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# Productivity and carbon sequestration potential of arecanut cultivars

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## ABSTRACT

**A field experiment was conducted at Agricultural and Horticultural Research Station, Thirthahalli, KSNUAHS, Shivamogga, Karnataka, India. Eight arecanut cultivars were evaluated for growth and yield performance for two consecutive years and above-ground carbon sequestration potential and the soil carbon sequestration potential were assessed. The cultivar SAS-1 performed superiorly over other cultivars for all the growth parameters *viz*., plant height, stem diameter, number of leaves and internodal distance. Highest yield of fruit bunch was recorded in the cultivar Mohithnagar (20.28 kg/palm), followed by Thirthahalli local (17.92 kg) and Sreemangala (17.46 kg). Maximum chali/ dried ripe nut yield was recorded in Thithahalli local (3.29 kg), Mohithnagar (3.10 kg) and Sreemangala (2.80 kg). Tender nut yield was also recorded maximum (2.83 kg) in Thirthahalli local, reconfirming the better adaptability to the region over other cultivars under study. Significantly higher values for standing biomass (15.49 t/ha), carbon stock (7.75 t/ha) and carbon sequestration (28.43 t/ha) were recorded in cultivar SAS-1 which are due to its better growth in terms of plant height, stem diameter and number of leaves. Soil parameters *viz*., bulk density, soil organic carbon and carbon stock in soil were analyzed in the rhizosphere of respective cultivars. Maximum soil organic carbon (13.10g/kg and 11.43g/kg at 0-30 & 30-60 cm depths, respectively) and carbon stock (52.77 t/ha at 0-30 cm and 46.41 t/ha at 30-60 cm depth) were recorded in cultivar Sumangala. The study proved that apart from being a commercial plantation crop, arecanut serves as a potential carbon sink.**

**Key words:** *Areca catechu*, Carbon stock, Growth, Yield

## INTRODUCTION

Arecanut (*Areca catechu* L. Family: Arecaceae) is a commercial plantation crop widely grown in the Southern and North Eastern states of the Indian subcontinent. Popularly known as betelnut, it is used for mastication with betel leaves and has a particular ethno-religious importance. Arecanut growing regions are primarily concentrated in the tropical belt between 26° North and 26° South of the equator, and India stands first in the production and consumption of arecanut in the world. India's share in the world area is 62%, accounting for 60% of the production. Indian states of Karnataka, Kerala, Assam, Meghalaya, West Bengal, Andaman and Nicobar Islands are regarded as traditional states for arecanut cultivation and dominate the production. The cultivation has also been extended to Andhra Pradesh, Maharashtra, and Tamil Nadu states. Karnataka dominates the production of arecanut, and much of its production comes from the traditional Malnad region placed in the Western Ghats range. Chikkamagalur is one of the major arecanut growing districts in the region. Local cultivars predominate in traditional belts; however, improved varieties and hybrids are also cultivated. There is a need to evaluate the performance of varieties over the long run in varied agro-climatic regions.

Land and plant resources have been exploited for human needs and greed since civilization, impairing the ecological balance. Burning fossil fuels and destroying forest cover aggravates the problem, leading to the build-up of greenhouse gases (GHGs), predominantly Carbon Dioxide ($CO_2$), one of the major culprits in global warming. Carbon is the major structural element in organic compounds and is an essential non-mineral nutrient element necessary for normal plant growth and development because plants are considered effective sinks that can fix the $CO_2$ during the process of photosynthesis and store the surplus carbon as biomass and add to soil carbon upon senescence and decay. Therefore, capturing atmospheric carbon and fixing it in the soil ecosphere is one of the viable alternatives and is proposed as the premier option for curtailing greenhouse gas emissions. Biological carbon sequestration is a process of capturing carbon from the atmosphere and storing it in the earth's biosphere (Chavan and Rasal, 6). The amount of carbon dioxide sequestered differs with crop species and the amount of biomass produced.

Perennial plantations constitute a potential source for climate change mitigation and are better

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alternatives to enhance the soil organic carbon in situations where forestry is impossible. In the above context, a field trial was conducted to assess the productivity and carbon sequestration potential of areca nut palms.

