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Evaluating The Efficacy of Slow-Release Fertiliser on Growth Performance for One Time Fertilisation of Sweet Corn

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Abstract: Excessive use of fertilisers to boost crop productivity often leads to nutrient loss and environmental degradation. Inefficient fertilizer use and insufficient agricultural labour also become an obstacle for sweet corn production especially in the highland area. To improve the efficiency of inorganic fertiliser, the use of control-release fertiliser (CRF) is designed to minimise nutrient loss into soil. This study aimed to evaluate the efficiency of control release fertiliser on growth and yield performance of sweet corn in a field experiment. The experiment was arranged in a randomized completely block design with four replications and five treatments. T1: control, T2: NPK 15:15:15, applied in three splits at 15, 30 and 40 days (75 gram per plant (g/plant)); T3: CRF at 3g/plant, 15 days after transplanting (DAT), T4: CRF at 4 g/plant, 15 DAT and T5: CRF at 5 g/plant, 15DAT. The results indicated that control release treatment performed comparably to conventional fertilisers in promoting vegetative growth, despite requiring only a single application. Notably, T4 produced significantly higher yield, 35.5% greater than the conventional fertilisers. These findings demonstrate that control release fertiliser can enhance corn productivity while reducing labor inputs and application frequency, offering more efficient and sustainable alternatives for fertiliser management in high land areas.

Keywords: control release fertiliser, plant growth, crop yield, sweet corn

1.0 Introduction

The world's growing population is anticipated to reach approximately 9.7 billion by 2050, effectively doubling current food demand (Food and Agriculture Organization [FAO], 2024). The Food and Agriculture Organization (FAO) of the United Nations (UN) estimates that global food production must increase by nearly 70% by 2050 (Boutriouia et al., 2024). Combined with rapid urbanization, climate changes, land degradation, water scarcity, and the depletion of natural resources, making global food security and sustainability increasingly critical. Consequently, enhancing agricultural productivity is a key strategy to meeting food demands while minimizing environmental degradation. Among the various inputs of crop production, fertiliser application remains one of the most influential agronomic inputs in increasing crop yields and sustaining intensive cropping systems (Noorsuhaila et al., 2024). Fertilisers are commonly applied in large quantities to support high-yielding varieties and intensive cultivation. The FAO reported that global agricultural consumption of inorganic fertilisers reached approximately 185 million tonnes (Mt) in 2022, with an average application rate of 133 kg per hectare (kg/ha) (FAO, 2025). In Malaysia, fertiliser usage is significantly higher than the global average, with recorded at 1,612.1 kg/ha of arable land, reflecting the country's heavy reliance on chemical fertilisers to sustain high crop productivity and meet increasing food demands. Malaysian inorganic fertiliser market was valued at USD 2.18 billion in 2024 and is projected to grow to USD 4.81 billion by 2032 (Verified Market Research, 2025). This

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growth is driven by increasing demand for both staple and high-value crops such as maize, rice, fruits, and vegetables which require intensive nutrient management for optimal production. However, prolonged and excessive consumption of inorganic fertiliser can lead to a deterioration in soil fertility due to nutrient losses through leaching, runoff and volatilization (Priya et al., 2024).

Approximately 40 to 70 % of nitrogen (N), 80 to 90 % of phosphorus (P), and 50 to 70 % of potassium (K) are lost to the environment due to leaching, denitrification, and volatilizing contributing to climate change and environmental population (Himmah et al., 2018; Ji et al., 2022; Rahman et al., 2021). Furthermore, crops assimilate only 50 to 60 % of the applied N and K, and 10 to 20 % of P in the first year, with an additional 1 to 2 % reduction in the following years indicating the low use efficiency of applied fertiliser (Kassem et al., 2024; Xiang et al, 2017). A recent meta-analysis covering studies from 1980 to 2024 revealed that long term N fertiliser application significantly accelerates soil acidification (Zhang et al, 2024). Previous studies have shown that prolonged and excessive application of chemical fertilisers adversely affects soil health by altering its chemical composition, physical properties, and biological functions (Dikir, 2023). Such adverse effects often trigger osmotic stress in seeds and roots systems leading to reducing crop productivity, contributing to soil compaction and degradation (Geisseler and Scow, 2014). Proper management of fertilisers is crucial in sustainable agriculture intensifications that aim at bringing economic and environmental benefits. Therefore, improving fertiliser use efficiency is essential to increase nutrient use efficiency and maximise crop productivity.

