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Performance Evaluation of English Cabbage Varieties for Main Season Production in Fiji

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

English cabbage (*Brassica oleracea* var. *capitata*) is an important vegetable crop in Fiji, playing a significant role in local food security and the livelihoods of farmers. However, there is limited information available on the adaptability and performance of different cabbage varieties under the main season growing conditions in Fiji. A study was conducted to evaluate the performance of six English cabbage varieties under field conditions in Fiji, assessing variability in germination, growth, maturity, morphological traits, and yield during the main growing season. The aim was to identify high-performing and adaptable cultivars suitable for local cultivation. The experiment consisted of six varietal treatments arranged in a randomized complete block design with four replicates under field conditions. The results showed significant differences ($p < 0.05$) among varieties for germination percentage, days to 50% heading, days to maturity, and most vegetative and yield components. Germination ranged widely from 30.07 % to 91.31 %, with V4 (Taiwan 228), V1 (FS Cross), and V6 (Taiwan No. 2) showing the highest establishment. Days to 50% heading and maturity also

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varied significantly, indicating clear differences in crop duration among varieties. Morphological traits such as plant height, plant width, leaf number, and leaf damage showed significant variation, reflecting strong genetic influence. Yield performance differed markedly, with V6 (Taiwan No. 2) producing the highest head weight (3.39 kg) and yield per hectare (52.04 t/ha), followed by V5 (Taiwan 493) and V4 (Taiwan 228). The V6 (Taiwan No. 2) variety demonstrated superior and stable performance, making it the most suitable variety for cultivation under the given conditions.

Keywords: Brassica oleracea; varietal evaluation; yield performance; adaptability; horticulture; Fiji.

1. Introduction

English cabbage (*Brassica oleracea* var. *capitata*) is one of the most widely cultivated and consumed leafy vegetables worldwide due to its nutritional value, versatility, and economic importance (Samec et al., 2017). It is an excellent source of vitamins A, C, and K, dietary fiber, minerals, and antioxidants that contribute to improved human health and nutrition (Wang et al., 2022). In Fiji, cabbage is an important vegetable crop commonly grown by both smallholder and semi-commercial farmers to meet the increasing demand from local markets, hotels, supermarkets, and the tourism industry. The crop plays a significant role in income generation, employment creation, and strengthening food and nutritional security within the horticultural sector (MOAW, 2020). The production of English cabbage in Fiji is influenced by several environmental factors, including temperature, rainfall, soil fertility, pest incidence, and seasonal variability (Fink et al., 2013). Although cabbage generally performs well under cool to moderate climatic conditions, the tropical environment of Fiji presents challenges such as excessive rainfall, high humidity, pest and disease pressure, and fluctuating temperatures during the main growing season (Cervenski et al., 2022). These conditions can significantly affect plant growth, head formation, yield, and market quality. Consequently, selecting suitable and adaptable cabbage varieties is essential for achieving stable production and improving farm profitability.

Varietal evaluation is an important approach for identifying cultivars with superior agronomic performance, adaptability, and tolerance to local production constraints (Kabululu et al., 2017). Different cabbage varieties may vary considerably in growth characteristics, maturity period, head size, compactness, yield potential, and resistance to pests and diseases (Narwariya et al., 2023). Therefore, evaluating introduced and locally available varieties under Fiji's agro-climatic conditions is necessary to determine their suitability for commercial cultivation. Reliable varietal performance data can support farmers, researchers, extension officers, and seed suppliers in making informed decisions regarding cultivar selection and crop management practices. Despite the increasing importance of vegetable production in Fiji, limited research has been conducted on the comparative performance of English cabbage varieties under main season field conditions. Most farmers continue to rely on a few commonly available cultivars without adequate information on their adaptability, productivity, and market performance. This may contribute to inconsistent yields and reduced production efficiency. Identifying high-performing varieties suitable for local conditions could enhance productivity, improve crop resilience, and support sustainable vegetable production systems in Fiji (Saxena et al., 2026).

The study was undertaken to evaluate the growth, yield, and overall performance of selected English cabbage varieties during the main production season in Fiji. This study is important for the scientific and farming communities because it provides baseline information on the adaptability and performance of English cabbage varieties under Fiji's tropical field conditions. Fiji. The findings are expected to contribute to the development of sustainable cabbage production systems by identifying varieties with improved growth, yield, and market potential. Furthermore, the study will support future horticultural research, varietal improvement programs, and evidence-based recommendations for farmers and extension services aimed at enhancing year-round vegetable production and food security in Fiji.

2. Materials and Methods

2.1 Study Area Description

An experimental trial was carried out at the Sigatoka Research Station (SRS) in Nadroga-Navosa Province, located to the South-Western part of Viti Levu, Fiji, during the 2025 cropping season, which spanned from July to October. The research site is at an elevation of 11 meters above mean sea level (m amsl), with coordinates 18°06'11.70" S latitude and 177°32'16.32" E longitude, approximately 130 km from Suva, the capital city (Fig. 1). The area experiences distinct wet and dry seasons, with the rainy season lasting from November to April and the dry season from May to October. The average annual rainfall is 1,831 mm, and temperatures range from a minimum of 18 °C to a maximum of 31 °C. Relative humidity averages is 80 % and ranges between 70 % and 80 %. The alluvial flats are primarily dedicated to horticultural research, involving a diverse range of field crops, vegetables, fruits, and nuts. Vegetable and field crops studied include tomatoes, beans, carrots, lettuce, cauliflower, cabbage, chillies, pumpkins, melons, maize, potatoes and sorghum. Fruit and nut crops include pawpaw, mango, avocado, citrus, passion fruit, nuts, and coconut. The hill country features rolling, hilly, and steep land used for research on goats, cattle, poultry, pasture species and other livestocks. A significant portion of the station consists of alluvial flats characterized by Fluventic and *Cumulic Haplustolls*, as well as *Tropic Fluvaquents* soils, which are utilized for horticultural and cropping trials.

