



Varietal Performances of Savoy Cabbage (*Brassica oleracea* var. *sabauda* L.), a Newly Introduced French Vegetable in Bangladesh as Influenced by Mulching

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ABSTRACT

Savoy cabbage (*Brassica oleracea* var. *sabauda* L.) is a newly introduced French vegetable, high-value crop in Bangladesh; however, empirical research optimizing its agronomic management under local agro-climatic conditions remains scarce. This study evaluated the interactive effects of cultivar selection and mulching regimes on the growth and yield metrics of Savoy cabbage. Arranged in a Randomized Complete Block Design (RCBD) with three replications, the experiment evaluated two cultivars, 'Savoy Vertus' [V₁] and 'Savoy Ormskirk (1)' [V₂], across five mulching treatments: control (M₀), straw (M₁), water hyacinth (M₂), sawdust (M₃), and black polyethylene (M₄). Both main and interaction effects significantly influenced vegetative growth, dry matter accumulation, and head yield. Cultivar 'Savoy Vertus' demonstrated superior performance over 'Savoy Ormskirk'. Among mulches, sawdust (M₃) recorded the highest marketable yield (48.38 t ha⁻¹), outperforming the control (M₀: 34.44 t ha⁻¹) by 40.5%, following the efficiency order of M₃>M₂>M₁>M₄>M₀. The combination V₁M₃ ('Savoy Vertus' + sawdust) achieved peak values across all measured traits, including plant height (52.75 cm), dry matter (16.97%), gross head yield (60.49 t ha⁻¹), and marketable yield (48.38 t ha⁻¹), whereas V₂M₀ produced the minimum values. Overall, combining 'Savoy Vertus' with sawdust mulching represents a promising agronomic practice to promote successful adoption and yield optimization of Savoy cabbage in Bangladesh.

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1. Introduction

Savoy cabbage (*Brassica oleracea* var. *sabauda* L.) is an economically vital temperate vegetable belonging to the family Brassicaceae, distinguished by its deeply crinkled, emerald-green leaves and tender texture. It is an herbaceous, biennial, dicotyledonous flowering plant marked by a short stem bearing a dense clump of loose wrinkled leaves, usually dark green, that when immature form a characteristic compact, spherical cluster structure known as a cabbage head. Savoy cabbage, named after the Savoy region of France, is also referred to as Milan or Lombard cabbage, reflecting its association with Milan and the Lombardy region of Italy (Titchmarsh et al., 2008).

Unlike common cabbage (*Brassica oleracea* var. *capitata*), Savoy cabbage is prized globally as a premium cultivar group due to its distinct culinary quality, high antioxidant activity, and dense phytochemical profile, including glucosinolates, isothiocyanates, beta-carotene, and essential vitamins (C, K, and folate) (Pennington and

Fish, 2010). It contains one of the highest quantities of beta-carotene, quercetin (an antioxidant), and a natural antihistamine that can help allergy patients (Masarirambi et al, 2013). Savoy cabbage juice can be used to cure stomach ulcers, prevent bleeding, and reduce constipation. Savoy cabbage leaves are also considered as an ideal roughage. A chemical (isothiocyanates) found in Savoy cabbages may reduce the incidence of lung cancer in smokers by up to 38% (Masarirambi et al, 2013). Savoy cabbage is also high in folate and omega-3 fatty acids, which have been shown to aid in brain growth in young children and retain mental sharpness in adults. Savoy cabbage has been shown to contain very few calories, making it ideal for weight loss. A head of Savoy cabbage contains approximately 25 calories and has nearly no saturated fat or cholesterol. Consuming cabbage and/or other cruciferous vegetables has been linked to a lower risk of numerous cancers, including bladder, breast, lung, stomach, colorectal, and prostate. The flavor of Savoy cabbage is related to the component

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known as Sinigrin glucoside (Moniruzzaman et al., 2019). Cultivated during the winter (Rabi) season in subtropical regions, the crop requires precise thermal regimes, with optimal vegetative growth and head initiation occurring between 15 °C and 20 °C (Wien, 2020).

In Bangladesh, per capita daily vegetable intake remains critically low at approximately 32 g day⁻¹, falling far below the Food and Agriculture Organization minimum recommendation of 200 g day⁻¹ (FAO, 2014). Although cruciferous crops occupy significant acreage yielding 879,694 tons across 45150.20 hectares (BBS, 2024)—national average productivity (19.48 t ha⁻¹) lags substantially behind global benchmarks such as South Korea (61.17 t ha⁻¹) and Germany (54.81 t ha⁻¹). This yield gap stems not from inherent genetic limitations, but from reliance on degenerated varieties, inadequate crop management, and insufficient adoption of sustainable agronomic technologies. Introducing high-value non-traditional vegetables like Savoy cabbage represents a viable pathway to diversify winter crop production, improve farm profitability, and enhance nutritional security.