## MATERIALS AND METHODS

Arecanut cultivars were evaluated at AHRS, Thirthahalli, Karnataka state, India, for two years (2019-20 and 2020-21) for their performance in terms of yield and carbon sequestration capacity. The palms were ten years old and were planted with 2.7 m × 2.7 m spacing in a square system. The statistical design adopted was a Randomized Block Design comprising eight arecanut cultivars (treatments) and replicated thrice. Standard agronomic practices were followed as per the strict schedule of recommendations with respect to nutrient application, weed management, irrigation during summer months, pest management and disease management. The observations on growth parameters *viz*., palm height and stem girth were recorded at harvest. The palm height was measured using a hypsometer (Nikon Forestry Pro) from the collar region of trunk to the point of attachment of crown. Diameter of stem was measured with the help of measuring tape at a height of 1.0 m from the collar region. Fruit bunch and yield parameters were recorded at harvest. Fruit bunches from marked palms were carefully lowered, and the weight was recorded immediately after harvest in the field using a portable electronic weighing balance. The growth and yield observations were made for two consecutive seasons *i.e.* 2019-20 and 2020-21, and the pooled mean of the two years analyzed data are presented.

The aerial biomass was assessed using the regression model given by Prayogo *et al.* (11) for arecanut to assess the above ground carbon sequestration. Accordingly, AGB= 0.03883×H×D1.2 where, AGB= Above Ground Biomass, H = Height of the palm (m), D = Stem Diameter at 1 m height (cm)

The carbon stock in the palm was calculated by multiplying the conversion factor of 0.5 by the AGB (IPCC, 8). $CO_2$ sequestered in the palm was calculated by multiplying the carbon stock in the palm by 3.67 (Balasimha, 2). The soil carbon stock estimation was done by drawing representative soil samples from two different depths in the garden, *i.e.* 0-30 cm and 30-60 cm, at a distance of 60 cm from the palm's base. The organic carbon content of the soil samples was estimated using a TOC analyzer, and the bulk density of soil samples was assessed through the core method as defined by Black (5). Soil carbon stock was estimated by applying the standard formula laid out by Srinivasan *et al*. (16).

C Stock (t/ha) = BD x OC x depth (m) x 10000/1000

Where, C= Carbon, OC= Organic Carbon, BD = Bulk Density

## RESULTS AND DISCUSSION

The cultivars differed significantly in growth and yield performance, as well as biomass production, which, in turn, is reflected in carbon stock and CO2 sequestration. Cultivar SAS-1 was found to be the tallest (9.02 m), while Mangala proved most dwarf (7.06 m). SAS-1 is an improved selection, a tall cultivar recommended for cultivation in the Hill zone of Karnataka. It is suitable for both Chali (ripe nut processing) and Kalipak (tender nut processing). Mangala is a semi-tall variety from ICAR-CPCRI, Kasargod, and is recommended for cultivation in coastal regions of the country for ripe nut processing (Table 1).

Maximum number of leaves (9.84) and stem diameter (18.07 cm) were also recorded in SAS-1. The lowest palm height and stem diameter of 13.14 cm were recorded in Mangala, confirming the earlier reports by Long (10), who classified the plams as tall and dwarf and reported that the tall types have thicker stems than the dwarf ones. A maximum internodal distance of 17.38 cm was recorded in cultivar SAS-1 and the lowest (11.78 cm) in cultivar Mangala. The cultivar Mangala also showed a maximum number of leaves (8.86), whereas it was the lowest in cv. Thirthahalli local (5.79), followed by tall cultivars, namely Sagara Local and SAS-1(Table 1).

In cultivar Mangala, the growth was rapid as evident from more number of nodes, slow vertical increment of stem resulting in lesser internodal distance. These characters are responsible for the semi tall nature of the palm. It can also be presumed that semi tall trait of the cultivar Mangala is manifested regardless of the growing conditions, and environment has no influence on the manifestation of the trait. The differences in morphological traits are ascribed to the congenital traits of the cultivars, and the results conform to those reported by Sane *et al.* (13) and Ray *et al.* (12).