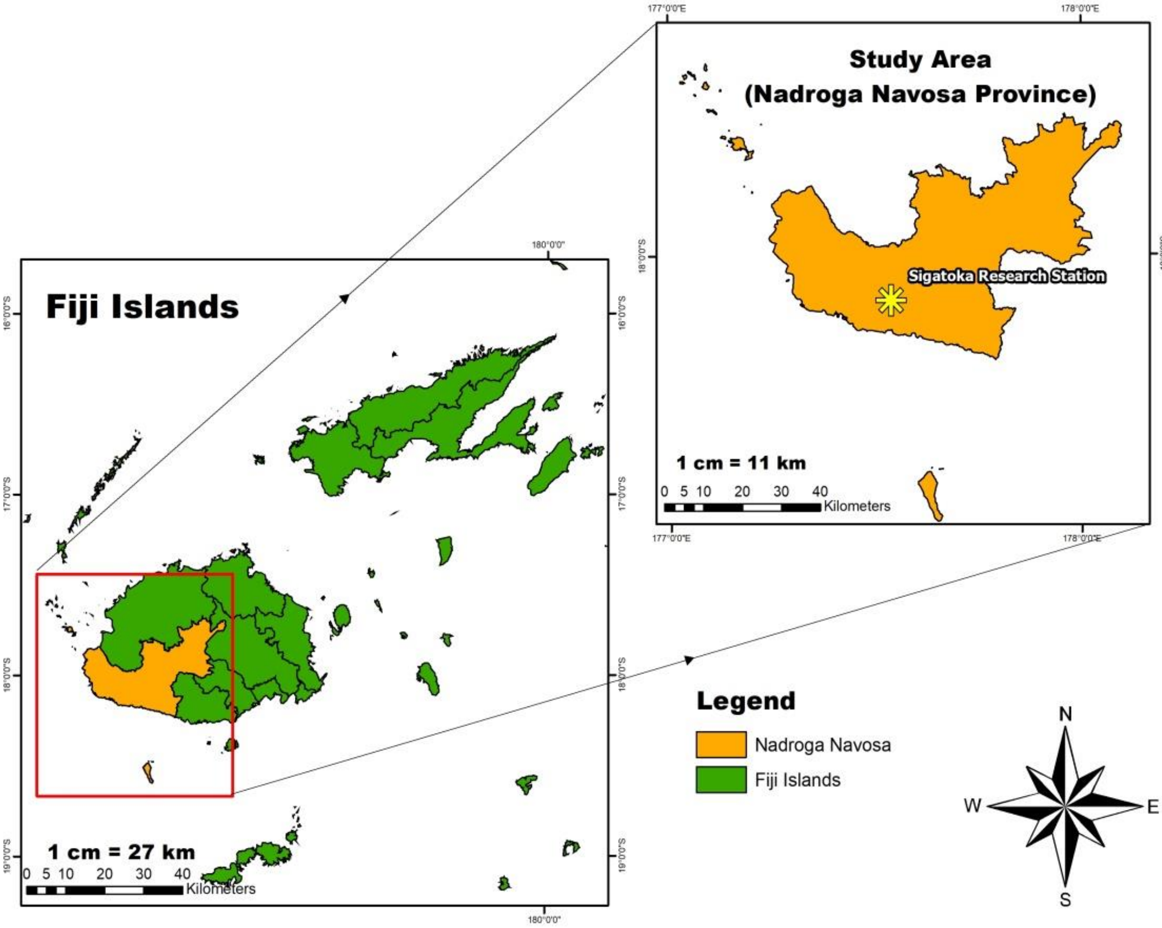


Fig. 1. Map of the study area

2.2 Experimental Design and Layout

The experiment was conducted at Field #04 of SRS, Fiji, to evaluate the performance of selected English cabbage varieties for offseason production under local environmental conditions. The study was laid out using a Randomized Complete Block Design (RCBD) with four replications. Six English cabbage varieties, namely FS Cross, KK Cross, Golden Acre, Taiwan 228, Taiwan 493, and Taiwan No. 2, were used as treatments. Each replication contained all six varieties randomly assigned within the block, resulting in a total of 24 plots. Individual plot size measured 1 m × 5 m, while the total trial area covered 245 m² (35 m × 7 m). Land preparation involved two ploughings, two harrowings, and one rotovation to achieve a fine seedbed suitable for transplanting seedlings. Recommended rates of N.P.K @200kg/ha fertilizer and urea @100kg/ha were applied throughout the growing period. Irrigation was initially carried out manually, while soaker hoses were later installed to improve water management. Weed control was achieved through manual hand weeding and the use of a brush cutter when necessary. Insect pests were managed using *Bacillus thuringiensis* (Bt), Fipronil and Spinosad, while Mancozeb was applied for disease control. Hilling was conducted two weeks after transplanting by topping up soil around the base of the plants to enhance plant stability and root development. Growth, yield, and other agronomic parameters were assessed to determine the most suitable English cabbage variety for offseason production in Fiji.