Despite its commercial potential, Savoy cabbage remains a non-traditional crop in Bangladesh, and empirical research on its acclimatization, cultivar performance, and management practices under local agro-climatic conditions is non-existent. Cultivar selection plays a key role in governing growth habits, leaf morphology, physiological efficiency, and environmental adaptability (Döring et al., 2005). Concurrently, soil moisture conservation via mulching is essential in winter production systems to regulate soil temperature, suppress weed competition, and enhance nutrient availability (Ramakrishna et al., 2006). While both biodegradable organic mulches (e.g., sawdust, rice straw, water hyacinth) and synthetic films (e.g., black polyethylene) are recognized for improving microclimatic conditions (Murungu et al., 2011), their interactive efficiency with specific Savoy cabbage genotypes has not been documented. To date, no systematic scientific trial has investigated the agronomic feasibility or optimizing management practices for Savoy cabbage in Bangladesh. Therefore, this study was conducted to establish foundational baseline data for this newly introduced crop. The specific objectives were to evaluate the growth dynamic and yield performance of distinct Savoy cabbage varieties under local field conditions, to identify the optimal mulching material for enhancing vegetative development and head yield, and to determine the interactive effect of variety selection and mulching regime to establish an efficient, sustainable production package for Savoy cabbage under Bangladesh conditions.

2. Materials and Methods

2.1. Experimental location and agro-climatic conditions

The experiment was conducted at the Agronomy Field A field experiment was conducted at the Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University (BAU), Mymensingh from October 2024 to March 2025. The experimental site falls under the Old Brahmaputra Floodplain Alluvial Tract (AEZ-9) (UNDP, 1988). The soil is classified as high land with a sandy loam

texture, well-drained, and slightly acidic to neutral (pH 6.5–7.0). The experimental location experiences a subtropical climate characterized by a wet monsoon season (April to September) and a dry winter (Rabi) season (October to March). The Rabi season provides optimal conditions for temperate vegetable production, marked by moderate temperatures, low rainfall, and high sunshine hours.

2.2. Plant materials and seedling raising

Seeds of two distinct Savoy cabbage (*Brassica oleracea* var. *sabauda*) varieties—'Savoy Vertus' and 'Savoy Ormskirk' were obtained via the Department of Horticulture, University of Wisconsin–Madison, USA. Seedlings were raised in raised seedbeds (3 m X 1 m) at the BAU Horticulture Farm. Soil was tilled to a fine tilth, solarized to suppress soil-borne pathogens and damping-off, and cleared of crop debris. Seeds (200 g per cultivar) were blended with fine sand and sown uniformly on 15 October 2024. Sown beds were lightly covered with topsoil, firmed, and managed under standard nursery practices (light hand-watering and manual weeding) until transplanting.

2.3. Experimental design and treatments

The trial was conducted using a 2 X 5 factorial experiment laid out in a Randomized Complete Block Design (RCBD) with three replications, yielding 30 individual experimental units (plots). The experiment comprised two factors viz. Factor A: two varieties, V₁ : Savoy Vertus, V₂: Savoy Ormskirk (1), and Factor B: five mulching treatments: M₀: Control (bare soil, no mulch), M₁: Rice straw (5 t ha⁻¹), M₂: Water hyacinth (*Eichhornia crassipes*, dried; 5 t ha⁻¹), M₃: Sawdust (5 t ha⁻¹) and M₄: Black polyethylene film (30 µm thickness). Each experimental plot measured 1.50 m × 1.25 m (1.875 m²). Plants were spaced at 60 cm × 40 cm, accommodating 6 plants per plot (equivalent to an effective planting density of 32,000 plants ha⁻¹). Inter-plot and inter-block spacing was maintained at 0.5 m to facilitate agronomic operations and prevent edge effects.

2.4. Crop management and cultural practices

2.4.1. Land preparation and fertilization

Primary tillage was performed using a power tiller on 7 October 2024, followed by 7 days of solar exposure. The soil was subsequently ploughed and cross-ploughed to achieve fine tilth, then levelled. To control soil-inhabiting pests (cutworms, mole crickets, and ants), Furadan 5G (carbofuran) was incorporated during final land preparation at 8 kg ha⁻¹. As Savoy cabbage is completely new winter vegetable crop in Bangladesh and there is no fertilizer recommendation for it so that fertilizers for related crop cabbage were applied according to Bangladesh Agricultural Research Council recommendations (FRG, 2018) (Table 1).

2.4.2. Transplanting and mulch application

Healthy, uniform 25-day-old seedlings were transplanted on 9 November 2024 during late afternoon hours to minimize transplanting shock. Seedbeds were irrigated 1 hour prior to uprooting to preserve root integrity. Seedlings were shaded using banana leaf sheaths during peak daylight hours for 5 days post-transplanting, while remaining exposed at night to benefit from dew

accumulation. Border rows of Savoy cabbage were planted around the experimental perimeter to minimize edge variation and provide replacement transplants. Mulch materials (M₁- M₄) were applied 20 days after transplanting (29 November 2024) following light surface

hoeing to break soil crusting and improve aeration. Organic mulches were spread evenly across the plot soil surface while keeping the immediate root collar zone clear. Black polythene mulch placed after 20 DAT by making whole where seedlings are planted.

Table 1. Interaction effects of variety and mulching on plant height and number of loose leaves per plant at different days after transplanting (DAT) of Savoy cabbage