One approach to reduce nutrient losses is through the application of control release fertiliser (CRF), which releases the rate of nutrients gradually at the desired rate or concentration level to the soil for a longer period. According to the European Standardisation Committee Task Force (CEN), the nutrient release of control release fertilisers should be slower and more gradual compared to conventional fertilisers, ensuring synchronisation with crop nutrient demand. Control release fertiliser is physically prepared by coating granules of conventional fertilisers with various materials that generally forms a physical barrier that breaks down the nutrient dissolution rate into soil (Dong et al., 2016). This process helps prevent fertiliser loss by making most fertiliser available to the plants on time during their growth and improves crop yields per unit of fertilizer used (Priya et al, 2024). Thereby, applying CRF is considered a best management practice tool for enhancing crop production, minimising environmental hazards, and improving nutrient use efficiency (Chaudhary et al, 2023). Moreover, it can reduce fertiliser application rates by 20 to 30 % compared to conventional fertilisers, making them more sustainable to the environment (Noorsuhaila et al., 2024).

Additionally, in the context of socio-economic changes, the use of CRF offers economic advantages for smallholder farmers by reducing frequency of fertiliser application, labor requirement, time saving, and lowering energy inputs (Haryati et al., 2021; Haryati et al., 2022). Several studies have emphasized the potential of CRF to overcome labor constraints while at the same time improving farm efficiency (Vejan et al., 2021; Mohd Hadi Akbar et al., 2024). Nevertheless, the effectiveness of CRF is often influenced by various factors, including soil properties, climate conditions, crop varieties, and management practices particularly in highland ecosystems. The variability in nutrient release rates under field conditions can lead to unpredictable agronomic outcomes, making challenges in integrating its application with local agroecological conditions for optimal nutrient use efficiency (Feng et al., 2021). In this study sweet corn (Zea mays L.) was selected as the test crop due to its wide cultivation in Malaysia and its relatively low susceptibility to nutrient deficiencies under optimal conditions (MARDI, 2005; Noorsuhaila et al., 2024). This study focuses on assessing the growth and yield performance of sweet corn under highland field conditions using different rates of CRF compared to conventional compound fertiliser. The objective of this study is to evaluate the efficiency of CRF on growth and yield performance of sweet corn in meeting the nutritional requirements of sweet corn during growth stages, and ultimately to promote sustainable sweet corn production.

2.0 Materials and methods

2.1 Site preparation

The field trial was conducted in an open field at Malaysian Agricultural Research and Development Institute (MARDI) Station in Cameron Highland, Pahang, Malaysia. The sweet corn variety 'Pearl B-75' was sown 14 days before transplanting. The sweet corn seedling was grown in a rain shelter and raised in polystyrene containers. The seedlings were transplanted manually at the age of 14 days with four developed leaves. The size of each bed was 4m × 1m. Each bed had two rows 75 cm apart and each plant was 25 cm apart which contained 24 plants per bed. Each planting hole had 1 seedling. Drip irrigation was used to water the plants two times in a day. Ground magnesium limestone (GML) was applied 21days before transplanting. Weeds were controlled with a preemergence application of atrazine (2-chloro-4-ethylamino-6 isopropylamino-s-triazine) at 2 liter/hectare (L/ha) and Metachlor at 2 L/ha, followed by post emergence Glyphosinate at 2L/ha in accordance with standard agricultural practise (MARDI, 2005).