2.3 Data Collection

Data were collected at two growth stages, namely the seedling stage and maturity stage. At the seedling stage, germination % was recorded for each cabbage variety by calculating the proportion of seeds that successfully germinated relative to the total number of seeds sown. At the maturity stage, days to 50% heading and days to maturity from transplanting, which were used to assess earliness and crop duration. Morphological traits such as plant height (cm), plant width (cm), number of leaves per plant, and number of leaves damaged were recorded to determine vegetative growth and plant health. Yield and head quality characteristics were also measured, including head weight (kg), head height (cm), and head diameter (cm). In addition, yield per plot (kg) was recorded and subsequently converted to yield per hectare (t/ha) to allow comparison of productivity across varieties under field conditions.

2.4 Data Analysis

All statistical analyses were performed using R software version 4.2.0 (R Core Team, 2022). Data were subjected to analysis of variance (ANOVA) to determine significant differences among cabbage varieties for the measured traits. Where significant differences were detected, mean separation was carried out using Tukey's Honest Significant Difference (HSD) test at the 5% level of significance ($p \leq 0.05$). Significant differences among means are indicated using letter groupings, where means sharing the same letter are not significantly different.

3. Results and Discussion

3.1 Results

3.1.1 Germination Percentage, Earliness and Crop Duration of English Cabbage Varieties

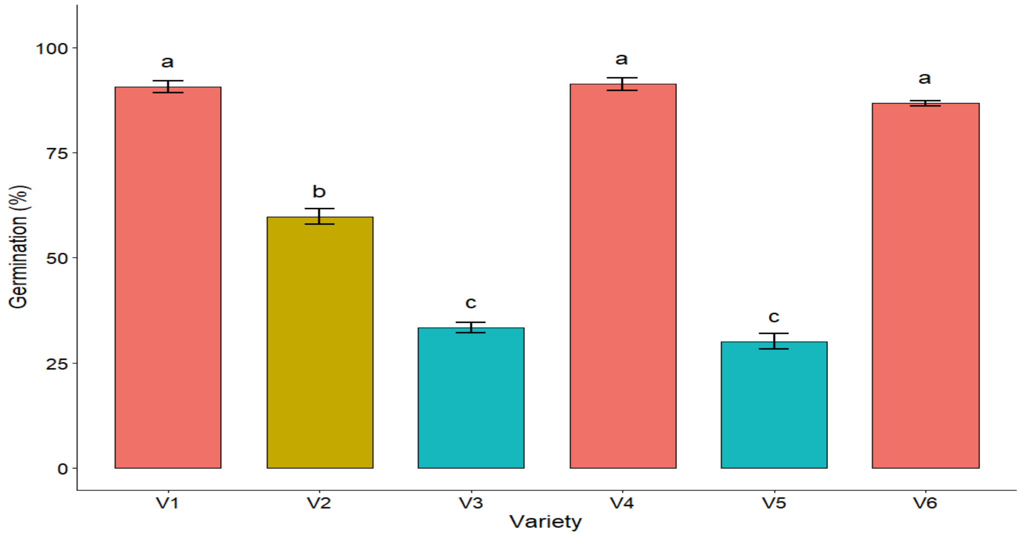
Significant differences ($p < 0.05$) were observed among the English cabbage varieties for Germination %, days to 50% heading and days to maturity (Table 1). Among the six varieties, V4 (Taiwan 228) recorded the highest germination percentage (91.31 %), which was statistically similar to V1 (FS Cross) (90.63 %) and V6 (Taiwan No. 2) (86.72 %). In contrast, V2 (KK Cross) showed a moderate germination percentage of 59.78 % and was significantly lower than the top-performing varieties. The lowest germination percentages were observed in V3 (Golden Acre) (33.34 %) and V5 (Taiwan 493) (30.07 %). Days to 50% heading ranged from 33 days to 46 days. The earliest heading was recorded in V3 (Golden Acre) (33 days), followed by V6 (Taiwan No. 2) (36 days), which were statistically different from the remaining varieties. The latest heading occurred in V4 (Taiwan 228) (46 days). Intermediate performance was observed in V1 (FS Cross), V2 (KK Cross), and V5 (Taiwan 493), which ranged between 40–42 days. Similarly, days to maturity varied significantly among varieties, ranging from 64 days to 82 days. V3 (Golden Acre) reached maturity earliest (64 days), followed by V6 (69 days) and V1 (70 days). The longest duration to maturity was recorded in V4 (Taiwan 228) (82 days), while V2 (77 days) and V5 (79 days) showed intermediate maturity periods. The results indicate clear varietal differences in crop duration (Fig. 2).

3.1.2 Morphological Growth Performance of English Cabbage Varieties

Significant variation ($p < 0.05$) was observed among the English cabbage varieties for all measured morphological traits, including plant height, plant width, number of leaves, and number of leaves damaged (Table 2). Plant height ranged from 24.3 cm to 32.3 cm (Fig. 3). The tallest plants were recorded in V5 (Taiwan 493) (32.3 cm), followed closely by V1 (FS Cross) (31.2 cm) and V6 (Taiwan No. 2) (31.0 cm), which were statistically similar. The shortest plants were observed in V3 (Golden Acre) (24.3 cm). Plant width varied from 25.3 cm to 29.8 cm, with V4 (Taiwan 228) recording the widest plants (29.8 cm), followed by V6 (28.9 cm). The narrowest plants were observed in V3 (25.3 cm). The number of leaves per plant ranged from 8 to 13. V4 (Taiwan 228) produced the highest number of leaves (13), while V2 (KK Cross) had the lowest leaf count (8). Intermediate values were recorded in the remaining varieties (Fig. 4). Leaf damage also differed among varieties, ranging from 2 to 5 damaged leaves per plant. V3 (Golden Acre) recorded the highest leaf damage (5), whereas V5 (Taiwan 493) showed the lowest damage level (2).