Cultivar Mohit Nagar had the maximum bunch yield of 20.28 kg per palm and it was the lowest in SAS-1(11.77 kg per palm). The tender nut (kalipak) yield was highest in Thirthahalli local (2.83 kg/ palm) and lowest in Mangala (1.81 kg/ palm). Dried ripe nut yield (Chali) of all the cultivars under study was found to be the highest in Thirthahalli local (3.29 kg/ palm) and lowest in Sumangala (2.24 kg/palm). Mohit Nagar and Mangala cultivars proved best suited for ripe nut processing, whereas SAS-1 and Thirthahalli local were best suited for tender nut processing. The results revealed the superiority of Thirthahalli local

**Table 1.** Performance of arecanut cultivars for growth traits.

| Arecanut Cultivars | Height of the palm (m) | Diameter of stem (cm) | Number of leaves | Internodal distance (cm) | Number of nodes (up to 1 m height) |
|---|---|---|---|---|---|
| Thirthahalli local | 7.25 | 17.10 | 5.79 | 15.55 | 9.34 |
| Sagara local | 7.64 | 16.88 | 5.99 | 17.31 | 9.63 |
| Tarikere local | 8.24 | 14.68 | 6.75 | 16.52 | 9.29 |
| SAS-1 | 9.02 | 17.38 | 6.01 | 18.07 | 9.84 |
| Mangala | 7.06 | 11.78 | 8.86 | 13.14 | 9.54 |
| Sumangala | 7.21 | 15.92 | 6.49 | 14.52 | 9.54 |
| Sreemangala | 8.02 | 15.56 | 6.39 | 16.66 | 9.68 |
| Mohit Nagar | 7.95 | 16.47 | 6.18 | 14.78 | 9.84 |
| S.Em ± | 0.28 | 0.69 | 0.36 | 1.01 | 0.22 |
| C.D. (5%) | 0.78 | 2.07 | 1.09 | 3.01 | 0.67 |

cultivar in terms of yield and reconfirmed the better adaptability to the region over other cultivars under study. The findings support the earlier findings of Ray *et al.* (12), who also observed superior performance of local cultivars of the region over the released varieties for yield (Table 2).

Above ground biomass of the palm, above-ground carbon stock, and CO2 sequestration varied significantly among the arecanut cultivars (Table 3). The cultivar SAS-1 recorded the highest above-ground biomass of 15.49 t/ha, carbon stock of 7.75 t/ha and CO2 sequestration of 28.43 t/ha, followed by Tarikere local. In contrast, the lowest values for above-ground biomass (8.27 t/ha), carbon stock (4.14 t/ha) and CO2 sequestration (15.18 t/ha) were recorded in cultivar Mangala. These variations in the cultivars for the said parameters could be attributed to the differences in the palm height and stem diameter among the cultivars, which are genetically controlled. The results agree with those of Bhagya *et al.* (4), Bhagya and Suresh (3), Singh *et al.* (15) and Kumar and Maheswarappa (9).

**Table 2.** Performance of arecanut cultivars for yield.

| Cultivars | Bunch yield (kg/palm) | Dried ripe nut yield (Chali) (kg/palm) | Tender nut (Kalipak) yield (kg/palm) |
|---|---|---|---|
| Thirthahalli local | 17.92 | 3.29 | 2.83 |
| Sagara local | 13.58 | 2.37 | 2.24 |
| Tarikere local | 15.31 | 2.63 | 2.30 |
| SAS-1 | 11.77 | 2.73 | 2.09 |
| Mangala | 14.93 | 2.31 | 1.81 |
| Sumangala | 14.60 | 2.24 | 1.89 |
| Sreemangala | 17.46 | 2.80 | 2.35 |
| Mohit Nagar | 20.28 | 3.10 | 2.49 |
| S.Em ± | 1.68 | 0.17 | 0.15 |
| C.D. 5% | 5.08 | 0.51 | 0.42 |

