

RESEARCH ARTICLE

STUDY THE CINNAMON (*Cinnamomum verum* J. Presl) YIELD INDICES UNDER MODIFIED PLANTING SYSTEMS

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ABSTRACT

The yield of cinnamon bark is determined by various factors. Number of harvestable stems per plant, harvestable length of a stem and unit bark weight are three major yield indices of cinnamon. Hence, the study was aimed at identifying the impact of spatial pattern, type of planting material and harvesting interval on the yield indices of cinnamon. Seedlings and vegetatively propagated cinnamon; variety Sri Gemunu were planted under three different spatial patterns as 1.2×0.6 m with three plants per hill, 1.2×0.4 m with two plants per hill and 1.2×0.2 m with one plant per hill while maintaining equal planting density in a unit area. Plants were harvested according to two harvesting intervals as 6 and 8 months and the number of harvestable stems per plant and the lengths of harvestable stems (length with brown bark) were recorded during harvesting. The number of harvestable stems per hectare was also calculated. Cinnamon quills were produced and unit bark weight was calculated by dividing the quill weight of each stem from its harvestable length. The results revealed that the effects of treatments were not significant ( $p < 0.05$ ) for the number of harvestable stems per hectare during the first harvest while the interaction effect between planting material and the spatial pattern was significant ( $p < 0.05$ ) for harvestable length and unit bark weight. The interaction effect between planting material and the spatial pattern was significant ( $p < 0.05$ ) during the second harvest for all three yield indices. The number of harvestable stems per hectare was significantly higher ( $p < 0.05$ ) in seedlings than vegetatively propagated plants during the third harvest. Moreover, the interaction effect between planting material and harvesting interval was significant ( $p < 0.05$ ) for the harvestable length of a stem during second and third harvests. Unit bark weight of vegetatively propagated plants was significantly higher than seedlings ( $p < 0.05$ ) during the third harvest.

Keywords: Cinnamon, Seedlings, Spatial pattern, Unit bark weight, Vegetatively propagated plants

INTRODUCTION

*Cinnamomum verum* J. Presl, commonly known as Ceylon cinnamon is a multifaceted evergreen tree mostly well known for the usage of its bark as a spice. The plant belongs to the family Lauraceae and synonym as *Cinnamomum zeylanicum* as it has been originated in the up-country area of Sri Lanka. The down south area of the country owns most of the Country's cinnamon lands which approximately covering 11,159 ha in Galle district, 8,453 ha in Matara district and 3,158 ha in Hambantota district (Fonseka *et al.* 2018). The land area under cinnamon cultivation has been increased by 12.8% during

the period from 2004 to 2014 (Wijesinghe and Weligamage 2018) and still growing. Being a major export agricultural crop in the country, cinnamon contribute largely to the Sri Lankan economy and the export value is about 153.4 million US Dollars during 2019 (Workman 2020).

Though a considerable amount of export income has been generated through cinnamon exports under prevailing conditions, it is a substantially lower value when compared with the potential export income. Low productivity of cinnamon lands has been identified as one of the major factors creating this situation (Samaraweera *et al.* 2020). While the

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potential annual yield is around 1500 kg/ha, the actual annual average yield has been stagnated around 500 kg/ha for a substantial period (Wijesinghe and Weligamage 2018). At the same time, the annual average production of 92% of local cinnamon farmers were under 1000 kg/ha (Jayasinghe *et al.* 2016). Hence the low productivity of cinnamon affects directly the living standards of around 60,000 smallholder cinnamon farmers as it is their primary source of income (Jayasinghe 2011). Productivity of the cinnamon land can be enhanced either by enhancing the overall performance of the land or enhancing the productivity of plants as single units.

Though cinnamon is a tree that can be grown up to about 10 m in height, in commercial cultivations it has been converted into a bush with many shoots through continuous coppicing. Having bark as the unique harvestable portion, to enhance the productivity of cinnamon plants, attention should be given to its yield indices. Three major yield indices have been identified for cinnamon as the number of harvestable stems per plant, length of the harvestable stem (stem with brown bark) and unit bark weight (Pathiratna 2007). By increasing one or more of the above factors, the productivity of a cinnamon plant can be enhanced as well. Therefore, identification of the factors affecting the above yield indices is crucial.

