected varieties are presented in Table 3. Harvest index was influenced by the selected varieties. The highest harvest index (48.020) was recorded in the variety V_3 (BARI

Gom 27). The lowest harvest index (44.221) was found in variety V_1 (Prodip). The data on harvest index as influenced by mulching are presented in Table 3. The harvest index was influenced by the use of mulching. The highest harvest index (49.442) was recorded in M_3 (Polyethylene sheet). The lowest harvest index (43.215) was recorded in M_0 (zero mulch). The harvest index was as influenced by the interaction of selected varieties and mulching in Table 3. The harvest index was highest (56.237) with the interaction effect of V_3 (BARI Gom 27) × M_3 (Polyethylene sheet). The lowest harvest index (41.532) was observed with V_1 (Prodip) × M_1 (water hyachinth).

Simple correlation between yield and yield contributing characters of wheat: Yield is the expression as a whole of the performance of various yield contributing characters and the results of interaction among them. Hence, it is of almost importance to know the quality of interrelationship among the yield and yield contributing characters. The correlation co-efficient is done to know the relations between the different yield and yield characters at harvest. The correlation matrix of the selected parameters is presented in Figures 1 to 4. The correlation co-efficient result indicated that plant height was positively correlated with number of effective tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, 1000 grain weight, grain yield, straw yield, biological yield and harvest index. Number of effective tillers plant^{-1} was positively associated with spike length, grains spike^{-1}, grain yield, straw yield, biological yield and harvest index and negatively correlated with spikelets spike^{-1} and 1000 grain weight. Spike length was positively correlated with spikelets spike^{-1}, grains spike^{-1}, 1000 grain weight, straw yield, biological yield, harvest index and negatively correlated with grain yield. Spikelets spike^{-1} was posetively correlated with grains spike^{-1}, 1000 grain weight, grain yield, straw yield and biological yield and negatively correlated with harvest index. Grains spike^{-1} was positively correlated with 1000 grain weight, grain yield, straw yield and biological yield and negatively correlated with harvest index. 1000 grain yield was positively correlated with straw yield and negatively correlated with grain yield, biological yield and harvest index. Grain yield was positively correlated with straw yield, biological yield and harvest index. Straw yield was positively correlated with biological yield and harvest index. Biological yield was positively correlated with harvest index. From above discussion it is observed that, among the yield contributing characters plant height, effective tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, 1000-grain, straw yield, biological yield and harvest index were positively correlated with grain yield. The correlation is briefly described below- The degree of relationship between effective tillers plant^{-1} and grain yield was studied (Figure 2). The result revealed that effective tillers plant^{-1} and grain yield have a significant positive relationship at 1% level of significance. The correlation co-efficient r= 0.794**. The positive slope indicates positive relationship which means that an increase in the number of effective tillers plant^{-1} will lead to an increase in grain yield. The degree of relationship between number of grains spike^{-1} and grain yield was studied (Figure 3). The result revealed that number of grains spike^{-1} and grain yield have a significant positive relationship at 1% level of significance. The correlation co-efficient r= 0.841**. The positive slope indicates positive relationship which means that an increase in number of grains spike^{-1} will lead to an increase in grain yield. Finally, the degree of relationship between 1000-grain weight and grain yield was studied (Figure 4). The result revealed that 1000-grain weight and grain yield have a significant positive relationship at 1% level of significance. The correlation co-efficient r= 0.531**. The positive slope indicates positive relationship which means that an increase in 1000-grain weight will lead to an increase in grain yield.

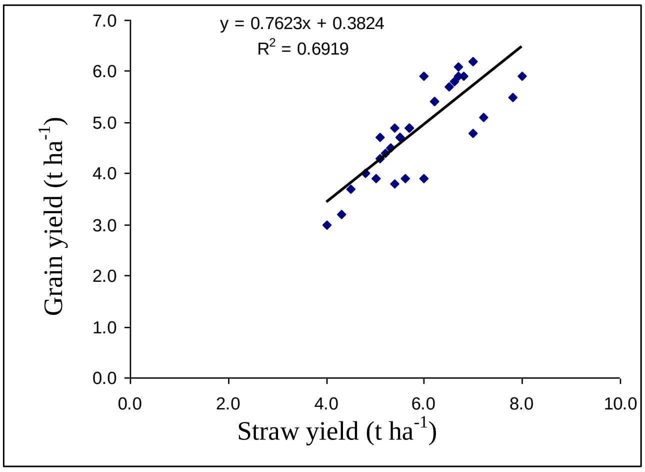

Figure 1. Relationship between straw yield and grain yield of wheat.