Treatment interaction	Plant height (cm) at different DAT						Number of loose leaves per plant at different DAT					
	20	30	40	50	60	70	20	30	40	50	60	70
V ₁ M ₀	10.32	15.07	20.12	25.02	31.03	37.14	5.26	6.83	9.33	12.50	14.83	16.92
V ₁ M ₁	13.88	21.07	27.82	33.77	40.59	46.82	7.31	10.25	14.08	18.08	21.17	23.08
V ₁ M ₂	15.22	22.01	29.43	35.70	42.60	49.87	8.22	11.25	15.17	19.92	23.17	24.92
V ₁ M ₃	17.34	23.98	31.38	37.72	45.04	52.75	10.09	13.92	17.00	21.17	25.17	27.33
V ₁ M ₄	12.55	19.22	25.73	31.90	38.98	44.84	6.21	8.75	12.17	16.33	19.33	21.17
V ₂ M ₀	9.62	12.98	18.02	23.17	28.51	35.97	3.88	5.58	7.75	10.83	12.75	14.75
V ₂ M ₁	12.76	19.12	25.23	31.68	39.23	45.26	6.32	9.17	12.33	15.17	19.00	20.67
V ₂ M ₂	14.43	20.93	27.16	33.95	41.11	48.34	7.15	10.17	13.25	17.33	20.83	23.00
V ₂ M ₃	16.04	22.75	29.10	35.76	43.43	50.63	8.69	12.83	15.33	19.26	23.00	25.17
V ₂ M ₄	11.71	17.13	23.03	29.68	37.18	43.36	5.19	8.00	11.17	13.33	16.92	18.83
LSD _{0.05}	0.17	0.24	0.17	0.08	0.17	0.24	0.17	0.17	0.30	0.30	0.11	0.17
Level of sig.	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1) and M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, M₄ = Black polythene.

2.4.3. Intercultural operations and plant protection

Irrigation was applied immediately after transplanting and continued up to mulching has been provided. Drainage channels were maintained around plots to prevent waterlogging following unseasonal rainfall.

Gap filling was carried out within 7 days of transplanting using border-row seedlings. Manual weeding and inter-row hoeing were executed periodically to maintain weed-free conditions. Earthing-up was performed at 20 and 40 DAT to support stem stability and root development.

Field cutworm (*Agrotis ipsilon*) outbreaks were managed through localized hand-picking combined with targeted foliar applications of abamectin (Sunmectin 1.8EC at 18g L⁻¹) or chlorpyrifos 2 g L⁻¹ at 7-day intervals. Avian damage caused by red-vented bulbuls (*Pycnonotus cafer*) feeding on tender leaf tissues and emerging heads was mitigated by positioning reflective black polyethylene banners on perimeter posts across the field. The weeding was done as and when necessary.

2.5. Harvesting

Selective hand harvesting was conducted from 7 February 2025 to 4 March 2025 as individual cabbage heads achieved physiological maturity and commercial compactness (assessed via gentle manual compression). Heads were harvested along with a short portion of the stalk using a sterile stainless-steel knife during early morning hours to maintain post-harvest turgidity.

2.6. Data collection protocols

To minimize edge effects, four plants were selected at random from the inner rows of each experimental plot for evaluating vegetative and individual head traits. Yield parameters were determined on a whole-plot basis (1.875 m²). Vegetative growth parameters including plant height, number of loose leaves per plant, and length and breadth of the largest leaf were recorded sequentially at 10-day

intervals (20, 30, 40, 50, 60, and 70 days after transplanting, DAT). Head morphometrics, dry matter percentage, and yield fractions were determined at final harvest.

2.6.1. Vegetative growth parameters

Plant Height are measured from ground level to the tip of the longest uncurled leaf using a graduated meter scale, averaged across the four sample plants. Number of loose leaves per plant are counted manually on sample plants. Fully expanded leaves were included, while emerging leaves at the terminal growing point were excluded. Leaf length and breadth are recorded on the largest fully expanded leaf of sample plants using a meter scale. Length was measured from the petiole insertion base to the leaf apex; breadth was measured at the widest mid-blade section.

2.6.2. Head morphometrics and dry matter content

Head thickness is determined at harvest by measuring the vertical distance between the base of the head attachment and the apex using a digital vernier caliper and expressed as cm. Head diameter is measured at the widest equatorial cross-section of the head using a digital vernier caliper and expressed as cm. For measurement of head dry matter content, a representative 100 g fresh head samples were sliced, pre-dried under ambient solar conditions to reduce free surface moisture, and subsequently oven-dried at 70 °C for 72 h until constant weight was achieved. Samples were cooled in a desiccator before weighing. Dry matter percentage was calculated as:

$$\% \text{ Dry matter} = \frac{\text{Fresh weight of cabbage head (g)}}{\text{Oven dry weight of cabbage head (g)}} \times 100$$

2.6.3. Yield fractions and productivity

Yield parameters were calculated per plot (kg plot⁻¹) and extrapolated to a per hectare basis (t ha⁻¹). Gross yield is measured as the total fresh biomass per plot (including both non-heading wrapper leaves and compact heads).

Marketable head yield is calculated by weighing only intact, fully formed, and compact heads per plot meeting commercial quality standards (wrapper leaves stripped). Loose leaf yield is computed as the weight difference between total gross yield and marketable head yield per plot. Extrapolations from plot yield to per-hectare productivity (t ha^{-1}) were calculated using:

$$\text{Yield (t ha}^{-1}\text{)} = \frac{\text{Yield (kg)} \times 10,000 \text{ m}^2}{1.875 \text{ m}^2 \times 1000 \text{ (kg)}}$$

2.7. Statistical analysis

The recorded data were analyzed using the MSTAT-C computer software package to determine the significance of differences among treatments. Treatment means were calculated, and analysis of variance (ANOVA) was performed using the F-test. The significance of differences between treatment means was evaluated by the Least Significant Difference (LSD) test at 5 and 1% levels of probability (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Plant characters