Table 1. Germination %, Days to 50% Heading and Days to Maturity of Different English Cabbage Varieties

Varieties	Germination %	Days to 50% Heading	Days to Maturity
V1 (FS Cross)	90.63 ± 1.40a	42 ± 0.65c	70 ± 0.87b
V2 (KK Cross)	59.78 ± 1.84b	40 ± 0.41c	77 ± 1.78c
V3 (Golden Acre)	33.34 ± 1.30c	33 ± 0.65 a	64 ± 1.58a
V4 (Taiwan 228)	91.31 ± 1.48a	46 ± 0.65d	82 ± 2.16d
V5 (Taiwan 493)	30.07 ± 1.83c	41 ± 0.41c	79 ± 2.16c
V6 (Taiwan No. 2)	86.72 ± 0.59a	36 ± 0.41b	69 ± 2.53b



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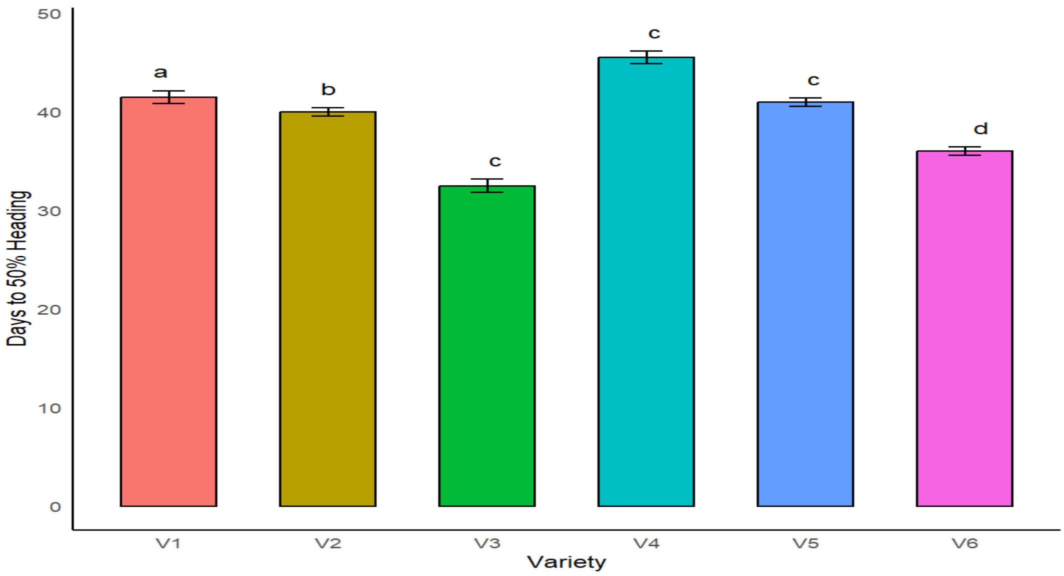

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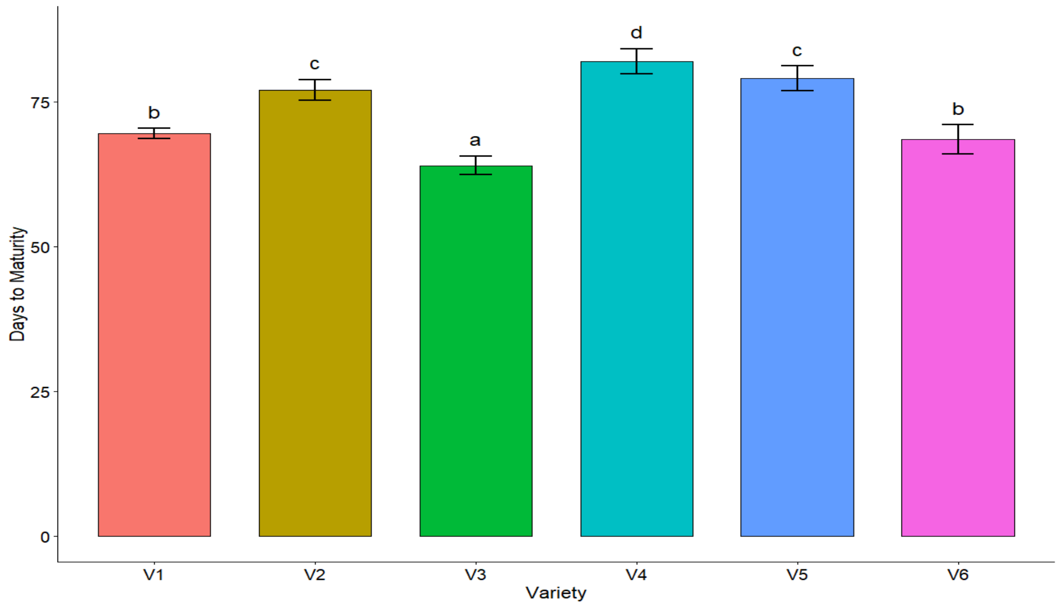
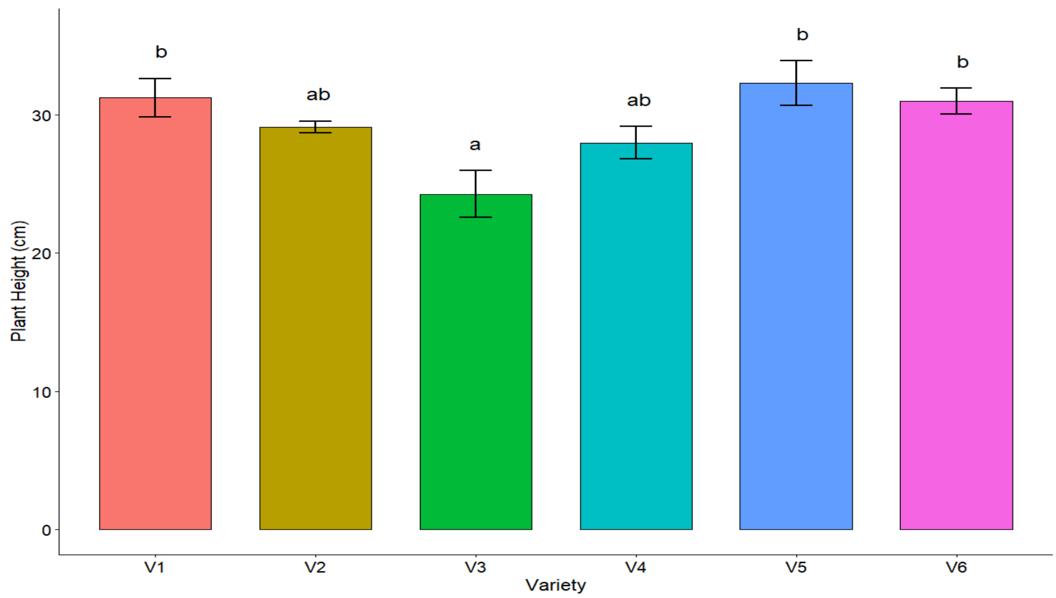


