

RESEARCH ARTICLE

EFFECT OF FERTILIZER SCHEDULES AND MEDIA COMPOSITION ON GROWTH AND YIELD OF *CAPSICUM CHINENSE* JACQ. UNDER PROTECTED HOUSE CONDITIONS IN A WARM AND HUMID CLIMATE

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ABSTRACT

Capsicum chinense Jacq. is an important vegetable crop cultivated widely in tropical and subtropical regions. The present study evaluated the effects of fertilizer schedules and growing-medium compositions on the growth and yield of *C. chinense* under protected conditions in the Low Country Wet Zone of Sri Lanka. Three fertilizer schedules (F1: existing fertilizer schedule), F2: fertilizer schedule 2, and F3: fertilizer schedule 3) and three growing-medium (M1: 50% coir dust + 30% partially burnt paddy husk + 20% coco chips (existing medium), M2: 70% coir dust + 30% partially burnt paddy husk, and M3: 70% coir dust + 30% coco chips) were evaluated in a two-factor factorial Completely Randomized Design with four replicates. The existing fertilizer schedule and growing medium served as the control treatment. The recorded parameters included the number of branches per plant and stem girth as growth parameters, and time to first flowering as a developmental (phenological) parameter. Pod circumference, number of pods per plant, fresh weight per pod, and pod weight per plant were recorded as yield-related parameters. Pod yield was graded according to market standards as a yield-quality parameter. In addition, the cost of production for each treatment was calculated. The interaction between fertilizer schedule and growing-medium composition did not significantly affect any measured parameters. However, fertilizer schedule significantly influenced the number of branches per plant, time to first flowering, pod circumference and pod weight per plant, pod grading, and benefit-to-cost ratio. Growing-medium composition significantly influenced stem girth. The results showed that 99% of the harvested pod yield met marketable standards for weight and colour. Based on the results, the existing fertilizer schedule can be recommended as the best fertilizer schedule among the tested schedules, and any of the three growing-medium compositions can be used to achieve satisfactory growth and yield of *C. chinense* under a warm, humid tropical environment.

Keywords: *Capsicum chinense*, Fertilizer schedules, Growth, Medium-composition, Protected house conditions

INTRODUCTION

Over the past two decades, a major objective of the agricultural sector has been to maximize sustainable crop yield per unit area in response to population growth, climate change, water scarcity, limited arable land, and increasing biotic and abiotic stresses affecting crop production (Rabbi *et al.*, 2019). Rapid population growth increases the demand for food and poses a serious threat to global food security by placing immense pressure on nat-

ural resources and altering agricultural practices (Hall *et al.*, 2017). To meet the growing demand for food while addressing these challenges through efficient resource utilization, protected cultivation can be adopted as a scientific approach that enables multiple cropping cycles per unit of land (Shukla *et al.*, 2019). Protected agriculture is a cropping technique in which the microclimate surrounding plants is partially or completely controlled during their growth using protective

structures such as net houses and polytunnels (Mishra *et al.*, 2010). This technique provide several benefits, including efficient utilization of agricultural inputs, increased crop yields, reduced agrochemical use, and enhanced water conservation. Additionally, protected agriculture reduces biotic and abiotic stresses affecting crop growth and yield while suppressing weed growth and the incidences of pests and diseases. It also improves the livelihoods and income of smallholder farmers by enabling the cultivation of high-value vegetable crops such as salad cucumber, tomato, and bell pepper (Kumara *et al.*, 2015). Although protected cultivation offers many benefits, it requires substantial initial capital investment, advanced technology, and higher maintenance costs (Banjare *et al.*, 2024).

Capsicum chinense is an important vegetable and spice crops cultivated widely around the world and belongs to the family Solanaceae (Saha *et al.*, 2024). It is commonly known as habanero pepper and is considered one of the hottest commercially cultivated chilli peppers, owing to its relatively high capsaicin content compared with many other chilli varieties (Gogoi, 2017). South America is the primary gene centre of *C. chinense* (Bharath *et al.*, 2013). *C. chinense* is mainly cultivated in tropical regions such as India, Indonesia, Myanmar, Bangladesh, Pakistan, and Thailand for both fresh and processing industries (Kamvorn *et al.*, 2014). Due to its high pungency, distinctive flavour, and rich content of bioactive compounds, it has great potential in the food, pharmaceutical, and cosmetic sectors (Devi *et al.*, 2022; Baruah and Lal, 2020).

Chilli is widely consumed in Sri Lanka and is cultivated mostly in dry and intermediate zones of the country (Hewage *et al.*, 2022). Sri Lanka has a divers range of *Capsicum* species, including underutilized village-level collections. These varieties possess unique aromas, levels of pungency, and flavour. *Capsicum annum* is the most commonly cultivated *Capsicum* species in Sri Lanka, including both pungent types and non-pungent types such as bell pepper, syn. *Capsicum*, paprika, etc. “*Kochchi*”, “*Nai Miris*”, and “*Hini Miris*” are other *Capsicum* species that show high

pungency, distinctive aroma, and taste. Among them, “*Kochchi*” is mainly grown in home gardens in Sri Lanka (Aruggoda, 2021). When *Capsicum* is grown under 100% drip irrigation, it produces plants with more branches, greater height, and higher yields because it controls nutrient delivery and optimizes water use (Antony and Singandhupe, 2004). In Sri Lanka, *C. chinense* is commonly known as “*Nai Miris*” and it has become a popular crop in recent years (Wickramaratne *et al.*, 2025). Its perennial growth habit, drought resistance, and lower susceptibility to pests and diseases are advantages for commercializing *C. chinense* in Sri Lanka (Nishani *et al.*, 2025). It is a high-value cash crop that is cultivated in both open fields and under protected cultivation. When *C. chinense* is grown under protected conditions, it improves crop duration, the number of pods per plant, pod weight, pod volume, total soluble solids (TSS), fruit vitamin C content, and the cost-to-benefit ratio compared with open-field conditions. Growing capsicum under protected conditions also ensures year-round production (Pramanik *et al.*, 2020). This crop serves as an income source for farming communities (Sheyoputri *et al.*, 2024).