2.2 Experimental layout

The experiment was arranged in a randomized completely block design (RCBD) with four replications and consisted of five treatments. The treatments consisted of Treatment 1 (T1: a control without fertiliser), Treatment 2 (T2: conventional compound fertiliser, NPK 15:15:15, applied in three splits at 15, 30 and 40 days (75 g/plant)); Treatment 3 (T3: control release fertiliser (CRF) at 3 (g/plant), 15 DAT), Treatment 4 (T4: CRF at 4 g/plant, 15 DAT) and Treatment 5 (T5: CRF at 5 g/plant, 15DAT).

2.3 Soil analysis

Topsoil samples (0-20 cm) were collected using an auger from the experiment site and bulked together to get a homogenised composite sample for the experimental site before planting. The soil samples were air-dried and sieved through a ≤ 2 mm sieve. The samples were analysed for pH, total N, P, K, and cation exchange capacity (CEC). Soil pH was determined in a 1:2.5 (soil: water) suspension using a glass electrode pH meter. Available P was determined by the ammonium molybdenum blue method (Bray and Kurtz, 1945), and the samples were determined by an autoanalyzer. Total N was analysed by employing Kjeldahl procedure (Kjeldahl, 1883). Cation exchange capacity was determined by the leaching method with ammonium acetate buffer solution (NH_4OA_C) at a pH of 7 (Lavkulich, 1981). The concentration of exchangeable bases was measured by the atomic absorption spectrophotometer, and K was determined using the flame photometer. Soil organic matter (OM) was determined according to the Walkey and Black method (Walkey and Black, 1934).

2.4 Data collection and measurements

Plants were randomly selected for each plot and tagged to measure growth characteristics. Plant height was measured from the base to top at 30 and 60 DAT using measuring tape. Stalk diameter was taken at the base of the sweet corn at 30 and 60 DAT using a digital vernier calliper. The number of leaves per plant was determined by counting manually at 30 and 60 DAT. Total chlorophyll content measurements were conducted using a portable chlorophyll meter SPAD-502. Plants were randomly selected and destructively sampled by harvesting the part of the leaf and root at 30 and 60 DAT. The leaf area of plant was measured by leaf area meter model Li-Cor LI-3000.The plant biomass was measured using a weighing machine after drying and was oven-dried at 50°C for 48-72 hours until obtaining constant weight. The sweet corn plants were harvested each plot using 1m × 1m square quadrate and the yield data components were recorded during harvest. The total fresh weight of the corn on each plot was measured using a weighing machine and computed the grain yield in kg/ha. The length of the corn was measured using a measuring tape and a ruler. The diameter of the corn was measured using a digital vernier calliper.

2.5 Statistical analysis

A one-way analysis of variance (ANOVA) with least significant difference (LSD) test was carried out for comparison of means among the treatments. A probability $p<0.05$ was used as the statistical significance level. Data was analysed using statistical analysis of system software (SAS version 9.4, SAS 2007).

3.0 Results

3.1 Soil characteristics before the onset of the experiment

Physico-chemical characteristics of soil for the experiment site are presented in Table 1. The soil pH was recorded at 7.1, which falls within the optimum range of 6.0 to 7.2, suggesting favourable conditions for nutrient availability. The total N content was 0.52 percent (%) slightly above the optimum range of 0.2 to 0.5%. However, available P was relatively low at 1847 parts per million (ppm) compared to the optimum range of 2000 to 5000 ppm. In contrast, exchangeable K was considerably high at 0.85 milliequivalent per kg (meq/kg) soil compared to optimum requirement of 0.20 to 0.30 meq/kg. The CEC was notably low at 4.3 cmol(+)/kg compared to the recommended range of 16.0 to 24.0 cmol(+)/kg. Additionally, the OM content was recorded low at 2.7%, which is below the optimum range of 4.0 to 10.0%.

Table 1: Initial soil chemical properties of study site

Soil variables	Content	Optimum requirement
pH (water)	7.1	6.0-7.2
Total N (%)	0.52	0.2-0.5
Av. P (ppm)	1847	2000-5000
Exc. K (meq/kg soil)	0.85	0.20-0.30
CEC (cmol+/kg soil)	4.3	16.0 – 24.0
OM (%)	2.7	4.0 -10.0

Source: Agegnehu, 2020; Campbell, 2000; Abagyeh et al., 2016.