Hence, the study was aimed at identifying the impact of spatial pattern, type of planting material and harvesting interval on the yield indices of cinnamon.

## MATERIALS AND METHODS

The study was conducted at the Faculty of Agriculture, University of Ruhuna, Sri Lanka. The area belongs to the low county wet zone (WL2) which receives more than 2,500 mm annual average rainfall.

### Planting material

Healthy seedlings and vegetatively propagated plants (rooted cuttings) of cinnamon variety Sri Gemunu with a uniform growth were selected.

### Field establishment

Plants were established according to three spatial patterns as (A) 1.2×0.6 m with three plants per hill, (B) 1.2×0.4 m with two plants per hill and (C) 1.2×0.2 m with one plant per hill after initial land preparation. The plot size was 2.4 × 3.0 m with three plant rows. Outer rows and three plants from the border of each side of the middle row were used to control the border effect. The plant density was equal (41,666 plants/ha) for all treatment combinations.

### Data collection and analysis

All the plants were maintained according to the recommendations of the Department of Export Agriculture, Sri Lanka and after two years from the establishment, stems were harvested 10 cm above ground level as the first harvest. Afterwards, plants were harvested according to two harvesting intervals as half of the field in 6 months and the other half in 8 months. Four middle trees from the middle row from every treatment combination were used to collect measurements. As stems were not reached the expected maturity level for the second harvest, another 6 months and 8 months were given for the respective treatments.

The number of harvestable stems per plant was recorded during harvesting and the length of harvestable stem (length with brown bark) was measured. For a better understanding, the number of harvestable stems per hectare was calculated and used for analysis. The bark was peeled off and quills were prepared with the support of skilled cinnamon peelers. The quills were air-dried for three days and quill weight was measured for each stem. Unit bark weight was calculated by dividing the quill weight of each stem from its harvestable length.

The experiment was conducted using three-factor factorial (three spatial patterns, two planting material types and two harvesting intervals) split-plot design with four replications and collected data were statistically analyzed using appropriate statistical techniques.

## RESULTS AND DISCUSSION

According to the results, interaction effects or main effects were not significant ( $p < 0.05$ ) for the number of harvestable stems per hectare during the first harvest (Fig. 1A). During the second harvest, the interaction effect between planting material and the spatial pattern was significant ( $p < 0.05$ ). The highest mean number of harvestable stems per ha (22,569) was recorded in seedlings established under spatial pattern B and it was significantly different ( $p < 0.05$ ) from vegetatively propagated plants established under all spatial patterns (Fig. 1 B). The number of harvestable stems per ha of plants established from seedlings (24,594) was significantly higher ( $p < 0.05$ ) than vegetatively propagated plants (18,518) during the third harvest (Fig. 1C).

Under commercial cultivations, cinnamon plants are converted into bushes with many shoots in different growth stages by continuous coppicing. Coppicing is the process of cutting trees at the base of the trunk in order to produce new shoots (Blake 1983) which considered to enhance the final biomass and an inexpensive alternative for replanting (Verwijst 1996). By identifying the optimum conditions, the number of shoots that reach the preferable maturity level during harvesting can be increased.

In previous studies, plant age has been identified as an important factor affecting the number of harvestable stems per plant. According to Pathiratna (2007), the number of harvestable stems per bush increases with the age of the bush. With age, the bushes become larger and about 5-7 stems can be harvested from a healthy bush around 80 years old (Pathiratna and Perera 2006). In *Populus* spp., an increase in the number of shoots per