**Table 3.** Estimated above ground biomass, carbon stock and $CO_2$ sequestration of arecanut cultivars.

| Cultivars | Standing biomass (t/ha) | Carbon stock (t/ha) | $CO_2$ sequestration (t/ha) |
|---|---|---|---|
| Thirthahalli local | 10.40 | 5.20 | 19.08 |
| Sagara local | 12.46 | 6.23 | 22.87 |
| Tarikere local | 12.71 | 6.35 | 23.32 |
| SAS-1 | 15.49 | 7.75 | 28.43 |
| Mangala | 8.27 | 4.14 | 15.18 |
| Sumangala | 9.52 | 4.76 | 17.48 |
| Sreemangala | 12.49 | 6.25 | 22.93 |
| Mohit Nagar | 10.73 | 5.36 | 19.68 |
| S.Em ± | 0.70 | 0.41 | 1.26 |
| C.D. 5% | 2.12 | 1.23 | 3.78 |

Soil bulk density exhibited no significant variation among the different cultivars of arecanut during the study (Table 4). Significant differences in organic carbon (OC) content were observed at both depths in the root zones of the studied cultivars. Maximum soil organic carbon content was recorded in that of Sumangala at 0-30 cm (13.10 g/kg) and 30-60 cm (11.43 g/kg) depth, and the least organic carbon content (8.33 g/kg at 0-30 cm and 7.82g/kg at 30-60 cm) was recorded with cultivar Mangala. The results are in corroboration with the findings of Apurva *et al.* (1).

**Table 4.** Bulk density and carbon status of the soil in the rhizosphere of different arecanut cultivars.

| Cultivars | Bulk density (g/cc) | | Organic carbon (g/kg) | | Carbon stock in soil (t/ha) | |
|---|---|---|---|---|---|---|
| | 0-30 cm | 30-60 cm | 0-30 cm | 30-60 cm | 0-30 cm | 30-60 cm |
| Thirthahalli local | 1.34 | 1.36 | 12.28 | 9.17 | 49.25 | 37.33 |
| Sagara local | 1.33 | 1.36 | 9.51 | 7.90 | 37.83 | 32.09 |
| Tarikere local | 1.33 | 1.35 | 12.59 | 8.13 | 50.22 | 32.76 |
| SAS-1 | 1.34 | 1.35 | 9.76 | 8.07 | 39.11 | 32.75 |
| Mangala | 1.34 | 1.35 | 8.33 | 7.82 | 33.40 | 31.73 |
| Sumangala | 1.34 | 1.35 | 13.10 | 11.43 | 52.77 | 46.41 |
| Sreemangala | 1.33 | 1.35 | 12.14 | 8.97 | 48.16 | 36.42 |
| Mohit Nagar | 1.34 | 1.35 | 11.55 | 8.85 | 46.31 | 35.74 |
| S.Em ± | 0.01 | 0.00 | 0.56 | 0.62 | 2.09 | 2.50 |
| C.D. 5% | NS | NS | 1.69 | 1.89 | 6.35 | 7.59 |

Significant variations were noted for the soil organic carbon stock in the rhizosphere among the cultivars (Table 4). Maximum soil carbon stock was recorded with the cultivar Sumangala (52.77 t/ha at 0-30cm and 46.41 t/ha at 30-60 cm depth). The lowest content of soil carbon stock was noticed in the rhizosphere of cultivar Mangala (33.40 t/ha at 0-30cm and 31.73 t/ha at 30-60 cm depth). Similar observations were reported by Shinde *et al.* (14) and Ghavale *et al.* (7).

The ability of plants to sequester atmospheric carbon varies between the species and within the species due to differential morpho-physiological parameters. The varietal difference in plant growth may be chiefly attributed to their genetic constitution, which will remarkably influence the plant biomass, carbon stock and CO2 sequestration potential. Besides being a commercial plantation crop, arecanut can also be appraised as a potential carbon sink to alleviate the excess CO2 from aerospace, thereby contributing to the well-being of the earth's atmosphere. Further studies in this line are needed in arecanut based cropping systems and other plantation crops to document their carbon sequestration potential.

## AUTHORS' CONTRIBUTION

Conceptualization of research (Maheshwarappa, HP; Bhoomika, HR); Designing of the experiments (Bhoomika, HR; Maheshwarappa, HP); Execution of field/lab experiments and data collection (Manasa R. Hegde); Analysis of data and interpretation (Manasa R. Hegde; Bhoomika, HR, Maheshwarappa, HP); Preparation of the manuscript (Bhoomika, HR).