(c)

Fig. 2. Germination % (a), Comparison of Days to 50% Heading (b) and Days to Maturity (c) across English Cabbage Varieties

Table 2. Morphological Traits of Different English Cabbage Varieties

Varieties	Plant Height (cm)	Plant Width (cm)	No. of Leaves	No. of Leaves Damaged
V1 (FS Cross)	31.2 ± 1.40b	27.0 ± 1.48b	11 ± 2.68b	3 ± 1.11b
V2 (KK Cross)	29.1 ± 0.43ab	27.1 ± 2.61ab	8 ± 1.55ab	3 ± 1.03ab
V3 (Golden Acre)	24.3 ± 1.70a	25.3 ± 1.26a	11 ± 0.85a	5 ± 0.48a
V4 (Taiwan 228)	28.0 ± 1.17ab	29.8 ± 1.44ab	13 ± 0.25ab	4 ± 0.48ab
V5 (Taiwan 493)	32.3 ± 1.62b	26.6 ± 0.62b	10 ± 1.60b	2 ± 0.65b
V6 (Taiwan No. 2)	31.0 ± 0.94b	28.9 ± 0.27b	12 ± 0.25b	4 ± 1.47b



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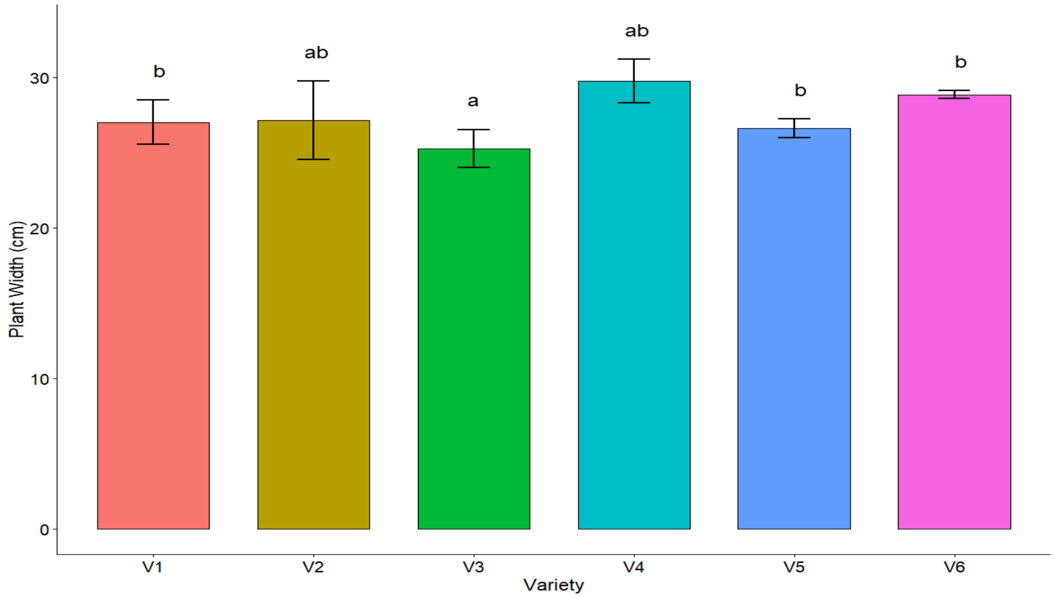


(b)

Fig. 3. Comparison of Plant Height (cm) [a] and Plant Width (cm) [b] across English Cabbage Varieties