3.2. Effect of variety on vegetative growth of Savoy cabbage

The varieties showed significant differences in all evaluated vegetative growth attributes, including plant height, loose leaf count per plant, leaf length, and leaf breadth across all sampling intervals from 20 to 70 days after transplanting (DAT). Results revealed that during the growth period, plant height increased gradually and reached a peak at 70 DAT (Figure 1). Higher plant height of 13.86, 20.27, 26.89, 32.82, 39.65 and 46.28 cm was recorded at 20, 30, 40, 50, 60 and 70 DAT respectively, from the variety Savoy vertus, whereas lower plant height of 12.91, 18.58, 24.51, 30.85, 37.89, and 44.71 was found at 20, 30, 40, 50, 60 and 70 DAT, respectively from the variety Savoy Ormskirk (1) (Figure 1). Taller plant of 'Savoy Vertus' reflects its genetic vigor and enhanced cell elongation capacity during early-to-mid vegetative stages under the subtropical Rabi climatic conditions of Bangladesh. The production of loose wrapper leaves and leaf blade dimensions (length and breadth) were expanded progressively from 20 to 70 DAT. The highest number of loose leaves per plant 7.42, 10.20, 13.55, 17.60, 20.73, and 22.68 were recorded at 20, 30, 40, 50, 60, and 70 DAT, respectively, from the variety Savoy Vertus (Figure 2). The lowest number of loose leaves per plant 6.25, 9.15, 11.97, 15.19, 18.50, and 20.48 were found at 20, 30, 40, 50, 60, and 70 DAT, respectively, in the variety Savoy Ormskirk(1). The highest leaf length, 14.93, 18.55, 21.84, 26.04, 29.91, and 33.83 cm, was recorded at 20, 30, 40, 50, 60, and 70 DAT, respectively, from the variety Savoy vertus. The lowest leaf length 13.96, 16.41, 20.07, 24.03, 27.55 and 31.89 cm was found at 20, 30, 40, 50, 60 and 70 DAT, respectively, in the variety Savoy Ormskirk(1) (Figure 3). Similarly, the highest leaf breadth 9.07, 11.67, 14.47, 17.29, 19.86 and 22.53 cm was recorded at 20, 30, 40, 50, 60 and 70 DAT, respectively, from the variety Savoy vertus whereas the lowest leaf breadth 8.27, 10.85, 13.22, 15.88, 18.62 and 20.72 cm was found at 20, 30, 40, 50, 60 and 70 DAT, respectively (Figure 4), from the variety Savoy Ormskirk(1). Overall, the varied performance of Savoy vertus and Savoy ormskirk (1) were found in terms of all these parameters due to the genotype of each variety

influencing growth habit, leaf development, and resource utilization efficiency, as well as their differential responses to prevailing environmental and management conditions. Similar findings were also reported by Giri et al. (2013) in broccoli and Sankhla et al. (2025) in kohlrabi.

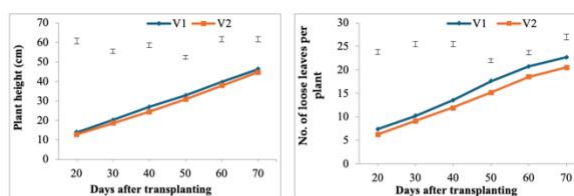


Figure 1: Effect of varieties on plant height at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1).

Figure 2: Effect of different varieties on number of loose leaves per plant at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; V₁ = Savoy vertus and V₂ = Savoy ormskirk (1).

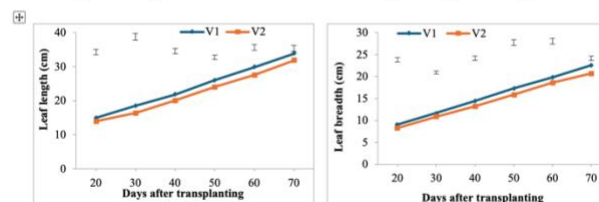


Figure 3: Effect of different varieties on leaf length at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; V₁ = Savoy vertus and V₂ = Savoy ormskirk (1).

Figure 4: Effect of variety on leaf breadth at different days after transplanting of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; V₁ = Savoy vertus and V₂ = Savoy ormskirk (1).

3.3. Effect of mulching on vegetative growth of Savoy cabbage

Similar to the varieties, the application of different mulches significantly influenced the growth parameters of Savoy cabbage. It was observed from Figure 5 that the plant height of Savoy cabbage increased with the advancement of time and was higher in plots where Sawdust mulch (M3) was used. The highest plant heights, 16.69, 23.37, 30.24, 36.74, 44.24, and 51.69 cm, were found at 20, 30, 40, 50, 60, and 70 DAT from the application of Sawdust mulch (M3) and the lowest plant heights 9.97, 14.03, 19.07, 24.09, 29.77, and 36.55 cm, were obtained at 20, 30, 40, 50, 60, and 70 DAT from the control (M0) (Figure 5). The highest number of leaves per plant was recorded from Sawdust (M3) mulch, followed by Water hyacinth (M2) mulch. From sawdust mulch treatment, the number of leaves per plant was 9.39, 13.38, 16.17, 20.21, 24.08, and 26.25 at 20, 30, 40, 50, 60, and 70 DAT, respectively. The lowest number of leaves 4.57, 6.20, 8.54, 11.67, 13.79, and 15.83 was recorded at 20, 30, 40, 50, 60, and 70 DAT, respectively, from the control (M0) (Figure 6). Application of sawdust mulch (M3) resulted in the highest leaf length 18.78, 22.20, 26.20, 30.24, 34.22 and 38.08 cm at 20, 30, 40, 50, 60 and 70 DAT, respectively, whereas the lowest leaf length 8.74, 11.36, 13.76, 17.00, 19.83 and 24.19 cm was recorded at 20, 30, 40, 50, 60 and 70 DAT, respectively, in the control (M0) (Figure 7). However, applying Sawdust mulch (M3) gave the highest leaf breadth 11.70, 14.68, 17.48, 20.49, 23.60 and 26.53 cm at 20, 30, 40, 50, 60 and 70 DAT, respectively, whereas the lowest leaf breadth 5.77, 7.63, 9.80, 11.66, 13.75 and 16.13 cm was obtained at 20, 30, 40, 50, 60 and 70 DAT, respectively, from the control (M0) (Figure 8). Mulching conserves soil moisture by reducing evaporation, ensuring a continuous water supply that promotes cell division and