In Sri Lanka, Albert’s solution is used as the primary fertilizer in greenhouse vegetable cultivation. It is essential to adjust its application according to the different phases of crop growth (Ranasinghe and Weerakkody, 2006). For the existing schedule, Albert’s solution was selected as it provides a balanced supply of both macro- and micronutrients required for crop growth. However, the main problem growers face is that Albert’s solution is moderately costly. This is one reason growers are discouraged from cultivating *C. chinense* inside a polytunnel. The selected fertilizers (Mugasol 20:20:20, Mugasol N plus 30:10:10, Mugasol K40 7:12:40, Densol N plus 28:11:14, Densol K plus 10:5:35 and Nitrophoska Gold 15:9:15) were chosen because they are commercially available and affordable for local farmers. These fertilizer mixtures also provide balanced (20:20:20 and 15:9:15), nitrogen-rich (30:10:10), and potassium-rich (7:12:40 and 10:5:35) formulations suitable for different crop growth stages. Nitrophoska

Gold (15:9:15) is a balanced and slow releasing complex fertilizer that contains both readily available nitrogen in the nitrate (2.5%) and ammonia form (7.5%) and slow-release (5%) nitrogen sources. According to Campiotti *et al.* (2022), slow-release nitrogen provides a continuous nutrient supply throughout the growth cycle of crop, while readily available nitrogen supports early crop growth.

In protected house cultivation, cocopeat, compost, and soil are commonly used as growing media. Sri Lanka is a leading manufacturer of high-quality coir products (Abad *et al.*, 2005). Partially burnt rice husk is also commonly used as a growing medium for *C. chinense* as it is cost-effective (Raphael *et al.*, 2022). At present, farmers are shifting to soilless media because it improves aeration, prevents soil-borne diseases and promotes crop growth (Fussy and Papenbrock, 2022). This study selected coir dust, partially burnt paddy husk, and coco chips as the growing media. These media are derived from agricultural by-products and serve as alternatives to growing commercial media. These three media were selected based on their physical properties, cost-effectiveness, and local availability. Coir dust was used as the primary component because of its high water-holding capacity, low bulk density, high aeration, and cost-effectiveness as a locally available substrate. Partially burnt paddy husk was added to improve aeration and drainage, while coco chips were incorporated to enhance the medium's porosity (Anikwe, 2000).

In Sri Lanka, protected-house cultivation of *C. chinense* using coco-peat-based grow bags as a potting medium is increasingly adopted. (Edirisinghe *et al.*, 2022). However, the growth and yield of *C. chinense* under protected-house conditions have not been comprehensively studied in the Sri Lankan context. Limited information is available on the combined effects of fertilizer schedules and growing-media composition on *C. chinense* under protected-house conditions in Sri Lanka.

Therefore, this study aims to evaluate the effects of fertilizer schedules and media composition on the growth performance, yield, pod quality, and benefit-cost ratio of *C. chinense*. Identifying alternative fertilizer formulations to replace Albert's solution, as well as alternative potting mixtures that promote plant growth and development, will expand the range of locally available options for growers. Furthermore, the findings of the present study provide evidence-based recommendations for growers in Sri Lanka regarding optimal fertilizer schedule and media composition to maximize the growth and yield of *C. chinense*.

MATERIALS AND METHODS

The experiment was conducted in a protected house at the Faculty of Agriculture, University of Ruhuna, located in the Low Country Wet Zone (WL2) of Sri Lanka from March to September 2024. The span-type protected house was covered with a 200 μm UV-stabilized polythene film (1000 gauge), while the sidewalls were enclosed with an insect-proof screening netting (40 $\times$ 25 mesh/inch²). Temperature and relative humidity inside the protected house were monitored daily using a digital thermometer and a hygrometer, respectively. The recorded temperature values represent the minimum and maximum temperatures within the protected environment. Daytime and nighttime temperatures ranged from 30-38 °C and 22-26 °C, respectively, while relative humidity ranged from 75-80%.

Thirty-six healthy and uniform seedlings of *C. chinense* cv. Piquante F1 were transplanted into grow bags, with one seedling per bag, after a twenty-one-day nursery period. The experiment used 40 $\times$ 40 cm open-top grow bags filled with soilless growing media consisting of coir dust, partially burnt husk, and coco chips in different proportions. The growing bags were placed on the floor of the protected house at 90 $\times$ 105 cm spacing. Albert's solution, Densol, and Mugasol fertilizer types were used according to the respective fertilizer schedules. One day before transplanting, the growing-media were sterilized using a fungicide solution prepared by dissolving 2 g Mancozeb in 1 liter of water.

The experiment was conducted using a two-factor factorial (3×3) Completely Randomized Design with four replicates, resulting in nine treatment combinations (T1-T9). The first factor of fertilizer schedule had three levels (F1- existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 consisting of Mugasol 20:20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3 consisting of Mugasol 20:20:20 + Mugasol 30:10:10 + Mugasole K40). The second factor was growing-medium composition, with three levels (M1- Existing composition- 50% coir dust + 30% partially burnt paddy husk + 20% coco chips, M2- 70% coir dust + 30% partially burnt paddy husk and M3- 70% coir dust + 30% coco chips). The combination of the existing fertilizer schedule (F1) and existing growing medium composition (M1) was used as the control treatment (T1), as this combination is commonly used by *C. chinense* growers in protected cultivation in Sri Lanka.

Irrigation was carried out manually twice daily, in the morning and afternoon, for all treatments. At maturity, approximately 800 ml of water was supplied per plant per day. Fertilizer application began 10 days after transplanting and was applied manually at 2-day intervals.

During the first week after transplanting, Albert's solution was added at a concentration of 1g/L at a rate of 50 mL per plant. Thereafter, the concentration was increased to 1.8 g/L and applied at 100 mL per plant. This fertilizer rate was continued for a week. At the same time, Maxicrop organic liquid fertilizer (3 ml/L) was sprayed twice per week as a foliar application. Subsequently, the application of Albert's solution was increased weekly to 200ml per plant and then 300ml per plant. The experimental fertilizer schedules began 25 days after transplanting. The 36 plants were divided equally among the three fertilizer schedules, with 12 plants per schedule.

For fertilizer schedule 1, during the first week, 300ml of Albert's solution (1.8 g/L) was applied twice per week. The concentra-

tion was increased to 3 g/L and applied twice per week for the following two weeks. During the subsequent eight weeks, each plant received 300 mL of 3 g/L Albert's solution three times per week. Mugasol 30:10:10 was included in fertilizer schedules of 1 and 3. Over the following six weeks, apply 300 mL of 1 g/L Mugasol 30:10:10 once per week per plant. Over the next three weeks, the application rate increased to 300 mL of 3 g/L, applied twice per week. During the final two weeks, apply 300 mL of 1 g/L Mugasol 30:10:10 once per week. Mugasol K40 was included in fertilizer schedules 1 and 3. During the first week, 300 mL of 1 g/L Mugasol K40 was added once a week. During the following five weeks, 300 mL of 2 g/L Mugasol K40 was added once a week. Then Mugasol K40 was not applied for three weeks to promote new leaf growth. Then, for another two weeks, each plant received 300 mL of 2 g/L Mugasol K40 once a week. Mugasol 20:20:20 soluble fertilizer was included in both fertilizer schedules 2 and 3. During the first week, 300 mL of 1.8 g/L Mugasol 20:20 was added three times per week. For the remaining nine weeks, 300 mL of 3g/L Mugasol 20:20:20 was added three times per week.