3.1.3 Yield Performance of English Cabbage Varieties

Significant variation ($p < 0.05$) was observed among the English cabbage varieties for head weight and yield per plot and per hectare, while differences in head height and head diameter were not statistically significant (Table 3). Head weight ranged from 1.51 kg to 3.39 kg. The highest head weight was recorded in V6 (Taiwan No. 2) (3.39 kg), followed by V5 (Taiwan 493) (3.12 kg), and V4 (Taiwan 228) (2.87 kg), which were statistically similar in some cases (Fig. 5). The lowest head weight was observed in V3 (Golden Acre) (1.51 kg). Head height ranged from 12.0 cm to 14.4 cm, with V3 (Golden Acre) recording the highest value (14.4 cm), while V2 (KK Cross) and V5 (Taiwan 493) recorded the lowest (12.0 cm and 12.0 cm, respectively). Head diameter varied from 19.2 cm to 22.6 cm, with V2 (KK Cross) producing the widest heads (22.6 cm), while V1 (FS Cross) had the smallest diameter (19.2 cm). Yield per plot ranged from 17.65 kg to 26.02 kg (Fig. 6). The highest yield was recorded in V6 (Taiwan No. 2) (26.02 kg), followed by V5 (24.05 kg) and V2 (23.49 kg). The lowest yield per plot was observed in V3 (Golden Acre) (17.65 kg) and V1 (17.76 kg). Similarly, yield per hectare ranged from 35.30 t/ha to 52.04 t/ha, with V6 (Taiwan No. 2) achieving the highest yield (52.04 t/ha), while V3 (Golden Acre) recorded the lowest (35.30 t/ha).

Table 3. Yield traits of different english cabbage varieties

Varieties	Head Weight (kg)	Head Height (cm)	Head Diameter (cm)	Yield Per Plot (kg)	Yield (t/ha)
V1 (FS Cross)	2.41 ± 0.39a	12.8 ± 0.93a	19.2 ± 2.16a	17.76 ± 1.55c	35.53 ± 3.11c
V2 (KK Cross)	2.79 ± 0.29ab	12.0 ± 0.43a	22.6 ± 1.24a	23.49 ± 2.74b	46.98 ± 5.48b
V3 (Golden Acre)	1.51 ± 0.54b	14.4 ± 1.60a	22.4 ± 2.27a	17.65 ± 3.57c	35.30 ± 7.14c
V4 (Taiwan 228)	2.87 ± 0.15ab	14.1 ± 1.56a	19.9 ± 2.29a	21.70 ± 1.46b	43.39 ± 2.91b
V5 (Taiwan 493)	3.12 ± 0.10a	12.0 ± 0.33a	21.6 ± 0.43a	24.05 ± 0.40b	48.10 ± 0.79b
V6 (Taiwan No. 2)	3.39 ± 0.26a	13.9 ± 1.60a	21.8 ± 2.06a	26.02 ± 1.80a	52.04 ± 3.60a