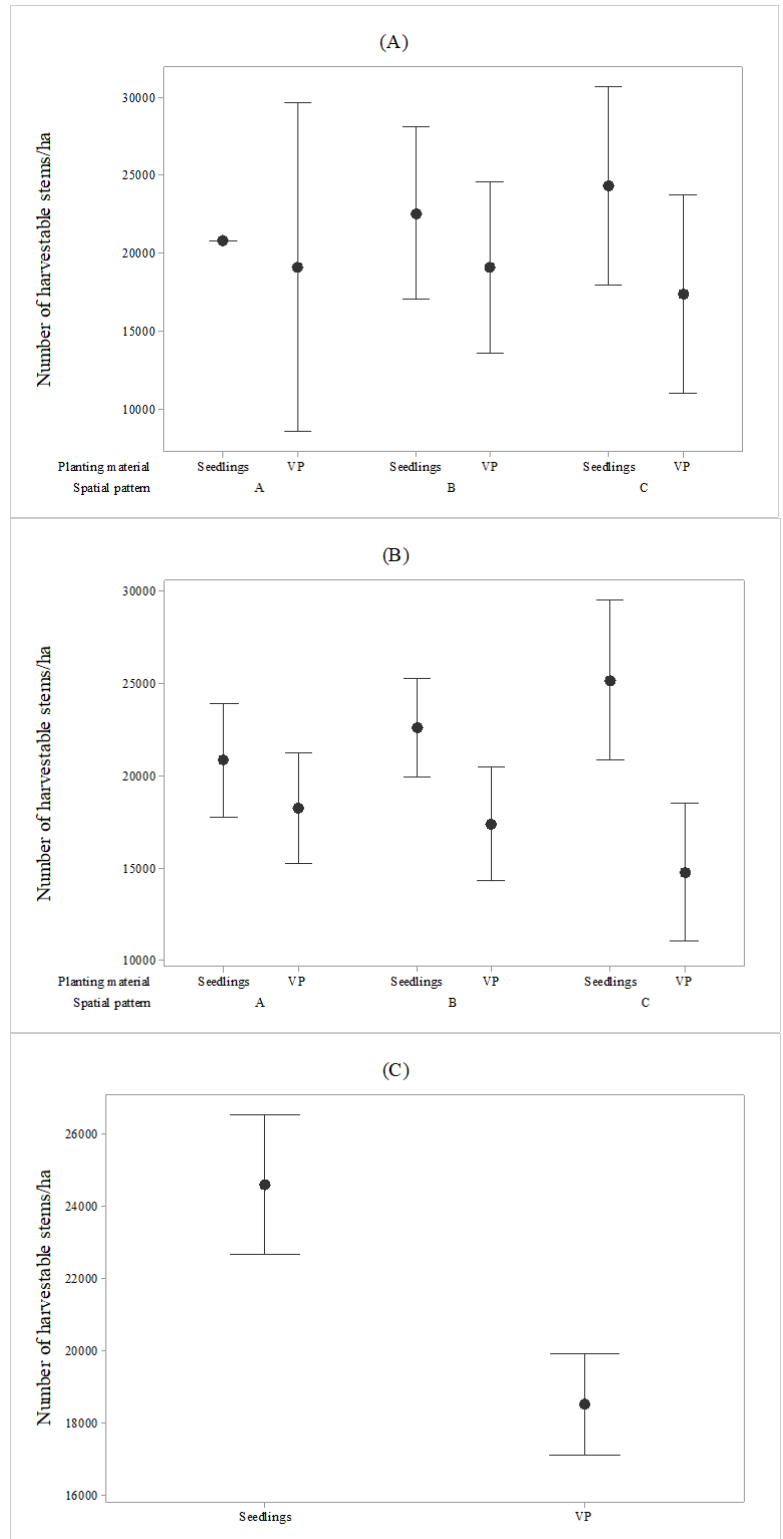


Figure 1 (A): Number of harvestable stems per hectare as affected by planting material and spatial pattern (A: 1.2×0.6 m, 3 plants/hill; B: 1.2×0.4 m, 2 plants/hill, C: 1.2×0.2 m, 1 plant/hill) during the first harvest; (B): Number of harvestable stems per hectare as affected by planting material and spatial pattern during the second harvest; (C): Number of harvestable stems per hectare as affected by planting material during the third harvest.