Fertilizer schedule 2 included Nitrophoska Gold fertilizer. It is a slow-release granular fertilizer. During the first two weeks, 1.5 g of fertilizer was added to each plant once every two weeks. During the first two weeks, 1.5 g of Nitrophoska Gold fertilizer was applied to each plant every two weeks. Then, for the remaining nine weeks, 2 g of Nitrophoska Gold fertilizer was applied to each plant every two weeks.

Densol N plus liquid fertilizer was included in fertilizer schedule 2. During the first two weeks, 3 ml/L was added to each plant once a week. It was not sprayed on plants during the reproductive phase. Then, 3 ml/L Densol N plus solution was sprayed twice a week for four weeks to promote new leaf growth. Densol K plus liquid fertilizer was included in fertilizer schedule 2. During the first six weeks, 3 ml/L was added to each plant twice a week. Then it was not sprayed for up to three weeks to promote new leaf growth.

Then, 3 ml/L Densol K plus solution was sprayed twice a week for two weeks. Additionally, Magnesium sulphate (2 g/L) was applied to all plants to strengthen plant structure and enhance crop growth. Calcium nitrate (2 g/L) was added to all plants to promote faster growth and increase fruit size. Calcibor + Zn liquid fertilizer was sprayed (3 ml/L) once a week, as it increases the amount of chlorophyll content in the plants' leaves, minimizes fruit rot and promotes the uptake of nutrients. After the reproductive phase, Mugasole P-52 fertilizer (2g/L) was applied to induce flower bud formation for the next round of production. A three-stem pruning method was implemented 14 days after being transplanted. Additionally, insecticides such as *Abamectin*, *Chess* and *Sunmite* were applied once a week in rotation to control pest-tattacks until flowering. Fungicides such as

Homai and *Mancozeb-Metalaxyl* were applied when necessary to control diseases.

The Number of branches per plant and stem girth were recorded at three-week intervals from the vegetative stage onward as growth parameters. The number of days to first flowering was recorded as a phenological parameter. Yield and yield-related parameters included pod circumference, pod length, fresh pod weight, pod yield per plant, and grading of pod yield according to market standards. Furthermore, the production costs and revenue associated with each treatment were calculated at the end of the experiment.

Two visual scoring indices were developed based on pod weight and colour according to the market standards for *C. chinense*. These indices were used to assess marketability and pod quality. As illustrated in Figure 1A, pods weighing more than 8g and free from

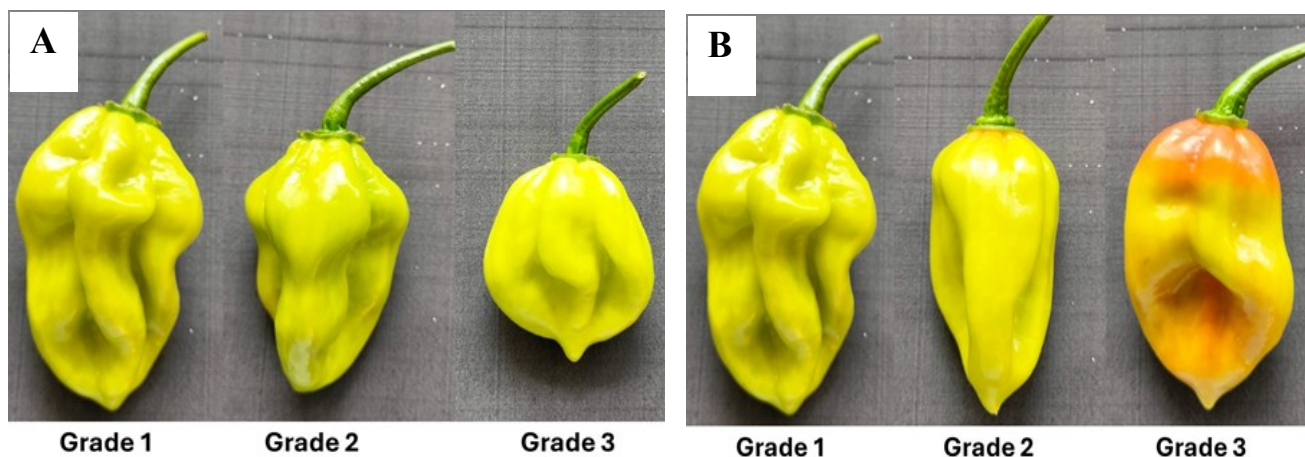


Figure 1: Visual grading system based on (A) weight of the pod (B) Color of the pod

visible defects were classified as Grade 1, whereas pod weighing 5- 8 g with minor defects covering less than 5% of the pod surface were classified as Grade 2. Pods weighing less than 5 g were classified as Grade 3 and considered non-marketable. Accordingly, only Grade 1 and Grade 2 pods were considered marketable by weight. Similarly, pod colour was evaluated using a visual grading scale (Figure 1B). Pods with a uniform light green colour were classified as Grade 1, while pods showing slight reddish discolouration covering less

than 10% of the pod surface were classified as Grade 2. Pods that were overmature or exhibited reddish colouration covering more than 10% of the pod surface were classified as non-marketable. Accordingly, pods classified as Grades 1 and 2 were considered marketable based on pod colour.

The benefit-to-cost ratio was calculated on a unit-area basis of the tunnel. Total production costs included expenditures on seedlings, grow bags, growing media, agro-chemicals, fertilizer, labour, electricity, and

water. Benefits were calculated solely from revenue generated by the harvested crop.

DATA ANALYSIS

Data were first tested for normality. Normally distributed data were analyzed using Two-Way ANOVA in SAS, followed by mean separation using Dunnett's Test at the 5% probability level as the primary objective of this study was to compare each treatment combination with the control treatment, Dunnett's Test was used to determine whether treatment means differed significantly from the control mean. Non-normally distributed data were analyzed using the Kruskal-Wallis test in Minitab 19.