3.2 Growth performance of sweet corn

The growth parameters of sweet corn are given in Table 2. Across all treatments, plant height, stalk diameter, number of leaves and chlorophyll content increased from 30 to 60 DAT, indicating gradual development of sweet corn over time. Although plant height increased gradually, no significant differences were observed among treatments at both 30 and 60 DAT. Nevertheless, T4 recorded the tallest plant, while the control (T1) showed the shortest plant. Stalk diameter showed a significant effect at 60 DAT, following the trend T4>T3>T2>T5>T1. Treatment 4 produced the biggest stalk diameter

(2.09 centimetres (cm)), which was significantly higher than the control (1.36 cm). Similarly, the number of leaves significantly increased among treatments, with T4 recording the highest number of leaves at both 30 and 60 DAT, whereas T1 recorded the lowest number of leaves. Chlorophyll content as indicated by SPAD values, was significantly different among treatments. Treatment 4 recorded the highest value of SPAD, followed by T3 and T5, while T1 had the lowest values of SPAD. At 60 DAT, T4 and T5 recorded SPAD values of 46.14 and 45.90, respectively, compared to control (30.14 SPAD units).

Table 2: Effect of different fertiliser treatments on growth performance and SPAD index of sweet corn

Treatment	Plant height (cm)		Stalk diameter (cm)		Number of leaves		Chlorophyll content (SPAD unit)	
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error
T1	40.73± 6.15[a]	73.8± 4.20[a]	0.53 ± 0.17[a]	1.36± 0.00[b]	5.80 ± 0.99[b]	7.00± 0.20[c]	22.65± 3.42[b]	30.14± 1.86[b]
T2	45.93± 3.41[a]	84.47± 11.54[a]	0.62± 0.10[a]	1.66± 0.20[ab]	6.53± 0.58[ab]	7.40± 0.31[bc]	30.09± 2.37[a]	38.79± 7.60[ab]
T3	47.80± 1.62[a]	97.89± 7.01[a]	0.72± 0.14[a]	2.06± 0.07[a]	7.47± 0.64[ab]	8.40± 0.46[a]	32.61± 1.63[a]	43.49± 2.45[ab]
T4	48.20± 5.29[a]	98.33± 3.48[a]	0.73± 0.11[a]	2.09± 0.04[a]	7.73± 0.24[a]	8.40± 0.50[a]	36.23± 0.20[a]	46.14± 0.53[a]
T5	54.53± 10.16[a]	84.93± 10.78[a]	0.57± 0.13[a]	1.79± 0.18[a]	7.20± 0.70[ab]	8.33± 0.29[ab]	30.77± 3.79[a]	45.90± 1.87[a]

Notes: Mean value followed by the same letters within columns are not different significantly as per the LSD at $p<0.05$. The values with ± are standard errors.

As shown in Table 3, fertilisation treatment resulted in increased shoot and root dry matter compared to control. At 30 DAT, shoot and root dry matter increased by 98.25% to 203.51%, while root dry matter increased by 23.33% to 210%. At 60 DAT, shoot dry matter increased by 6.90% to 69.04%, and root dry matter increased from 410.83% to 830.83% for root dry matter. Despite these increases, the differences were not statistically significant. Similarly, leaf area showed no significant difference among treatments at 30 DAT. Nonetheless, fertilisation treatment increased leaf area by 77.50% to 136.85% compared to the control. Treatment 4 recorded a significantly larger leaf area, showing a 31.47% increase compared to the control.