elongation, leading to enhanced vegetative growth. It also moderates soil temperature, creating an optimal root-zone environment that improves root activity and nutrient uptake, thereby greatly influencing plant growth parameters. The results on plant height of cabbage obtained in the present study are in agreement with the findings of Farjana and Islam (2019) and Moniruzzaman et al. (2019) who reported that mulching significantly enhances plant height by conserving soil moisture and improving nutrient availability.

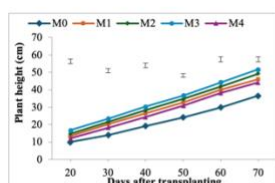


Figure 5: Effects of mulching on plant height at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, and M₄ = Black polythene.

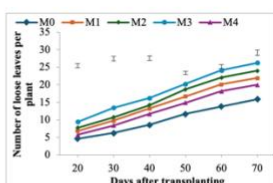


Figure 6: Effects of mulching on number of loose leaves per plant at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, and M₄ = Black polythene.

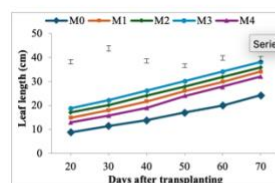


Figure 7: Effect of mulching on leaf length at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, and M₄ = Black polythene.

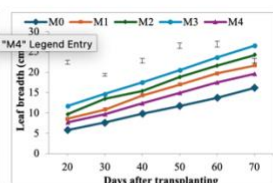


Figure 8: Effects of mulching on leaf breadth at different days after transplanting (DAT) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bars indicate LSD at the 1% level of probability; M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, and M₄ = Black polythene.

3.4. Interaction effect of variety and mulching on vegetative growth of Savoy cabbage

The combined effect of variety and different mulching treatments showed significant differences in the growth parameters of Savoy cabbage. At 70 DAT, results showed that the maximum plant height (52.75 cm) was observed from V1M3, followed by V2M3 (50.63 cm), and the minimum plant height (35.97 cm) was observed from V2M0 (Table 1). At 70 DAT, results showed that the maximum number of leaves (27.33) was observed from V1M3, followed by V2M3 (25.17), and the minimum number of leaves (14.75) was observed from V2M0 (Table 1). Results showed that the highest leaf length (39.05 cm) was observed in V1M3, followed by V2M3 (37.12 cm), and the minimum leaf length (23.11 cm) was observed in V2M0 (Table 2). The highest leaf breadth 11.98, 15.18, 18.01, 21.03, 24.16 and 27.34 cm was observed in V1M3 at 20, 30, 40, 50, 60 and 70 DAT, respectively, whereas the lowest leaf breadth 5.67, 7.31, 9.59, 11.19, 13.25 and 15.08 cm was observed from V2M0 at 20, 30, 40, 50, 60 and 70 DAT, respectively (Table 2). Sawdust mulching conserves soil moisture, moderates soil temperature, and reduces weed competition, resulting in improved root activity, nutrient uptake, and photosynthetic efficiency. These physiological advantages promote greater cell division and leaf expansion. Savoy vertus, having higher inherent vegetative vigor and leaf expansion capacity, responds more positively to these improved conditions. In contrast, the absence of mulch in Savoy ormskirk (1) exposes plants to moisture stress and nutrient competition, limiting physiological processes and vegetative growth. Thus, the interaction between sawdust mulching and the superior growth potential of Savoy vertus leads to maximum enhancement of vegetative growth parameters at 70 DAT.

Table 2. Combined effects of variety and mulching on leaf length and leaf breadth at different days after transplanting (DAT) of Savoy cabbage

Treatment combination	Leaf length (cm) at different DAT						Leaf breadth (cm) at different DAT					
	20	30	40	50	60	70	20	30	40	50	60	70
V ₁ M ₀	9.34	12.22	14.94	18.12	21.06	25.27	5.87	7.95	10.00	12.13	14.25	17.17
V ₁ M ₁	15.17	19.23	22.03	27.02	31.13	34.99	9.23	11.21	15.13	18.03	20.50	22.68
V ₁ M ₂	17.52	21.31	25.06	28.74	32.88	36.73	10.39	13.95	16.32	19.72	22.11	25.28
V ₁ M ₃	19.32	23.28	27.13	31.22	35.39	39.05	11.98	15.18	18.01	21.03	24.16	27.34
V ₁ M ₄	13.32	16.73	20.06	25.10	29.11	33.10	7.86	10.03	12.88	15.53	18.28	20.21
V ₂ M ₀	8.13	10.50	12.58	15.88	18.59	23.11	5.67	7.31	9.59	11.19	13.25	15.08
V ₂ M ₁	14.58	16.64	21.29	24.94	28.61	33.28	7.88	10.48	13.43	15.93	18.92	20.63
V ₂ M ₂	16.48	19.03	23.19	27.14	30.95	34.91	8.93	12.98	14.33	17.99	21.14	23.18
V ₂ M ₃	18.24	21.11	25.27	29.27	33.04	37.12	11.43	14.18	16.96	19.95	23.03	25.73
V ₂ M ₄	12.38	14.74	18.03	22.91	26.54	31.05	7.46	9.29	11.80	14.33	16.75	18.96
LSD _{0.05}	0.08	0.11	0.34	0.09	0.24	0.11	0.17	0.08	0.51	0.34	0.11	0.30
Level of sig.	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1) and M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust, M₄ = Black polythene.