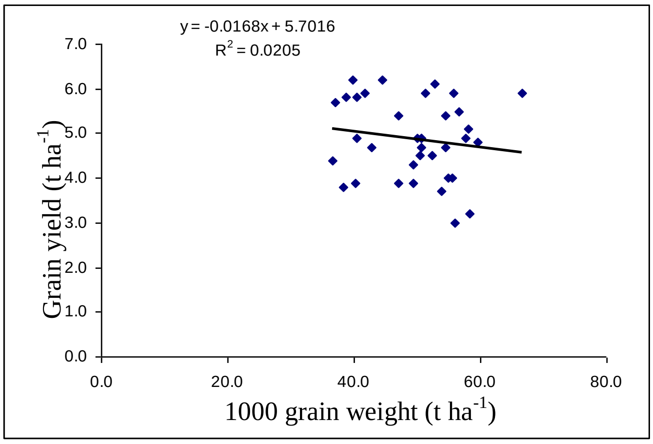

Figure 2. Relationship between 1000 grain weight and grain yield of wheat

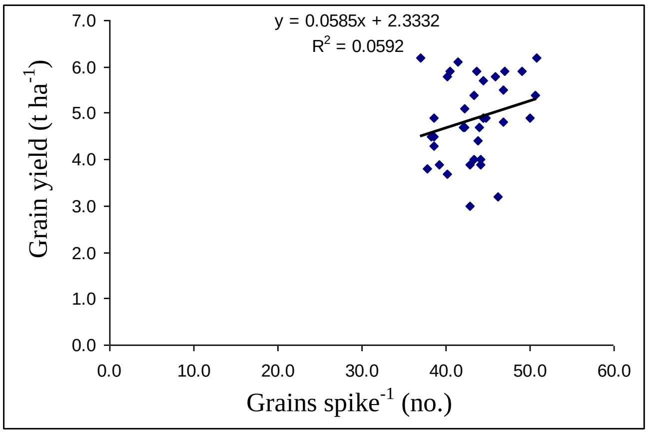

Figure 3. Relationship between grains spike^{-1} and grain yield of wheat.

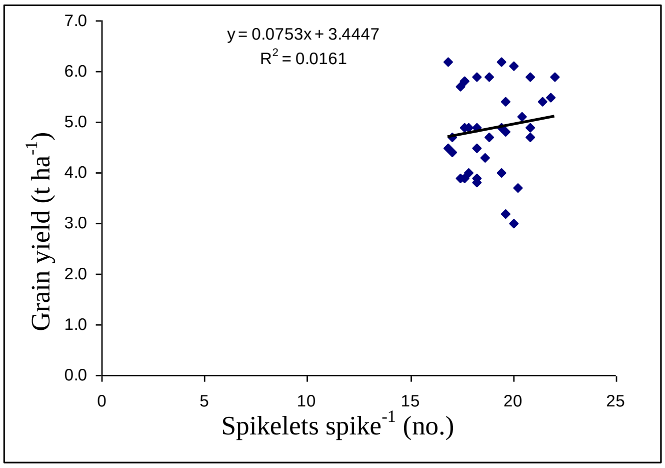

Figure 4. Relationship between Spikelets spike^{-1} and grain yield of wheat.

4. Conclusion

The study highlights the significant role of mulching and variety selection in enhancing wheat production under rainfed conditions. Among the varieties tested, Bijoy consistently performed the best in terms of plant height, total dry matter production, and crop growth rate, particularly when combined with water hyacinth mulch. The use of water hyacinth mulch was notably effective in improving soil moisture conservation, which in turn led to better crop performance across all parameters. These findings emphasize the importance of selecting appropriate mulching materials and wheat varieties to optimize yield, especially in moisture-limited environments. This research provides valuable insights for farmers and agronomists in regions facing similar challenges, offering practical solutions for improving wheat productivity.

Conflict of Interest

Authors have no conflict of interest on this article.

Authors' Contributions

Author-1 wrote the first draft of the manuscript, researched literature and conceived the study. Author-2 involved in protocol development and assist in manuscript writing, Author-3 is the corresponding author, was involved in protocol development gaining ethical approval, patient recruitment, and data analysis revised the final draft of the manuscript. Both 2nd & 3rd authors reviewed and edited the manuscript and approved the final version of the manuscript.

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