Table 3: Effect of different fertiliser treatments on dry matter mass and leaf area of sweet corn

Treatment	Dry weight of plant part (g/plant)				Leaf area (cm²)	
	Leaves		Root			
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error	Mean ± std error
T1	0.57± 0.20[a]	13.05± 3.93[a]	0.30± 0.10[a]	1.20± 0.40[a]	96.9± 17.24[a]	889.81± 61.11[b]
T2	1.13± 0.80[a]	13.95± 0.40[a]	0.37± 0.15[a]	6.13± 4.43[a]	172.0± 82.98[a]	1134.05± 80.69[a]

T3	1.50± 0.62[a]	15.72± 4.63[a]	0.40± 0.20[a]	6.50± 5.25[a]	229.6± 68.01[a]	1079.79± 255.53[a]
T4	1.73± 0.82[a]	22.06± 3.44[a]	0.93± 0.55[a]	11.17± 9.02[a]	225.5± 159.68[a]	1169.85± 346.08[a]
T5	1.57± 1.23[a]	18.23± 4.90[a]	0.43± 0.12[a]	6.90± 5.56[a]	207.0± 93.07[a]	1013.15± 209.45[ab]

Notes: Mean value followed by the same letters within columns are not different significantly as per the LSD at p<0.05. The values with ± are standard errors.

3.3 Yield performance of sweet corn

As shown in Table 4, the application of fertilisers significantly increased cob weight compared to the control. The heaviest cob weight was recorded in T4 at 652.24 ± 434.26 g, followed by T3 (619.96 ± 370.02 g), T2 (543.21 ± 228.82 g) and T5 (404.21 ±168.25 g). In contrast, the control treatment produced the lowest cob weight (162.16 ± 110.04 g), which was significantly lower than T3 and T4. CRFs improved cob length relative to the control except T5. The longest cobs were observed in T4 (19.79 ± 0.37 cm), followed by T3 (18.37 ± 0.52 cm), whereas T1 recorded the shortest cobs (15.74 ± 0.04 cm). CRF treatment also improved cob diameter relative to the control. Similarly, T4 produced the largest cob diameter (4.94 ± 0.24 cm), whereas T1 recorded the smallest (3.72 ± 0.18 cm). Among all treatments, T4 improved significantly cob length and cob diameter compared to both conventional fertiliser (T2) and control. As shown in Figure 1, total yield was significantly improved by fertilisation treatments compared to the control, with yield increases ranging from 8.97% to 34.6%. Among all treatments, T4 recorded the highest yield at 14.5 tonnes per hectare (t/ha), which was significantly greater than both the conventional fertiliser treatment T2 (10.78 t/ha) and the control (7.8 t/ha). Yield increases compared to control (T1) were 38.2% (T2), 70.5% (T3), 85.9% (T4), and 53.8% (T5). However, there is no significant difference in yield between T3 and T5 compared to conventional fertiliser.

Table 4: Effect of different fertiliser treatments on yield components of sweet corn

Treatment	Weight of cob (g)	Length of cob (cm)	Diameter of cob (cm)
	Mean ± std error	Mean ± std error	Mean ± std error
T1	162.16± 11.04[b]	15.74± 0.04[c]	3.72± 0.18[c]
T2	543.21± 228.82[ab]	17.67± 0.49[b]	4.37± 0.32[bc]
T3	619.96± 370.02[a]	18.37± 0.52[ab]	4.52± 0.25[ab]
T4	652.24± 434.26[a]	19.79± 0.37[a]	4.94± 0.24[a]
T5	404.21± 168.25[ab]	17.87± 0.64[bc]	4.47± 0.12[b]

Notes: Mean value followed by the same letters within columns are not different significantly as per the LSD at p<0.05. The values with ± are standard errors.