Table 3. Effects of variety on yield-contributing characters and yield of Savoy cabbage

Variety	Thickness of head (cm)	Diameter of head (cm)	Fresh weight (g)	Dry weight (g)	Percent (%) dry matter of head	Gross yield plot ⁻¹ (kg)	Gross yield ha ⁻¹ (ton)	Marketable yield plot ⁻¹ (kg)	Leaf yield (kg)
V ₁	15.58	15.05	74.00	5.43	14.08	10.34	55.17	8.45	5.12
V ₂	14.43	13.51	68.07	5.24	13.31	9.56	51.03	7.65	3.47
LSD _{0.05}	0.13	0.15	1.04	0.15	0.11	0.05	0.40	0.08	0.05
Level of sig.	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; V₁ = Savoy vertus and V₂ = Savoy ormskirk (1)

In alignment with the present study, Masarirambi et al. (2013) also reported in their study that application of sawdust mulch increased plant height, stem diameter, leaf area, and yield of baby savoy cabbage. The findings were again in consistent with the findings of Tiwari et al. (2003). Moreover, the results of the experiment partially support the findings of Hidayati et al. (2016).

3.5. Effect of variety on yield of Savoy cabbage

The thickness of head, head diameter, percent dry matter content of head, gross yield and marketable yield of head, and leaf yield of Savoy cabbage parameters were statistically significant in terms of different varieties. The highest thickness of head (15.58 cm), head diameter (15.05 cm), and head dry matter content (14.08 %) were found from the variety Savoy vertus. In contrast, the lowest head thickness (14.43 cm), head diameter (13.51 cm), and head dry matter content (13.31%) were recorded in the variety Savoy ormskirk (1) (Table 3). The varied performance of Savoy vertus and Savoy ormskirk (1) in yield-contributing characters might be primarily due to the genotype and phenotype of each variety influencing head development, assimilate accumulation, and dry matter partitioning, which determines their yield potential under the same growing conditions. These results are in agreement with the findings of Mosleh Ud-Deen and Islam (2023) in cabbage, and Singh et al. (2015) in broccoli.

The highest gross yield per plot (10.34 kg) and per hectare (55.17 t/ha) were recorded from the variety Savoy vertus, whereas the lowest gross yield per plot (9.56 kg) and per hectare (51.03 t) was found from variety Savoy ormskirk (1) (Table 3). The variety Savoy vertus produced the highest marketable yield per plot (8.45 kg) and per hectare (45.07 t). In contrast, the lowest yield per plot (7.65 kg) and per hectare (40.81 t) was recorded in Savoy ormskirk (1) (Table 3, Figure 9). The maximum leaf yield per plot (5.12 kg) and per hectare (27.31 t) was found from the Savoy vertus variety whereas, the minimum leaf yield per plot (3.47 kg) and per hectare (18.49 t) were recorded from the variety Savoy ormskirk (1) (Table 3, Figure 10). These results are similar to those reported by Singh et al. (2015) in cauliflower and Giri et al. (2013) in broccoli.

3.6. Effect of mulching on yield of Savoy cabbage

Significant variation was recorded in yield parameters of Savoy cabbage as affected by different mulching treatments. The highest head thickness (17.31 cm) was found from the Sawdust mulch (M3), followed by Water hyacinth (M2) (15.83 cm) and Straw mulch (M1) (14.89 cm). Similarly, the highest head diameter (16.30 cm) was found from the Sawdust mulch (M3), followed by Water hyacinth mulch (M2) (15.26 cm) and Straw mulch (M1) (14.41 cm), whereas the lowest head thickness (13.26 cm) and head diameter (12.46 cm) were recorded from the control (M0) (Table 4). Sawdust mulch showed superiority over the control in respect of percent dry matter of head. Sawdust mulch (M3) produced the highest head dry matter (16.53 %), followed by water hyacinth mulch (M2) (15.69 %), and the lowest percent dry matter of head (9.48 %) was produced by the control (M0) (Table 4). The maximum increase in yield-contributing parameters of Savoy cabbage occurs due to the creation of a favorable

soil environment. As a result, greater accumulation and translocation of photosynthates occur in the cabbage heads, producing thicker and larger heads with increased dry matter content. A similar beneficial effect of mulches on the yield of cabbage was also reported by Tiwari et al. (2003), Beshir (2017), and Verma et al. (2017). Crusciol et al. (2005) also found similar results to the present study.

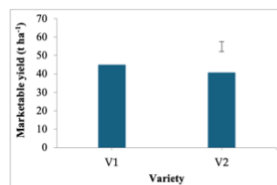


Figure 9: Effect of different varieties on marketable yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at the 1% level of probability; V1 = Savoy vertus, V2 = Savoy ormskirk (1).