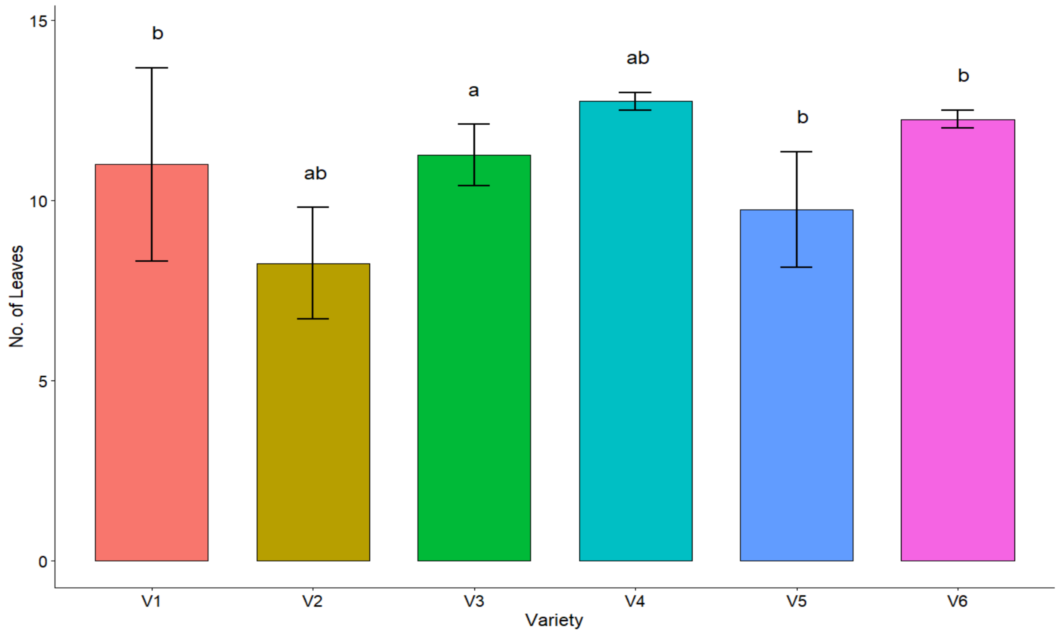
3.2 Discussion

3.2.1 Varietal Differences in Germination, Heading and Maturity of English Cabbage

The significant differences observed in germination percentage among the cabbage varieties may be attributed to genetic variability and seed vigor characteristics of each variety (Yadav et al., 2025). Varieties V1 (FS Cross), V4 (Taiwan 228), and V6 (Taiwan No. 2) exhibited superior germination performance, indicating better seed viability and adaptability under the prevailing experimental conditions. High germination percentages are desirable because they ensure uniform crop establishment and better field performance during the early growth stages (Farooq et al., 2019; Lamichhane and Soltani, 2020). The moderate germination observed in V2 (KK Cross) suggests that this variety possesses intermediate seed vigor compared to the higher-performing varieties. Environmental factors such as moisture availability, temperature, and seed physiological condition could also have influenced germination performanc (Ceccato et al., 2015). The poor germination percentages recorded in V3 (Golden Acre) and V5 (Taiwan 493) may indicate lower seed viability, dormancy issues, or reduced tolerance to the experimental conditions. Low germination can negatively affect plant population establishment and ultimately reduce crop productivity (Reed et al., 2022). Similar varietal differences in seed germination have been reported in cabbage and other vegetable crops, where genetic makeup and seed quality strongly influence germination behavior and seedling establishment (Pavlović et al., 2019; Finch-Savage, 2020; Sikder et al., 2025). The observed variation in days to 50% heading and maturity among cabbage varieties reflects genetic differences in growth rate and developmental patterns. Early heading in V3 (Golden Acre) and V6 (Taiwan No. 2) suggests that these varieties have faster vegetative development and are more suitable for short-season production systems or markets requiring quick turnover. Early maturing varieties are often preferred in intensive cropping systems as they allow timely land preparation for subsequent crops (Saxena et al., 2019). In contrast, the delayed heading and maturity observed in V4 (Taiwan 228), V2 (KK Cross), and V5 (Taiwan 493) may be associated with prolonged vegetative growth, which can contribute to larger biomass accumulation but also extends the cropping period (Egli, 2011). Such varieties may be advantageous in situations where extended field duration is not a limitation and where higher yield potential is prioritized over earliness. The intermediate performance of V1 (FS Cross) suggests moderate adaptability, making it suitable for general production conditions.

3.2.2 Varietal Differences in Morphological Growth Characteristics of English Cabbage

The observed variation in morphological traits among cabbage varieties indicates strong genetic influence on vegetative growth performance (Shi et al., 2021; Ozer et al., 2023). Taller plants in V5 (Taiwan 493), V1 (FS Cross), and V6 (Taiwan No. 2) suggest better vertical growth potential, which may be associated with improved biomass accumulation. However, excessive plant height alone does not necessarily translate to higher yield, as balance with head formation is critical in cabbage (Sundaresh, 2019; Liu et al., 2024). Wider plant spread observed in V4 (Taiwan 228) suggests a more expansive canopy structure, which may enhance photosynthetic capacity due to greater leaf area exposure. However, wider plant architecture may also increase competition for space under high-density planting conditions (Burgner et al., 2020).



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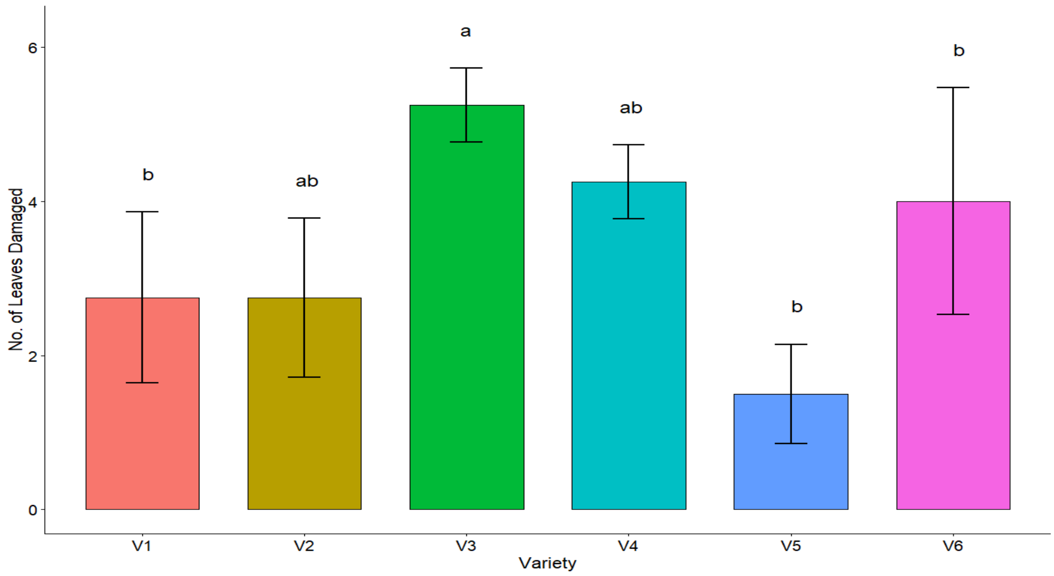

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Fig. 4. Comparison of No. of Leaves (a) and No. of Leaves Damaged (b) across English Cabbage Varieties

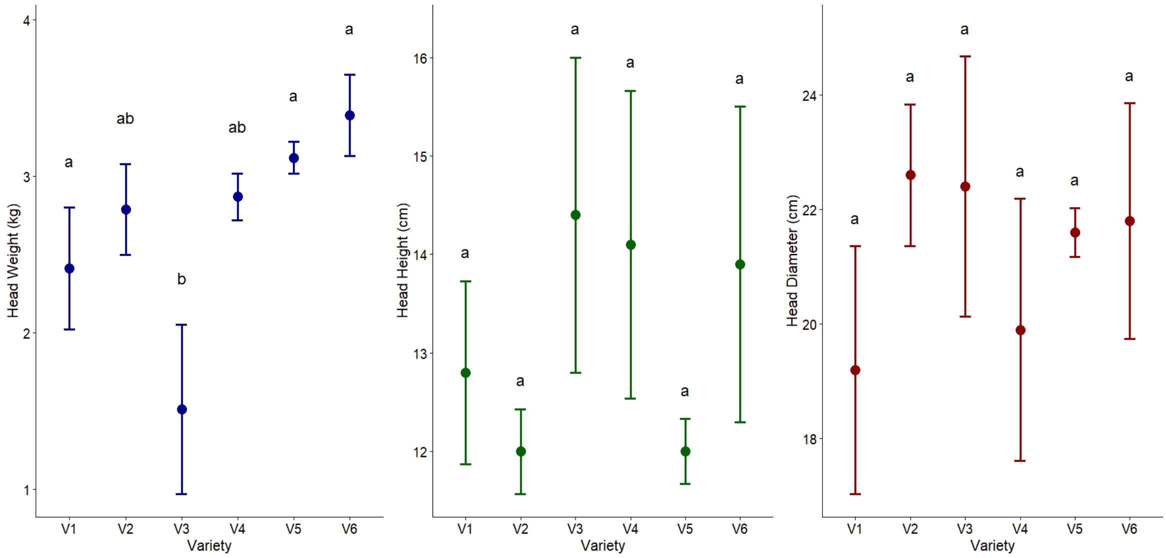

Fig. 5. Head Weight (kg), Head Height (cm), and Head Diameter (cm) of Different English Cabbage Varieties