RESULTS AND DISCUSSION

The interaction effect between fertilizer schedule (Factor 1) and growing-medium composition (Factor 2) did not significantly affect the measured growth parameters of the experiment, including the number of branches per plant, stem girth and time taken to first flowering nor the reproductive parameters such as the number of pods per plant, fresh weight per pod, pod circumference, pod length and fresh weight of pods per plant. The non-significant interaction indicates that the effect of fertilizer schedule on the measured parameters did not depend on growing medium composition. However, fertilizer schedule significantly influenced the number of branches per plant ($p < 0.01$) (Figure 2). A significant difference was observed between the control (F1- existing fertilizer schedule) and F3 (fertilizer schedule 3), but F2 (fertilizer schedule 2) was not significantly different from the existing fertilizer schedule (F1). Fertilizer schedule 3 (F3) recorded the highest number of branches per plant (92). The higher number of branches observed under F3 may be attributed to the increased availability of nitrogen supplied through Mugasol 20:20:20 and Mugasol 30:10:10 fertilizers. Nitrogen plays an important role in cell division, leaf expansion, and the initiation of lateral buds, thereby promoting vegetative growth and plant vigour (Aminifard *et al.*, 2012).

Foliar application of inorganic fertilizer has been reported to enhance the number of branches of chilli plants compared to the standard foliar fertilizer. Sugiyanta *et al.* (2018) reported that applying inorganic fertilizer at half the recommended rate significantly increased plant height, number of branches and pods per plant, weight of pods, weight of 10 pods and yield per plant leading in a relative agronomic effectiveness of

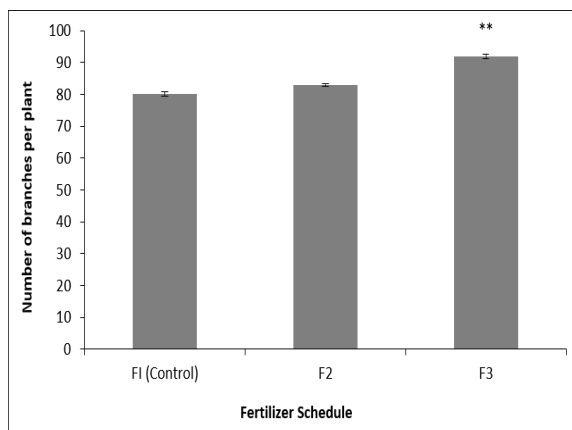


Figure 2: Effect of different fertilizer schedules on the number of branches per plant (F1 - existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 - consisting of Mugasol 20:20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3- consisting of Mugasol 20:20:20 + Mugasol 30:10:10 + Mugasole K40). Error bars represent the standard error of the means

113% and an increase in chilli yield per hectare. Similarly, Anatalia *et al.* (2022) reported that the NPK fertilizer application interval significantly affects the number of dichotomous branches, dry stove weight, and cumulative pod weight and pod length at the first harvest of chilli. The number of dichotomous branches of chilli plants increased by 23% when NPK fertilizer was at 15-day intervals. This finding further demonstrates that the timely application of inorganic fertilizer enhanced the branching of plant and overall growth.

Stem girth was significantly influenced by growing-medium composition ($p < 0.0001$;

Figure 3). However, neither M2 nor M3 differed from the existing medium (M1). These findings indicate that although growing-medium composition significantly affected stem girth overall, the alternative media compositions performed comparably to the existing medium. However, Sharda *et al.* (2023) reported that increasing the cocopeat content from 25% to 50% in briquette-based growing

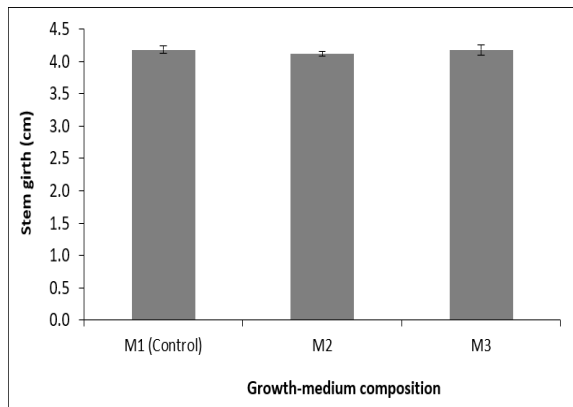


Figure 3: Effect of different growing-medium compositions on stem girth (M1- Existing composition of 50% coir dust + 30% partially burnt paddy husk + 20% coco chips, M2 - 70% coir dust + 30% partially burnt paddy husk and M3 - 70% coir dust + 30% coco chips). Error bars represent the standard error of the means

media prepared from maize and paddy straw improved chilli plant growth, pod yield, and quality. The present study suggests that appropriate combinations of coir dust, coco chips, and partially burnt paddy husk can enhance vegetative growth and overall plant health in chilli.

The observed response may be attributed to the physical and chemical properties of the individual growing-medium components. Coir dust is a suitable organic component for container cultivation as it has high water-holding capacity, good drainage, low weed and pathogen incidence, slow decomposition rate, favourable pH, cation exchange capacity (CEC), and electrical conductivity (EC). It also contains relatively high levels of potassium and phosphorus but comparatively low levels of calcium, magnesium, and nitrogen

(Abad *et al.*, 2002). Partially burnt paddy husk improves porosity, drainage, and aeration. Quintero *et al.* (2013) reported a water-holding capacity of 477–539% by mass and total pore space of 66–76% by volume for partially burnt paddy husk.

Paddy husk is also a readily available growing-medium amendment in Sri Lanka and contains several mineral nutrients, including calcium, magnesium, potassium, sodium, and phosphorus, although its nitrogen content is relatively low. Paddy husk ash has an alkaline pH ranging from 8.1 to 11.0 and contains variable concentrations of phosphorus and potassium (Priyadharshini and Seran, 2010). Its incorporation can improve medium pH and aeration and increase phosphorus availability. The nutrient composition of paddy husk varies depending on the temperature and duration of burning (Buck and Evans, 2010). Collectively, these properties may have contributed to the suitability of the evaluated growing-media compositions for supporting chilli plant growth and stem development.

Figure 4 illustrates the effect of fertilizer schedules on the time taken to reach first

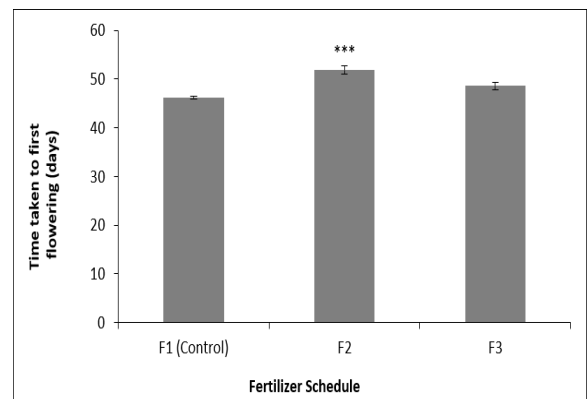


Figure 4: Effect of different fertilizer schedules on the time taken to first flowering (F1 - existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 - consisting of Mugasol 20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3 - consisting of Mugasol 20:20:20 + Mugasol 30:10:10 + Mugasole K40). Error bars represent the standard error of the means

flowering ($p < 0.0001$). A significant difference was observed between fertilizer schedule 2 (F2) and fertilizer schedule 1 (F1). However, fertilizer schedule 3 (F3) did not differ significantly from the control (F1). Among the three fertilizer schedules, plants receiving F2 took the longest time to initiate flowering, while plants under F1 and F3 initiated flowering earlier. These results indicate that the fertilizer composition and application schedule may influence the transition from vegetative to reproductive growth in *C. chinense*.