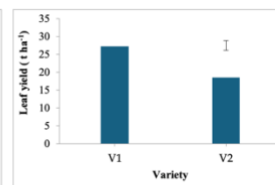


Figure 10: Effect of different varieties on leaf yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at the 1% level of probability; V1 = Savoy vertus, V2 = Savoy ormskirk (1).

The highest gross yield per plot (10.93 kg) and per hectare (58.29 t) was found from the Sawdust mulch (M3), followed by from Water hyacinth mulch (M2) (56.18 t) and from Straw mulch (M1) (54.55 t), whereas the lowest gross yield per plot (8.24 kg) and per hectare (8.24 t) was recorded from the control condition (M0) (Table 4). The highest marketable yield per plot (9.07 kg) and per hectare (48.38 t) was found from the treatment with sawdust mulch (M3), followed by Water hyacinth mulch (M2) (45.85 t) and Straw mulch (M1) (43.95 t), whereas the lowest marketable yield per plot (6.46 kg) and per hectare (34.44 t) was recorded from the control condition (M0) (Table 4, Figure 11). The highest yield of leaves per plot (6.36 kg) and per hectare (33.93 t) was found from the Sawdust (M3) mulch, followed by Water hyacinth (M2) mulch (29.03 t), whereas the lowest yield of leaves per plot (1.90 kg) and per hectare (10.12 t) was found from the control (M0) (Table 4, Figure 12).

Sawdust mulching results in higher yield of Savoy cabbage by improving water relations, nutrient uptake, and assimilate partitioning. The mulch reduces soil moisture loss and stabilizes root-zone temperature, which enhances root growth and maintains higher leaf water potential. These favors sustained stomatal opening and higher photosynthetic rate, thereby increasing yield.

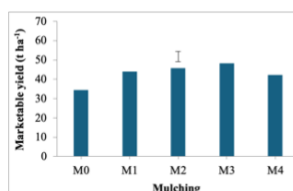


Figure 11: Effects of mulching on marketable yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at 1% level of probability; M0 = Control (No mulch), M1 = Straw, M2 = Water hyacinth, M3 = Sawdust and M4 = Black polythene.

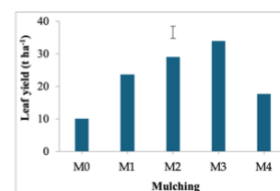


Figure 12: Effects of mulching on leaf yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at 1% level of probability; M0 = Control (No mulch), M1 = Straw, M2 = Water hyacinth, M3 = Sawdust and M4 = Black polythene.

Biswas et al. (2022) reported in their study that reduction of soil temperature by mulching at the head filling stage (51–50 DAT) may also be the reason for higher yield. The result obtained from the present experiment was similar to the findings of Farjana and Islam (2019) in cabbage.

Table 4. Effects of mulching on yield-contributing characters and yield of Savoy cabbage

Mulching	Thickness of head (cm)	Diameter of head (cm)	Fresh weight (g)	Dry weight (g)	Percent (%) dry matter of head	Gross yield plot ⁻¹ (kg)	Gross yield ha ⁻¹ (ton)	Marketable yield plot ⁻¹ (kg)	Leaf yield plot ⁻¹ (kg)
M ₀	13.26	12.46	64.50	6.79	9.48	8.24	44.10	6.46	1.90
M ₁	14.89	14.41	80.83	5.62	14.37	10.23	54.55	8.24	4.44
M ₂	15.83	15.26	66.67	4.27	15.69	10.53	56.18	8.60	5.44
M ₃	17.31	16.30	76.67	4.65	16.53	10.93	58.29	9.07	6.36
M ₄	13.73	12.97	66.50	5.36	12.41	9.82	52.38	7.89	3.32
LSD _{0.05}	0.21	0.24	1.65	0.24	0.17	0.08	0.63	0.12	0.09
Level of sig.	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust and M₄ = Black polythene

Table 5. Combined effects of variety and mulching on yield and yield-contributing characters of Savoy cabbage

Treatment combination	Thickness of head (cm)	Diameter of head (cm)	Fresh weight (g)	Dry weight (g)	Percent (%) dry matter of head	Gross yield plot ⁻¹ (kg)	Gross yield ha ⁻¹ (ton)	Marketable yield plot ⁻¹ (kg)	Leaf yield plot ⁻¹ (kg)
V1M0	13.63	12.87	68.33	6.95	9.83	8.51	45.37	6.68	2.51
V1M1	15.39	15.47	83.33	5.58	14.83	10.63	56.69	8.71	5.46
V1M2	16.56	16.10	66.67	4.11	16.22	10.96	58.46	9.00	6.32
V1M3	18.32	17.31	75.00	4.43	16.97	11.34	60.49	9.54	7.12
V1M4	14.01	13.52	76.67	6.09	12.57	10.28	54.81	8.32	4.20
V2M0	12.90	12.05	60.67	6.64	9.14	7.98	42.82	6.23	1.29
V2M1	14.39	13.36	78.33	5.67	13.90	9.83	52.41	7.77	3.42
V2M2	15.10	14.41	66.67	4.42	15.17	10.11	53.90	8.19	4.57
V2M3	16.31	15.30	78.33	4.87	16.08	10.51	56.08	8.60	5.60
V2M4	13.45	12.43	56.33	4.63	12.24	9.37	49.95	7.46	2.45
LSD _{0.05}	0.30	0.34	2.33	0.34	0.24	0.11	0.89	0.17	0.12
Level of sig.	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1), M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust and M₄ = Black polythene.