Leaf production is an important indicator of vegetative vigor, and the higher leaf number in V4 (Taiwan 228) suggests strong vegetative development, which may support better head formation (Virk et al., 2020). In contrast, the lower leaf number in V2 (KK Cross) may indicate relatively slower vegetative growth or a more compact growth habit. Leaf damage variation among varieties reflects differences in tolerance to environmental stress or pest pressure (Tooker and Frank, 2012; Koch et al., 2016). The higher damage observed in V3 (Golden Acre) suggests lower resistance or weaker adaptability under field conditions, while lower damage in V5 (Taiwan 493) indicates better field resilience.

3.2.3 Varietal Differences in Yield Characteristics of English Cabbage

The significant variation in yield performance among cabbage varieties highlights the strong influence of genetic factors on productivity under field conditions (Polupan et al., 2019; Hafeez et al., 2025). The superior head weight and yield performance of V6 (Taiwan No. 2) suggest strong assimilate partitioning towards head development, making it a highly productive variety under the experimental conditions (Wang et al., 2023). Similarly, V5 (Taiwan 493) and V4 (Taiwan 228) also demonstrated high yield potential, indicating their suitability for commercial production systems. Although head height and head diameter did not differ significantly among varieties, numerical differences suggest variability in head compactness and structure, which may still influence market preference and consumer acceptability. For example, wider heads in V2 (KK Cross) may be more visually appealing, while moderate-sized heads with higher weight in V6 may indicate better head density. The lower yield observed in V3 (Golden Acre) is likely associated with its reduced head weight and overall vegetative vigor, as also reflected in earlier growth parameters (Chatterjee, 2014). This suggests that early maturing varieties may not always translate into higher yield potential compared to medium or late maturing types. The results indicate that V6 (Taiwan No. 2) is the most promising variety for yield performance, followed by V5 (Taiwan 493), making them suitable candidates for improved cabbage production in similar agro-climatic conditions.

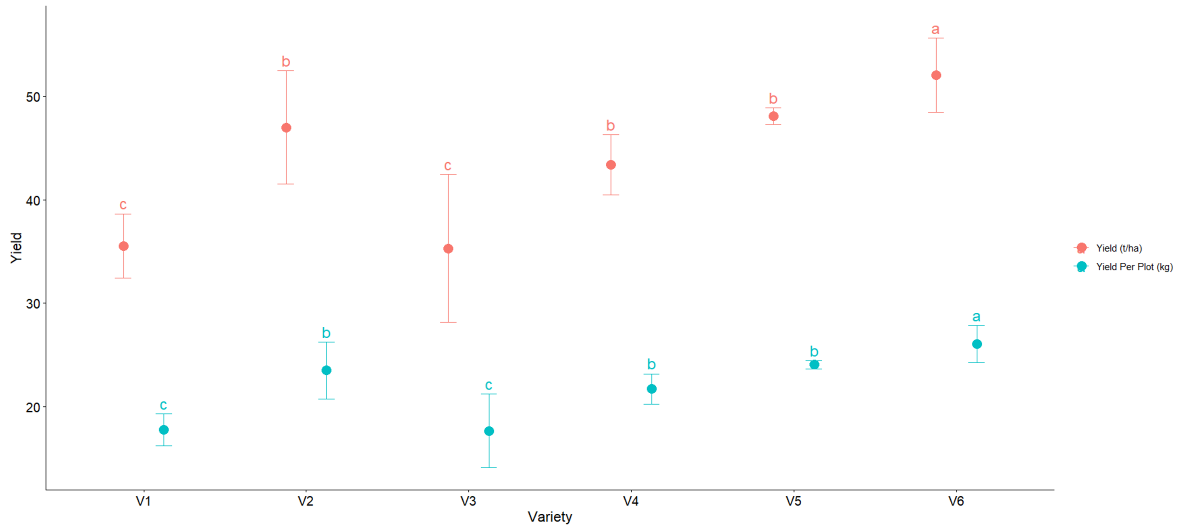

Fig. 6. Comparison of Mean Yield Per Plot (kg) and Yield (t/ha) of Different English Cabbage Varieties

4. Conclusion

In conclusion, the English cabbage varieties exhibited significant genetic variability in germination, growth, maturity, morphological traits, and yield performance. Although V4 (Taiwan 228) and V1 (FS Cross) showed excellent germination and strong vegetative growth, these advantages did not consistently translate into superior yield. V6 (Taiwan No. 2) demonstrated the most favorable and stable performance across key agronomic traits, particularly in head weight and yield per hectare, indicating its strong suitability for commercial cultivation in the study environment. In contrast, V3 (Golden Acre) and V5 (Taiwan 493) performed poorly in establishment and yield-related traits, suggesting limited adaptability. These findings highlight the importance of varietal selection in optimizing cabbage productivity under local growing conditions.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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