The delayed flowering observed under fertilizer schedule 2 (F2) may be due to its relatively high nitrogen supply. Excess nitrogen application during the vegetative phase can promote vegetative growth at the expense of reproductive development, thereby delaying flower initiation. In the present study, in fertilizer schedule 2 (F2), N supplied through Densol N plus can be absorbed through the leaves during foliar application. Continuous and excess nitrogen may favour vegetative growth over reproductive development, delaying flowering.

Aminifard *et al.* (2012) reported that the rate of nitrogen fertilizer significantly influenced the time to first flowering. A lower nitrogen rate of 50 kg ha⁻¹ enhanced reproductive growth in *Capsicum*, whereas a higher nitrogen rate of 150 kg ha⁻¹ increased the number of days to flowering and fruit set, indicating delayed reproductive development. These findings support the present results, suggesting that excessive nitrogen availability under F2 may have promoted prolonged vegetative growth and consequently delayed flowering.

Fertilizer schedules significantly affected fresh pod weight per plant ($p < 0.01$), with the highest value in the control fertilizer schedule (F1) (Figure 5). Plants receiving F1 produced a fresh pod weight of 754.5 g per plant, which was significantly higher than those receiving in F2 (551.3 g) and F3 (496.5 g).

Thus, both alternative fertilizer schedules resulted in significantly lower fresh pod weight per plant than the existing fertilizer schedule. The superior performance of F1 may be at-

tributed to the use of Albert's solution as the major fertilizer component. Albert's solution is a balanced, water-soluble fertilizer commonly used in soilless cultivation to provide essential macro and micronutrients. The fertilizer schedule significantly affected fresh

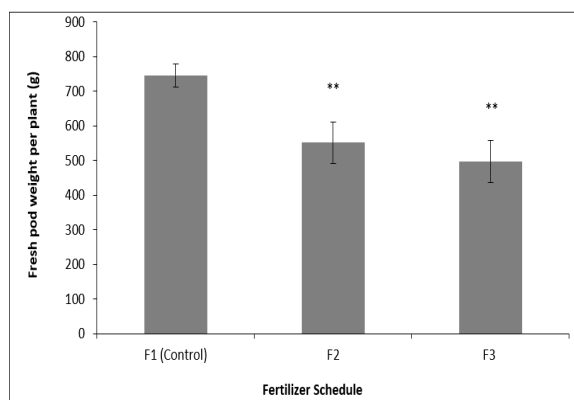


Figure 5: Effect of different fertilizer schedules on fresh pod weight per plant (F1 - existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 - consisting of Mugasol 20:20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3 - consisting of Mugasol 20:20:20 + Mugasol 30:10:10 + Mugasole K40). Error bars represent the standard error of the means

weight per pod ($p < 0.001$; Table 1). Fresh weight per pod differed significantly between the existing fertilizer schedule (F1) and fertilizer schedule 2 (F2). However, fertilizer schedule 3 (F3) did not differ significantly from the existing fertilizer schedule (F1). Overall, fertilizer schedule 3 (F3) resulted in a fresh weight per pod comparable to the existing fertilizer schedule, which was considered the control (F1). According to Arthanawa *et al.* (2022), chilli pod weight can be influenced by the availability of required macronutrients.

Macronutrients are needed to activate meristematic cells and facilitate photosynthesis, which increases photosynthate production and helps increase fruit weight. Babanjeet *et al.* (2022) highlighted that as the dosage of potassium and nitrogen fertilizers increased, average pod weight also increased because nitrogen translocates photosynthates with the

help of potassium, increasing pod weight.

Results showed that the fertilizer schedule significantly affected pod circumference ($p < 0.01$; Table 1). The existing fertilizer schedule (F1) and fertilizer schedule 2 (F2) differed significantly, but fertilizer schedule 3 (F3) did not differ significantly from the ex-

isting fertilizer schedule or the control (F1). This may be due to balance supply of macro and micronutrient throughout the reproductive phase. Nitrogen stimulates photosynthetic activity and assimilates production, while potassium enhances cell expansion and fruit enlargement (Tavallali *et al.*, 2018). Rawung *et al.* (2021) found that biological and NPK

Table 1: Effect of different fertilizer schedules on fresh weight per pod and circumference of pods with the standard error of means

Fertilizer schedule	Fresh weight per pod (g)	Circumference of the pod (cm)
F1 (Existing schedule)	7.6 ± 1.4	9.9 ± 1.2
F2	$6.9 \pm 0.9^*$	$9.2 \pm 1.4^*$
F3	7.4 ± 1.1	9.7 ± 0.8

* Indicated the significant difference between F2 and F1 fertilizer schedule at 5% probability level

fertilizers significantly affected red chilli growth and yield, and that applying biological fertilizer (6 l/ha) with NPK fertilizer (750 kg/ha) increased plant height, pod circumference and chilli yield.

Yield distribution among the three fertilizer schedules varied across pod grades based on pod weight score (Figure 6A). For Grade 1 pods, the highest proportion was observed under the existing fertilizer schedule (F1), at approximately 40%, followed by F3 (29%) and F2 (20%). Grade 3 pods, considered non-

marketable, were absent under F1, whereas they accounted for approximately 17% and 11% of the yield under F2 and F3, respectively. Overall, Grade 2 pods were the predominant yield category across all fertilizer schedules, while F1 favoured a higher proportion of Grade 1 pods and F2 produced a greater proportion of Grade 3 pods. The yield distribution differed among the three fertilizer schedules, with Grade 1 pods consistently accounting for the largest proportion of total yield (Figure 6B).