3.7. Combined effect of varieties and mulching on yield of Savoy cabbage

The combined effect of different varieties and mulching treatments showed significant variation in Savoy cabbage yield parameters. The highest head thickness (18.32 cm) was recorded in the V1M3 treatment, followed by V2M3 (16.31 cm) and V1M2 (16.56 cm), while the lowest head thickness (12.09 cm) was observed in V2M0. Results showed that the highest head diameter of Savoy cabbage (17.31 cm) was observed in V1M3, followed by V1M2 (16.10 cm), and the lowest head diameter of Savoy cabbage (12.05 cm) was observed in V2M0 (Table 5). The highest head dry matter (16.97 %) was found in the treatment combination of V1M3, followed by V1M2 (16.22 %) and V2M3 (16.08%), whereas the lowest head dry matter content (9.14 %) was found in the control V2M0 (Table 5). Sawdust mulching conserves soil moisture, regulates soil temperature, and enhances nutrient uptake, which sustains higher photosynthetic activity and efficient translocation of assimilates to the developing heads. Savoy Vertus, possessing greater sink strength and head compactness, utilizes these favorable conditions more effectively, resulting in larger, thicker heads with higher dry matter accumulation. In contrast, the absence of mulch in Savoy Ormskirk (1) leads to moisture stress and reduced assimilate availability, thereby limiting head development and dry matter content. The results of the experiment support the findings of Singh et al. (2015).

The highest gross yield per plot (11.34 kg) and per hectare (60.49 t) was recorded from the treatment combination of V1M3, followed by the treatment combination of V1M2 (58.46 t) and V1M1 (56.69 t), whereas the lowest gross

yield per plot (7.98 kg) and per hectare (42.82 t) was found from the control V2M0 (Table 5). The highest marketable yield per plot (9.54 kg) and per hectare (50.89 t) was recorded from the treatment combination of V1M3, followed by V1M2 (48.02 t/ha), whereas the lowest marketable yield per plot (6.23 kg) and per hectare (33.24 t) was found from the treatment combination of V2M0 (Table 5, Figure 13). The maximum yield of leaves per plot (7.12 kg) and per hectare (37.97 t) was obtained from the treatment combination V1M3, followed by V1M2 (33.69 t). In contrast, the lowest yield of leaves per plot (1.29 kg) and per hectare (6.88 t) resulted from the treatment combination V2M0 (Table 5, Figure 14). Savoy vertus, with Sawdust mulch responsible for greater genetic capacity for head development and dry matter accumulation, responds more efficiently to the favorable conditions. A similar result was also observed by Ramakrishna et al. (2006) and Tiwari et al. (2003) who reported that mulched plants had higher yield than plants from bare soil in cabbage.

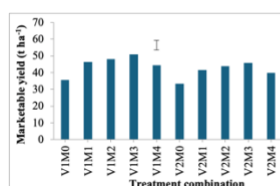


Figure 13: Combined effects of different varieties and mulching on marketable yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1) and M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust and M₄ = Black polythene.

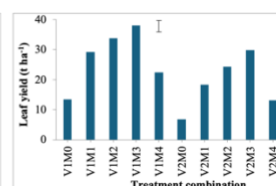


Figure 14: Combined effects of different varieties and mulching on leaf yield (t ha⁻¹) of Savoy cabbage (*Brassica oleracea* var. *sabauda*). Vertical bar indicates LSD at 1% level of probability; V₁ = Savoy vertus, V₂ = Savoy ormskirk (1) and M₀ = Control (No mulch), M₁ = Straw, M₂ = Water hyacinth, M₃ = Sawdust and M₄ = Black polythene.

4. Conclusion

This study provides the first systematic evaluation of varietal adaptability and both organic and inorganic mulching regimes for Savoy cabbage (*Brassica oleracea* var. *sabauda*) production in Bangladesh. Both main and interaction effects of variety selection and mulching material significantly influenced vegetative and yield components. 'Savoy Vertus' (V₁) exhibited superior genetic adaptability over 'Savoy Ormskirk (1)' (V₂), producing larger canopy architectures and higher head yields. Among the evaluated mulching practices, organic mulches consistently surpassed the unmulched control and synthetic black polyethylene. Sawdust mulching (M₃) emerged as the most effective agronomic treatment, yielding the maximum marketable productivity by optimizing topsoil moisture retention. The treatment combination V₁M₃ ('Savoy Vertus' + sawdust mulch) achieved the highest overall agronomic performance, recording peak values for plant height (52.75cm), leaf count (27.33 leaves plant⁻¹), head dry matter content (16.97%), leaf yield (37.97 t ha⁻¹), and gross head yield (60.49t ha⁻¹), with a peak marketable head yield of 48.38 t ha⁻¹. Conversely, unmulched 'Savoy Ormskirk' (V₂M₀) resulted in the lowest yield metrics across all evaluated criteria (42.82 t ha⁻¹ gross head yield). Consequently, integrating the 'Savoy Vertus' cultivar with locally sourced sawdust mulching represents an efficient, sustainable agronomic practice for the successful acclimatization and yield optimization of Savoy cabbage. Adopting this package offers a viable pathway to improve grower profitability, diversify winter vegetable production systems, and contribute to nutritional security in Bangladesh. As Savoy cabbage is European winter vegetable and a new crop in Bangladesh so various further research needed including planting time, fertilizer application, spacing, seed production, etc. are recommended for its cultivation in Bangladesh.

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Authors contribution

All listed authors significantly contributed to the work both intellectually and directly, and have given their approval for its publication.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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