## DECLARATION

The authors do not have any conflict of interest

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## REFERENCES

1. Apurva, V., Ganapathi and Mallesh, K. U. 2018. A study of selected carbon fractions in soil under arecanut based cropping systems of Coastal Zone of Karnataka. *Int. J. Curr. Microbiol. App. Sci.***7**: 2184-92.
2. Balasimha, D. 2011. Carbon sequestration potential in cocoa plantations. *Seminar on Strategies for Enhancing Productivity of Cocoa,* CPCRI, RS, Vittal, January 28-29,p. 111-15.
3. Bhagya, H. P. and Suresh, K. 2018. Carbon sequestration potential in oil palm- cocoa cropping system grown in Andhra Pradesh under irrigated conditions. *Int. J. Curr. Microbiol. App. Sci.,***7**: 358-62.
4. Bhagya, H. P., Maheswarappa, H. P., Surekha and Bhat, R. 2017. Carbon sequestration potential in coconut-based cropping systems. *Indian. J. Hortic.*,**74**: 1-5.
5. Black, C.A. 1965, Methods of soil analysis part-I, Physical and minerological properties agronomy monograph no.9, *American Soc. Agron. Inc.*, Madison, Wisconsin, USA, pp. 18-25.
6. Chavan, B. and Rasal, G. 2012. Total sequestered carbon stock of *Mangifera indica*. *Environ. Earth Sci.,* **2**: 37-48.

7. Ghavale, S. L., Shinde, V. V., Wankhede, S. M., Maheswarappa, H. P. and Haldankar, P. M. 2020. Carbon Sequestration and Productivity Potential of Coconut (*Cocos nucifera* L.) Hybrids and Varieties under Coastal Eco-System of Maharashtra. *Curr. J. Appl. Sci. Technol.***39**: 30-37.

8. IPCC (Intergovernmental panel on Climate Change), 2003. In: Penman J. *et al.,* (eds.) Good practice guidance for land use, land use change and forestry (GPG-LULUCF), IPCC-IGES, Japan.

9. Kumar, K. S. N. and Maheswarappa, H. P. 2019. Carbon sequestration potential of coconut-based cropping systems under integrated nutrient management practices. *J. Plant. Crops,* **47**: 107-14.

10. Long, V. V. 1993. Coconut selection and breeding programme in Vietnam. In: Advances in Coconut Research and Development. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 107-114.

11. Prayogo, C., Sari, R. K., Asmara, D. H., Rahayu, S. and Hairiah, K. 2018. Allometric equation for Pinang (*Areca catechu*) biomass and C stocks. *AGRIVITA J. Agric. Sci*., **40**: 381-89.

12. Ray, A. K., Borah, A. S., Ananda, K. S. and Maheswarappa, H. P. 2008. Performance of different varieties of arecanut in Assam. *J. Plant. Crops,* **36**:73-74.

13. Sane, A., Ananda, K. S., Kumar, S. N. S., Sannamarappa, S. And Ramanujam, B. 2002. Yield performance of arecanut (*Areca catechu* L.) varieties in Maidan region of Karnataka. *J. Plant. Crops,* **30**: 22-26.

14. Shinde, V. V., Maheswarappa, H. P., Ghavale, S. L., Sumitha, S., Wankhede, S. M. and Haldankar, P. M. 2020. Productivity and carbon sequestration potential of coconut-based cropping system as influenced by integrated nutrient management practices. *J. Plant. Crops,* **48**: 103-10.

15. Singh, S. L., Sahoo, U. K., Kenye, A. andGogoi, A. 2018. Assessment of growth, carbon stock and sequestration potential of oil palm plantations in Mizoram, Northeast India. *J. Environ.*, **9**: 912-31.

16. Srinivasan, V., Maheswarappa, H.P. and Lal, R. 2012. Long term effects of topsoil depth and amendments on particulate and non-particulate carbon fractions in a Miamian soil of Central Ohio. *Soil Tillage Res.* **121**: 10-17.


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