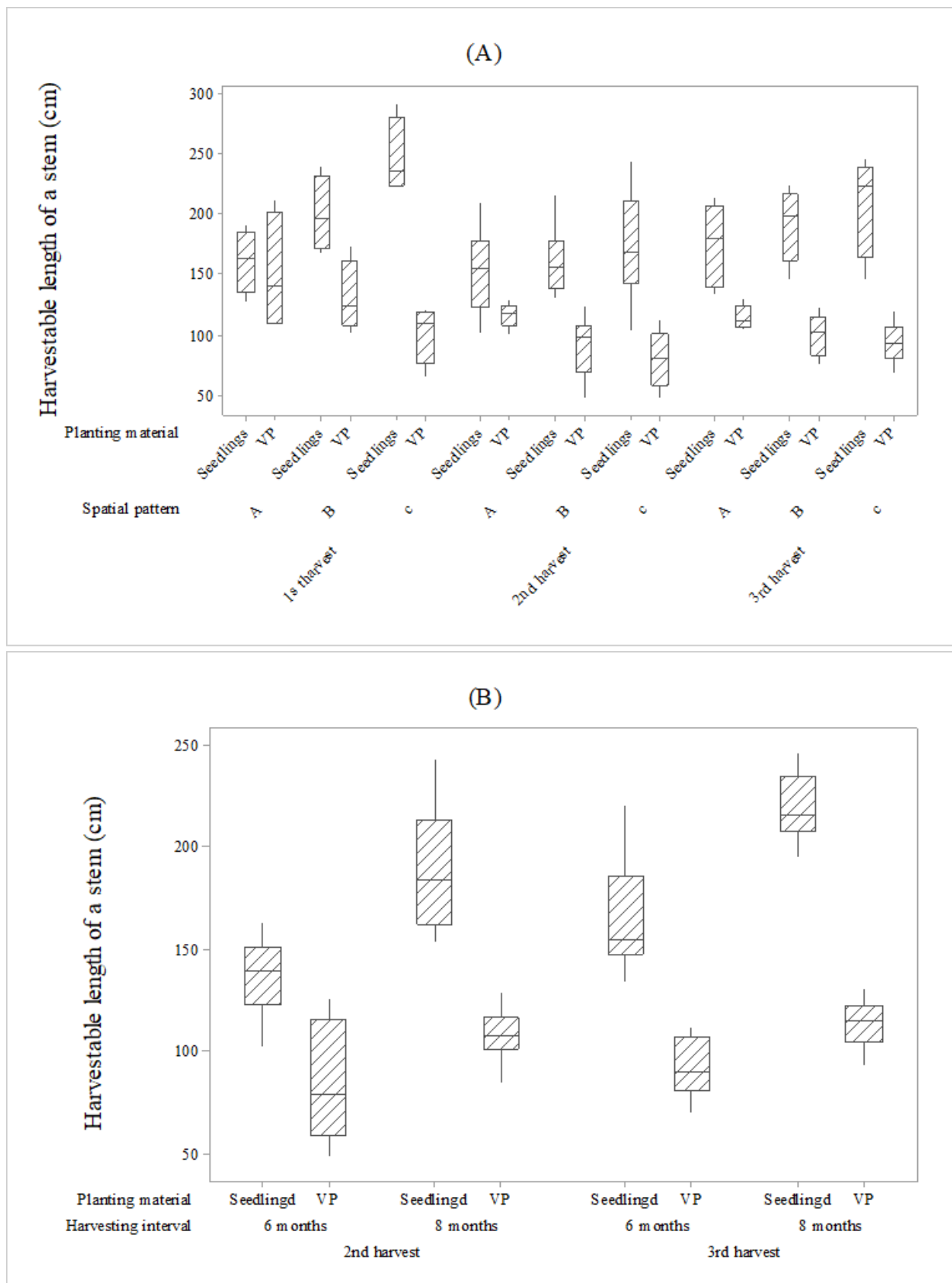


Figure 2: (A) Harvestable length of a stem as affected by Planting material and spatial pattern (A: 1.2×0.6 m, 3 plants/hill; B: 1.2×0.4 m, 2 plants/hill, C: 1.2×0.2 m, 1 plant/hill); (B) Harvestable length of a stem as affected by planting material and harvesting interval.

plant has been observed with increasing the number of coppicing cycles and the course believed to be an enhancement of the vigour of the rooting system with time (Afas *et al.* 2008). The current study revealed that type of planting material, as well as the interaction effect between planting material and spatial pattern also have an impact on the number of harvestable stems.