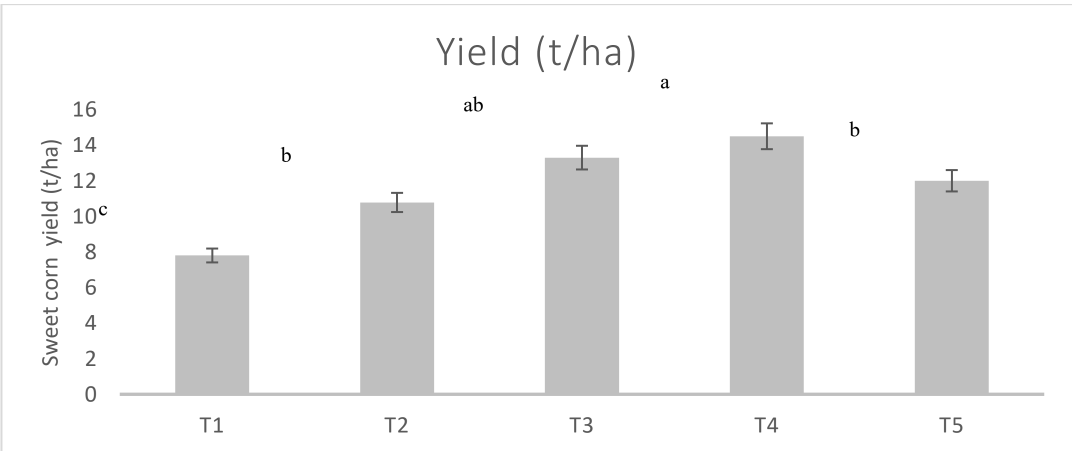

Fig. 1: Total yield of maize according to treatments

4.0 Discussion

The physico-chemical characteristics of soil at the experiment site indicated moderately favourable conditions for sweet corn production. The neutral pH promoted beneficial microbial activity, which essential for early root development and nutrient mineralization (Mohd Hadi Akbar et al., 2024). The slightly elevated total N content indicated adequate N supply to support the crop's high demand during the early vegetative stage. Sweet corn exhibits high N demand during early vegetative growth, this condition may have contributed to enhanced leaf expansion and plant vigor (Noorsuhaila et al., 2017). However, available P was below the optimum range, potentially limiting early root development. This deficiency may result from intensive cropping cultivation and imbalances nutrient which contribute to P fixation and thus reduced P availability in soil. In contrast, high levels of exchangeable K would enhance plant uptake from soil and positively influence crop yields. The high K content might be attributed to predominance of K rich minerals in soil. However, continued cropping, subsequent nutrient removals by crops during harvest and repeated use of acidifying fertilisers may lead to gradual K depletion over time (Rop et al, 2019). Low CEC and low OM indicated poor nutrient holding capacity which can contribute to nutrient leaching and potentially reduced fertiliser use efficiency (Shafar et al., 2013). According to Paramanthan (2000) such low CEC values are often associated with P fixation and the acidic nature of tropical soil in Malaysia. While the low OM in soil likely due to the removal of crop residues during harvest and minimal application of organic amendments for the next cropping cycles. Overall, these initial soil conditions highlight the necessity of soil fertility management strategies. The use of CRF could offer agronomic and environmental advantages by enhancing nutrient retention in low CEC soils, reduced leaching losses, and contributing to sustainable crop productivity.

Growth performance of sweet corn exhibited that CRF treatments enhanced plant height, stalk diameter, leaf number, and chlorophyll content compared to control. This suggests that adequate nutrient availability provided by CRFs was maintained throughout the growth period such as N and K. Nitrogen and potassium plays a crucial role in promoting cell elongation, contributing to increased node and internode formation, stem thickening, thereby improving resistance to lodging (Gautam et al, 2022; Govindasamy et al., 2023; Wu et al, 2023). These findings are consistent with Zhai et al. (2022), who reported that balanced fertilisation improves stem structural stability in maize. The highest number of leaves observed in CRF treatments at both stages indicates that optimised fertilisation, particularly the availability of N and P, supports vigorous vegetative growth and promotes leaf expansion (De Grazia et al., 2003). A greater number of leaves increases the total photosynthetic surface area, which enhances biomass accumulation and contributes to crop productivity (Weraduwage et al., 2015). The highest chlorophyll content observed in CRF treatments suggests that gradual nutrient release from CRFs enhance nutrient availability at the root zone and support efficient translocation to leaves, thereby supporting plant metabolic activity. This mechanism significantly enhances growth and chlorophyll content in sweet corn, contributing to improved yield potential (Firmanda et al., 2022; Ravindran et al., 2025). These findings are supported by Dond et al. (2016), who noted that the SPAD index is a reliable indicator for assessing leaf N status and guiding precise timing for fertiliser application. These results confirm that synchronised nutrient release from CRF can provides a steady nutrient supply during the early vegetative growth of sweet corn and timely release during the reproductive stage, aligning with the crop's increased nutrient demand at flowering stage.