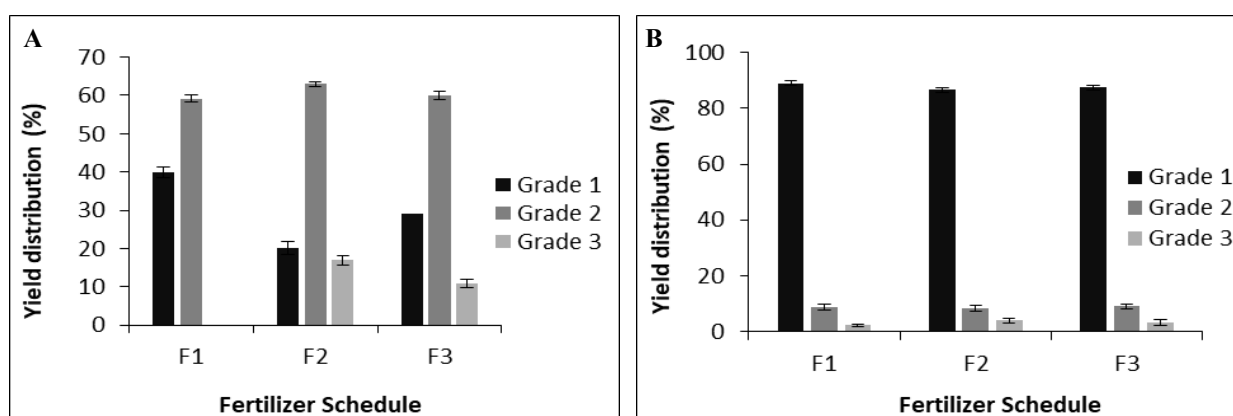


Figure 6: Effect of different fertilizer schedules on yield distribution according to the grading systems based on (A) pod weight and (B) pod colour (F1 - existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 - consisting of Mugasol 20:20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3 - consisting of Mugasol 20:20:20 + Mugasol 30:10:10 + Mugasole

Under F1, F2, and F3, Grade 1 pods represented approximately 89%, 87%, and 88%

of the total yield, respectively. This indicates that all three fertilizer schedules produced a

predominantly Grade 1 yield, with only minor differences among treatments. Overall, the results indicate that fertilizer schedule had relatively little effect on pod colour distribution, as Grade 1 pods consistently represented the major proportion of the yield. Importantly, F3 produced a distribution of pod colour grades comparable to the current fertilizer schedule (F1), with a similarly high proportion of Grade 1 pods and a very low propor-

tion of Grade 3 pods. This suggests that F3 maintained acceptable pod colour quality while achieving a grading profile close to that of the control fertilizer schedule.

Figure 7 (A and B) shows the effect of fertilizer schedule on marketable yield. In Figure 7A, marketable yield based on pod weight varied across fertilizer schedules. The existing fertilizer schedule (F1) recorded the high-

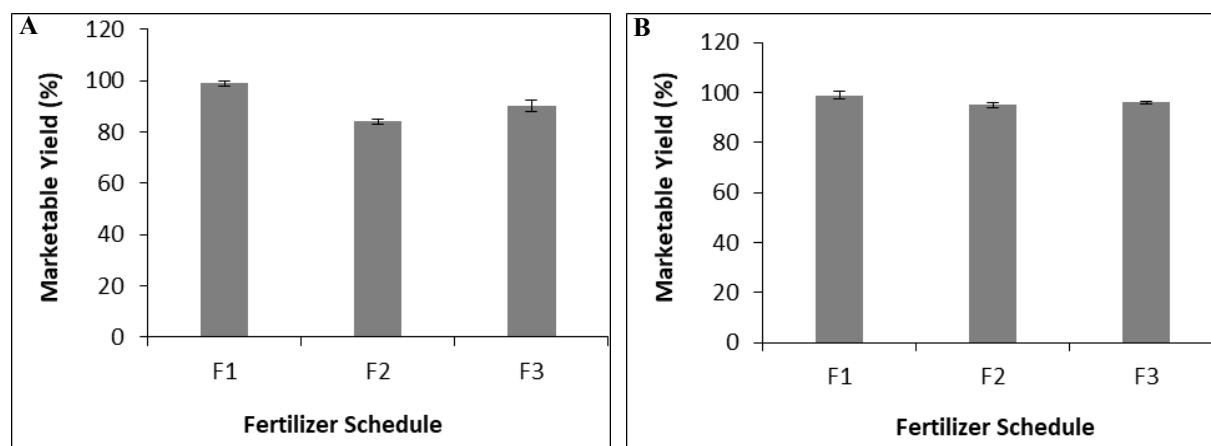


Figure 7: Effect of different fertilizer schedules on pod marketability based on (A) pod weight and (B) pod colour (F1- existing fertilizer schedule includes Albert's solution + Mugasol 30:10:10 + Mugasole K40, F2 - consisting of Mugasol 20:20:20 + Nitrophoska Gold 15:9:15 + Densol K plus + Densol N plus foliar fertilizers and F3- consisting of

est marketable yield, at approximately 98%, followed by F3 at about 89%. Fertilizer schedule 2 (F2) resulted in the lowest marketable yield, at approximately 84%. Thus, F1 showed the most favorable marketable yield, whereas F2 resulted in a noticeable reduction compared with F1. In Figure 7B, marketable yield based on pod colour remained consistent across all fertilizer schedules (95% to 98%). The differences among fertilizer schedules were relatively small, indicating that fertilizer schedule had a limited effect on marketable yield based on pod colour. Overall, existing fertilizer schedule (F1) produced the highest marketable

yield based on both grading systems, while fertilizer schedule 2 (F2) showed the greatest reduction. Fertilizer schedule 3 (F3) performed comparatively well and maintained a marketable yield close to that of F1, suggesting that F3 could provide a marketable yield comparable to the current fertilizer schedule.

Fertilizer schedules significantly affected the cost and benefit per square foot of the polytunnel floor and the benefit-to-cost ratio. The existing fertilizer schedule recorded the greatest value compared to the other two fertilizer schedules (Table 2). The cost of

Table 2: Cost of production, benefits and benefit-to-cost ratio of the production cycle based on different fertilizer schedules of the experiment

Fertilizer schedule	Cost/ft ² (Rs.)	Benefit/ft ² (Rs.)	Benefit: Cost Ratio
F1 (Control)	59.03	106.51	1.80
F2	54.61*	78.77*	1.44*
F3	51.67*	72.19*	1.40*

* Indicated a significant difference between F1 (control) and other fertilizer schedules at the 5% probability level

fertilizers used in fertilizer schedules 2 and 3 was lower than the cost of fertilizer applied in the existing schedule. However, the existing schedule produced a higher total yield than the other schedules used in the study, increasing the benefits. The existing fertilizer schedule (F1) had the highest cost (Rs.59.03/ft²), but also produced the highest benefit (Rs. 106.51/ft²) and the highest Benefit: Cost ratio (1.80). Fertilizer schedule 2 (F2) reduced the cost by about 7.5% compared with F1, but its benefit decreased by about 26.0%. Fertilizer schedule 3 (F3) had the lowest cost (Rs. 51.67/ft²), but also the lowest benefit (Rs. 72.19/ft²) and the lowest Benefit: Cost ratio (1.40). Therefore, the existing fertilizer schedule (F1) was the most economically advantageous treatment based on the Benefit: Cost ratio, while fertilizer schedule 3 (F3) minimized production cost.