Cinnamon bark is considered to be harvestable once the green colour turned into brown. Hence, the stem length with brown bark considered as the harvestable length of the stem. Similarly, over matured stems are not harvested as they do not produce high-quality bark. Therefore, the harvestable length of a stem is limited to less than 2.5m as a result of continuous coppicing (Pathiratna 2007). The impact of spatial pattern, type of planting material and harvesting interval was studied during the study in order to identify the optimum combination for the highest harvestable length of a stem.

Both interaction effects (1. Planting material and spatial pattern, 2. Planting material and harvesting interval) were showed a significant effect ( $p < 0.05$ ) on harvestable length of a stem during second and third harvests while the interaction effect between planting material and the spatial pattern was significant ( $p < 0.05$ ) for the first harvest (Fig. 2A and B).

When considering the interaction effect between planting material and harvesting interval, the highest mean harvestable lengths during the second harvest (173.26 cm) and third harvest (208.86 cm) was recorded in seedlings established under spatial pattern C which was significantly different from all other treatments except seedlings established under spatial pattern B during the second harvest and significantly different from all other treatments during the third harvest.

Considering the interaction effect between planting material and harvesting interval, the highest mean harvestable lengths during second harvest (187.62 cm) and third harvest (219.28 cm) was recorded in seedlings established under spatial pattern C which was

significantly different from all other treatments in both harvests.

Plant height is a factor mostly determined by the shade. Pathiratna and Perera (2006) stated that the length of cinnamon sticks has been affected by the mutual shading of plants that occurred due to the reduction of the Red: Far Red ratio within canopies. According to Ballare *et al.* (1995) shade-intolerant species tend to increase shoot height as a defence mechanism for the competition caused by neighbouring plants.

Naturally, seedlings grow tall while vegetatively propagated plants to tend to produce a rather bushy and dwarf structure when compared to seedlings. Hence, mutual shading caused by cinnamon seedlings and vegetatively propagated plants could be different causing the optimum spatial pattern for each planting material different.

Bark thickness has been an important measurement in many studies related to tree bark properties. But the measurement does not provide clear insight and difficult to measure at the same time (Pathiratna 2007). Therefore, unit bark weight is considered as a more promising measurement and one of the three main yield indices of cinnamon.

The interaction effect between planting material and the spatial pattern was significant ( $p < 0.05$ ) for the unit bark weight during the first and second harvest (Fig. 3A) while the impact of planting material was significant ( $p < 0.05$ ) during the third harvest (Fig. 3B).

The highest mean unit bark weight (0.28 g cm<sup>-1</sup>) was recorded in vegetatively propagated plants established under spatial pattern C which was significantly different from all other treatments except vegetatively propagated plants established under the spatial pattern B. The lowest unit bark weight (0.187 g cm<sup>-1</sup>) was recorded in seedlings established under the spatial pattern C.

According to Squire (1990), dry matter distribution through different plant parts varies with the maturity of the plant. Generally, dry matter allocation for vegetative parts is prominent during the early stages