Biomass production was positively influenced by CRF, as shoot and root dry matter and leaf area increased consistently with plant age. The expansion of leaf area is closely associated with an increased number of leaves per plant, as both parameters contribute to the total photosynthetic area. A greater leaf area enhanced greater light interception, thereby enhancing the production of photosynthates that support plant growth and development (Govindasamy et al., 2023). The improved performance in terms of leaf area and dry matter accumulation under CRF treatments can be attributed to enhanced nutrient uptake efficiency. This aligns with previous studies that have highlighted the potential of CRFs to promote biomass accumulation and improve physiological efficiency in maize and other cereals (Noorsuhaila et al., 2017; Noorsuhaila et al., 2024). The gradual nutrient supply provided by CRF ensures consistent nutrient availability in the root zone, optimising nutrient absorption and minimising nutrient losses through leaching or volatilisation (Haryati et al., 2021; Haryati et al., 2022).

The improvements in yield components particularly cob weight, length and diameter improved significantly under CRF. These improvements can be attributed to enhanced nutrient synchronisation with crop demands, which supports assimilate translocation to reproductive parts. These findings are consistent with Haryati et al. (2020), who highlighted the importance of N and K in promoting early cob development and grain filling in sweet corn. In contrast, the low yield in control treatment reflects the reliance of sweet corn on adequate and timely nutrient supply for yield productivity. These observations are supported by Lone and Khan (2007), who reported fertilisation can improve crop yield by 40-60%, primarily by enhancing photosynthetic efficiency through improved nutrient uptake. This study also demonstrates the agronomic efficiency of CRF compared to conventional fertilisers, which require three separate applications. In the context of highland soil at study site which have low CEC and poor nutrient retention, a single optimised rate of CRF application at 4g/plant was sufficient to produce significantly higher yield compared to the conventional fertiliser. This rate provides a steady nutrient supply while minimising leaching losses, thereby enhancing both growth and yield performance of sweet corn. Increasing CRF rate beyond this level did not lead to additional yield gains, which is consistent with previous findings in maize and cereals where moderate CRF rates sustain high yield while maximising nitrogen use efficiency (NUE) (Gheng et al., 2016; Xiang-ling et al., 2021; Zhang, 2018; Zheng et al., 2025).

This mechanism allows sweet corn to achieve comparable or greater yield with less fertiliser input. This aligning with results from Cui et al. (2022), who found that controlled-release urea improved NUE by 9.7% to 12.1% in winter wheat compared to conventional urea. Similarly, Du et al. (2022) reported that control release fertiliser increased NUE and reduced nutrient losses in maize production, even when applied at equivalent rates to conventional fertilisers. These findings highlight the dual agronomic and economic advantages of CRFs, especially for smallholder farmers in highland areas with limited resources and labour constraint. From a sustainability perspective, CRF application minimises nutrient losses, enhances fertiliser efficiency, and lowers environmental risks. This approach is consistent with Malaysia's National Agrofood Policy 2021–2030, which emphasizes productivity, strengthen food security, and sustainable agriculture practices.

5.0 Conclusion

The application of control release fertiliser at a optimise rate (4 g/plant) produced promising results with marked improvement in plant height, stalk diameter, and plant dry weight compared to conventional fertiliser. A single application of control release fertiliser was sufficient to achieve this improvement, eliminating the need for multiple applications required under conventional fertiliser. This not only reduces labour, time, and energy inputs but also enhances fertiliser use efficiency and minimises nutrient losses aligns with Malaysia's National Agrofood Policy (2021-2030).

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Conflict of Interest

The authors declare no conflict of interest.

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