CONCLUSION

The study showed that fertilizer schedule significantly influenced growth, flowering, yield, pod quality and economic performance of *Capsicum chinense* under protected house conditions. In contrast, growing-medium composition had limited effects on these parameters. No significant interaction was observed between fertilizer schedule and growing-medium composition. The existing fertilizer schedule (F1) produced the highest fresh pod yield, favourable pod characteristics, greatest marketable yield, and highest benefit-to-cost ratio. Although alternative fertilizer schedules reduced production costs, their lower yields resulted in reduced economic returns. Overall, the three growing-medium compositions performed comparably. Therefore, F1 is recommended for *C. chinense* cultivation, while any evaluated growing medium can be used depending on local availability. Further experiments across different seasons, locations and *C. chinense* cultivars, together with measurements of nutrient uptake and substrate properties, would strengthen the basis for developing fertilizer and growing-medium recommendations for commercial protected cultivation in Sri Lanka.

AUTHOR CONTRIBUTION

RIE conducted the research, analyzed data, and drafted the manuscript. KMCF conceptualized and supervised the study and contributed to data analysis and manuscript drafting. KKLBA supervised the study and contributed to manuscript drafting. RIE and KMCF prepared the final version of the manuscript.

REFERENCES

- Abad, M., Noguera, P., Puchades, R., Maquieira, A. and Noguera, V. (2002) 'Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants', *Bioresource Technology*, 82(3), pp.241-245. [https://doi.org/10.1016/S0960-8524\(01\)00189-4](https://doi.org/10.1016/S0960-8524(01)00189-4)
- Aminifard, M. H., Aroiee, H., Nemati, H, Azizi, M. and Khayyat, M. (2012) 'Effect of nitrogen fertilizer on vegetative and reproductive growth of pepper plants under field conditions', *Journal of Plant Nutrition*, 35(2), pp.235–242. <https://doi.org/10.1080/01904167.2012.636126>
- Anatalia, R., Harsono, P., Yunindanova, M.B. and Purnomo, D. (2022) 'Effect of NPK fertilizer and foliar fertilizer on chilli growth and yield', *Agrotechnology Research Journal*, 6(2), pp.73-79. <https://doi.org/10.20961/agrotechresj.v6i2.54540>
- Anikwe, M.A.N. (2000) 'Amelioration of a heavy clay loam soil with rice husk dust and its effect on soil physical properties and maize yield', *Biore-source technology*, 74(2), pp.169-173. [https://doi.org/10.1016/S0960-8524\(00\)00007-9](https://doi.org/10.1016/S0960-8524(00)00007-9)
- Antony, E. and Singandhupe, R.B. (2004) 'Impact of drip and surface irrigation on growth, yield and WUE of capsicum (*Capsicum annum* L.)', *Agricultural Water Management*, 65(2), pp. 121–132. <https://doi.org/10.1016/j.agwat.2003.07.003>
- Arthanawa, I.G.N., Astika, I.N., Darmawan, I.K., Yana, D.P.S., Situmeang, Y.P. and Sudita, I.D.N. (2022) 'The effects

- of organic and inorganic fertilizers on red chilli plants', *SEAS, Sustainable Environment Agricultural Science*, 6(1), pp.70-80. <https://doi.org/10.22225/seas.6.1.5104.70-80>
- Aruggoda, A.G.B. (2021). 'Morphological interrelationship of selected economically important *Capsicum* spp in Sri Lanka', *Journal of Engineering and Technology of The Open University of Sri Lanka (JET-OUSL)*, 9(2), pp. 49-58.
- Babanjeeth, Talwar, D., Singh, K. and Jindal, S.K. (2022) 'Influence of nitrogen and potassium on growth and yield of chilli (*Capsicum annuum* L.)', *Vegetable Science*, 49(01), pp.41-46. <https://doi.org/10.61180/vegsci.2022.v49.i1.06>
- Banjare, C., Mahanta, D., Sahu, P. and Choudhary, R. (2024) 'A comprehensive review on protected cultivation: Importance, scope and status', *International Journal of Environment and Climate Change*, 14(7), pp. 46-55. <https://doi.org/10.9734/ijecc/2024/v14i74250>
- Baruah, J., Lal, M. (2020) *Capsicum chinense* Jacq.: Ethnobotany, Bioactivity and Future Prospects. In: Singh, B. (eds) *Botanical Leads for Drug Discovery*. Springer, Singapore. https://doi.org/10.1007/978-981-15-5917-4_16
- Bharath, S.M., Cilas, C. and Umaharan, P. (2013) 'Fruit trait variation in a Caribbean germplasm collection of aromatic hot peppers (*Capsicum chinense* Jacq.)', *HortScience*, 48(5), pp.531-538. <https://doi.org/10.21273/HORTSCI.48.5.531>
- Buck, J.S. and Evans, M.R. (2010) 'Physical properties of ground parboiled fresh rice hulls used as a horticultural root substrate', *HortScience*, 45(4), pp.643-649. <https://doi.org/10.21273/HORTSCI.45.4.643>
- Campiotti, C.A., Gatti, L., Campiotti, A., Consorti, L., De Rossi, P., Bibbiani, C., Muleo, R. and Latini, A. (2022). 'Vertical greenery as natural tool for improving energy efficiency of buildings. *Horticulturae*', 8(6), 526. <https://doi.org/10.3390/horticulturae8060526>
- Devi, M.B., Verma, V.K., Talang, H.D., Assumi, S.R., Vanlalruati, H.R., Chanu, L.J. and Hazarika, S. (2022) 'Comparative performance of King Chilli (*Capsicum chinense* Jacq.) under naturally ventilated polyhouse and open field conditions for yield and earliness under agroclimatic conditions of Meghalaya', *Indian Journal of Hill Farming*, 35(02), pp.178-183. <https://doi.org/10.56678/iahf-2022.35.02.26>
- Edirisinghe, H., Pushpakumara, A., Karunaratne, K., Nuwarapaksha, T., Gunaratna, R. (2022) 'Incorporating Guinea Grass and Enriched with Biochar for *Capsicum* Var. Muriya Cultivated under Protected Agriculture System', *Proceedings of the 20th Agricultural Research Symposium, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka*: pp. 589-593.
- Fussy, A. and Papenbrock, J. (2022) 'An overview of soil and soilless cultivation techniques-Chances, Challenges and the Neglected Question of Sustainability', *Plants*, 11(9), 1153. <https://doi.org/10.3390/plants11091153>
- Gogoi, B. (2017) '*Capsicum chinense* Jacq. (Bhut Jolokia)-rich source of capsaicin with wide application and economic potential' *Annals of Plant Sciences*, 6 (8), pp. 1664-1667. <http://dx.doi.org/10.21746/aps.2017.08.003>
- Hall, C. Dawson, T.P., Macdiarmid, J.I., Matthews, R.B. and Smith, P. (2017) 'The impact of population growth and climate change on food security in Africa: looking ahead to 2050', *International Journal of Agricultural Sustainability*, 15(2), pp. 124-135. <https://doi.org/10.1080/14735903.2017.1293929>