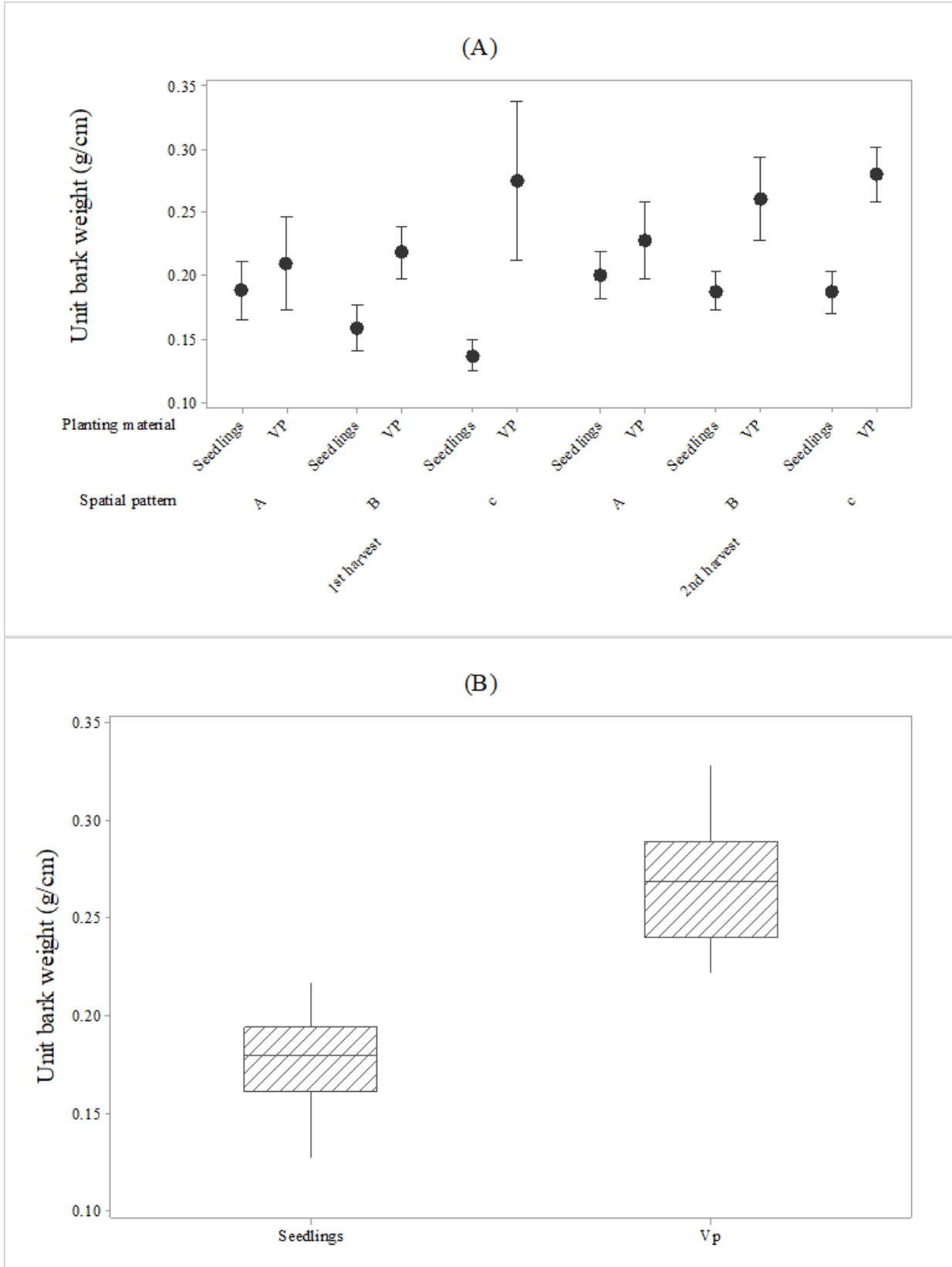


Figure 3 (A): Unit bark weight ( $\text{g cm}^{-1}$ ) as affected by Planting material and spatial pattern (A:  $1.2 \times 0.6$  m, 3 plants/hill; B:  $1.2 \times 0.4$  m, 2 plants/hill; C:  $1.2 \times 0.2$  m, 1 plant/hill) during first and second harvests; (B): Unit bark weight ( $\text{g cm}^{-1}$ ) as affected by Planting material during the third harvest.

while dry matter allocation for reproductive organs becomes prominent with the flower initiation. As flowering of cinnamon occurs during January (Purseglove *et al.* 1981), the month of the year during harvesting also should have a significant impact on unit bark weight of cinnamon. But plants should reach the desired maturity stage and the environmental conditions should be preferable to initiate flowering (Huxley 1996). Continues coppicing in cinnamon cultivations promote shoot initiation and growth throughout the year suppressing reproductive growth. Hence, the plant is maintained under the vegetative stage. Therefore, the harvesting interval did not affect significantly the unit bark weight during the study while the impact of planting material as well as the interaction effect, between planting material and spatial pattern were prominent.

### CONCLUSION

The impact of spatial pattern, type of planting material and harvesting interval were evaluated on the major yield indices of cinnamon. All three factors revealed significant influence as combinations or single factors.

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### Author Contribution

HNA, DLCKF and CKB conceptualized and designed the study. HNA performed the experiments, analyzed and interpret the data. HNA and DLCKF contributed in drafting the manuscript and DLCK and CKB critically revised the manuscript.

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