- Hewage, S., Bandara, S. and Rathnayake, D. (2022). Local hybrid chilli cultivation and dry chilli production. Hector Kobbekaduwa Agrarian Research Training Institute, Sri Lanka, Technical Report, 48.
- Kamvorn, W., Techawongstien, S., Techawongstien, S. and Theerakulpisut, P. (2014) 'Compatibility of inter-specific crosses between *Capsicum chinense* Jacq. and *Capsicum baccatum* L. at different fertilization stages' *Scientia Horticulturae*, 179, pp.9-15. <https://doi.org/10.1016/j.scienta.2014.09.003>
- Kumara, S.K., Weerakkody, R. and Epasinghe, S. (2015) 'Viability of Controlled Environmental Agriculture for Vegetable Farmers in Sri Lanka', Hector Kobbekaduwa Agrarian Research and Training Institute, Research Report, 179.
- Mishra, G.P., Singh, N., Kumar, H. and Singh, S.B. (2010) 'Protected cultivation for food and nutritional security at Ladakh', *Defense Science Journal*, 60(2), pp. 219–225. <https://doi.org/10.14429/dsj.60.343>
- Nishani, Y.A.R., Shyamalee, H.A.P.A. and Ranawake, A.L. (2025) 'Characterization and diversity analysis of underutilized *Capsicum chinense* L. accessions in Sri Lanka', *Tropical Agricultural Research and Extension*, 28(2), pp 73-91. <https://doi.org/10.4038/tare.v28i2.5754>
- Pramanik, K., Mohapatra, P.P., Pradhan, J., Acharya, L.K. and Jena, C. (2020) 'Factors Influencing Performance of Capsicum under Protected Cultivation: A Review', *International Journal of Environment and Climate Change*, 10(12), pp. 572–588. <https://doi.org/10.9734/IJECC/2020/v10i1230339>
- Priyadharshini, J. and Seran, T.H. (2010) 'Paddy husk ash as a source of potassium for growth and yield of cowpea (*Vigna unguiculata* L.)', *Journal of Agricultural Sciences–Sri Lanka*, 4 (2), pp 67-76. <https://doi.org/10.4038/jas.v4i2.1646>
- Quintero, M.F., Ortega, D., Valenzuela, J.L. and Guzmán, M. (2013) 'Variation of hydro-physical properties of burnt rice husk used for carnation crops: Improvement of fertigation criteria', *Scientia Horticulturae*, 154, pp.82-87. <https://doi.org/10.1016/j.scienta.2013.02.019>
- Rabbi, B., Chen, Z.H. and Sethuvenkatraman, S. (2019) 'Protected cropping in warm climates: A review of humidity control and cooling methods', *Energies*, 12 (14), 2737. <https://doi.org/10.3390/en12142737>
- Ranasinghe, R.A.S. and Weerakkody, W.A.P. (2006), 'Effects of fertilizer dosage and nutrient balance on the growth and nutrient uptake of greenhouse tomatoes', *Tropical Agricultural Research*, 18, pp. 394-398.
- Raphael, O.D., Aniobi, M.M. and Aremu, C.O. (2022) 'The use of rice husk as soilless medium to grow capsicum Chinense: Effect of biochar and irrigation' In IOP Conference Series: Earth and Environmental Science, 1054: 012001). <https://doi.org/10.1088/1755-1315/1054/1/012001>
- Rawung, J.B.M., Sahara, D., Indrasti, R., Mustaha, M.A., Fadwiwati, A.Y. and Yapanto, L.M. (2021) 'Increasing fruit yields and income of red chilli farming by using chemical and biological fertilizers in rainfed rice fields', *Academy of Strategic Management Journal*, 20 (2), pp.1-10.
- Saha, S., Nisa, F.Y., Majid, M., Rafi, M.K.J., Siddique, T.A., Sultana, F., Khan, M.A.N., Ahmed, A.A., Rahman, M.A. and Gholamreza, A. (2024) 'Up regulatory action of antioxidative genes potentiates *Capsicum chinense* Jacq as an antidiabetic functional food evident in biochemical, histopathological, and network pharmacological impacts', *Journal of Functional Foods*, 115, 106103. <https://doi.org/10.1016/j.jff.2024.106103>
- Sharda, R., Singh, A. and Pandey, K. (2023) 'Paddy and maize straw-based media

as an alternative for cocopeat in soil-less cultivation', *Journal of Plant Nutrition*, 46(20), pp.4679-4697. <https://doi.org/10.1080/01904167.2023.2240848>

Sheyoputri, A.C.A. (2024) 'Opportunities and Challenges for Katokkon Chilli (*Capsicum chinense*. Jacq) Agribusiness as a Highland Endemic Crop: Lessons Learned from Indonesia', *Journal of Economics, Finance, and Accounting Studies*, 6(4), pp.37. <https://doi.org/10.32996/jefas.2024.6.4.5>

Shukla, C., Acharya, S.K., Bhakar S.R., and Jamrey, P.K. (2019) 'Effect of different microclimate on the physiological parameters and yield of capsicum', *Horticulture International Journal*, 3(2), pp.61-65. <https://doi.org/10.15406/hij.2019.03.00113>.

Sugiyanta, S. and Kartika, J.G. (2018) 'Increasing production of chilli (*Capsicum annum* L.) through foliar fertilizer application'. *Journal of Tropical Crop Science*, 5(1), pp 34-40.

Tavallali, V., Esmaili, S. and Karimi, S. (2018), 'Nitrogen and potassium requirements of tomato plants for the optimization of fruit quality and antioxidative capacity during storage'. *Journal of Food Measurement and Characterization*, 12(2), pp.755-762. <https://doi.org/10.1007/s11694-017-9689-9>

Wickramarathne, H.G.A.M., Fonseka, R.M. and Somachandra, K.P. (2025) 'Optimization of some Agronomic Practices to Enhance Yield of Scotch Bonnet Pepper (*Capsicum chinense* Jacq.) under Controlled Cultivation', *Tropical Agricultural Research*, 36(2), pp 181-186. <https://doi.org/10.4038/tar.v36i2.8936>