www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(11): 441-445

www.thepharmajournal.com
Received: 28-07-2022
Accepted: 30-09-2022

Murali V
Assistant Professor, Department of Agronomy, College of Horticulture, SKLTSHU, Telangana, India

Gowthami P
Assistant Professor, Department of Crop Physiology, College of Horticulture, SKLTSHU, Telangana, India

Prashanth Kumar A
Scientist, Department of Plant Pathology, JVR Horticultural Research Station, SKLTSHU, Telangana, India

Gajanand P
Assistant Professor, Department of Agricultural Extension, Horticultural Polytechnic College, SKLTSHU, Telangana, India

Corresponding Author:
Murali V
Assistant Professor, Department of Agronomy, College of Horticulture, SKLTSHU, Telangana, India

Carbon sequestration potential of different mango cultivars in the tropical hot and semi-arid climate of Deccan Plateau, India

Murali V, Gowthami P, Prashanth Kumar A and Gajanand P

Abstract
The present study was aimed to measure the carbon sequestration potential of ten different mango cultivars belonging to different eco-geographical regions of India planted in a mother orchard located in semiarid climatic conditions of Deccan plateau. There was a marked difference in the biomass compartmentalization and carbon sequestration potential of the varieties. After 10 years of planting, varieties with low carbon sequestration potential (<1.5 e- CO_2 metric ton tree^{-1}) were Cheruku rasam, Alphonso and High carbon sequestration potential (> 3.0 e- CO_2 metric ton tree^{-1}) were Jehangir and Langra respectively. The varieties with moderate carbon sequestration potential were Baneshan, Pedda rasam, Suvarna rekha, Himayat and Dasheri. The newly established orchard growers and horticulturists may use this information to claim carbon credits for the benefit of farmers.

Keywords: Mango, eco-geographical regions, grafted plants, carbon sequestration potential

Introduction
Mango (*Mangifera indica*) is regarded as "king of fruits" and is the leading fruit crop of India. Mango occupies about 36% of the total area under fruits (2019-20) comprising of 2.3 million hectares, with a total production of 20.44 million tons, contributing 40.50% of the total world production of mango (National Horticultural Board, 2022) [8]. Major mango producing states area wise are Andhra Pradesh (16.5%), Uttar Pradesh (12.1%), Odisha (8.3%), Karnataka (7.7%) and production wise Uttar Pradesh (23.4%) ranks first closely followed by Andhra Pradesh (23.1%). In Telangana mango is cultivated in 1, 28, 000 ha with productivity of 992 kg ha^{-1} (Horticulture Statistics Division, DAC&FW, 2021) [5].

Mango fruits are utilized at all stages of development, raw fruits are used for making chutney, pickles and ripened fruits are used as desert, also used in the preparation of squashes, syrups, nectars, jams and jellies. Mango varieties can be propagated by both seed sowing and vegetatively through grafting, layering and cuttings. Polyembryonic varieties are true to parental type and propagated through seeds. The monoembryonic varieties are not true to parental characteristics and hence grafted onto seedling rootstocks with pre-selected scion material of superior varieties from mother orchards. The root stock becomes the lower trunk and root system of the tree and scion becomes the canopy of the tree having similar characteristics of mother plant.

Mango varieties in India, exhibit a wide variation in flowering, fruit forms, flavours and tastes. The names of mango varieties signify quality, lateness or earliness, size and shape of fruit, name of the place, rivers, king's name, skin colour or in local dialects. Over 1200 varieties are said to be exist in the country and only a few varieties are commercially cultivated (Mukherjee, 1948) [7]. In comparison to other fruit crops, mango is hardy in nature, can be grown on a variety of soils and in different agro-climatic zones, with less orchard management costs. Environmental factors like rainfall, temperature and humidity has greater influence on growth and flowering behavior of mango varieties. Most of the Indian mango varieties have specific eco-geographical requirements for optimum growth and fruiting. South Indian variety such as Neelam if grown in North India, remain dormant and Performance of the north Indian varieties like 'Langra' and 'Dashehari' if grown under south Indian conditions, shows sparse flowering and fruiting was observed (Kishore *et al*., 2015 and Singh *et al*., 2011) [6, 11]. It is estimated that, total C sequestered per mango tree across the country varied from 446.2 to 934.7 kg tree^{-1} and, grafted mangoes sequestered 733.03 kg C tree^{-1}, thus Indian mango orchards had carbon sequestration potential of 285.005 m t of carbon (Ganeshamurthy *et al*., 2019) [4].

Each carbon credit corresponds to one metric ton of reduced, avoided or removed CO_2 or equivalent Green House Gases (GHG). Carbon credits can be used by a company or an individual to compensate for the emission of one ton of CO_2 or equivalent gases by purchasing carbon credits generated by the plantation projects. The current market price for the each carbon credit was valued at USD$ 50 to 100 /tCO_2e (Metric tons of carbon dioxide equivalent (World Bank 2022)). With integration of government schemes such as Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) on area expansion of horticultural crops, small farmers were able to grow perennial fruit crops such as guava, sapota, mango, coconut, amla, custard apple on marginal soils. Once established, these orchards turn into prospective carbon sinks as they can capture a large quantity of C in their vegetation. Orchard growers can sell the surplus of carbon credits to producers who emit higher amounts of greenhouse gases (GHGs). Further, linking these orchards to carbon markets would help the small and marginal farmers earn extra revenue. It is customary practice by the mango growers to establish multi-varieties in orchards primarily to extend harvest season, enhance farm income, reduce the yield and price risks.

The study objectives are to characterize the varieties and estimate the above and below ground biomass and carbon sequestration potential of different mango cultivars belonging to different eco-geographical regions of India, planted in a mother orchard under semi-arid climatic conditions of Deccan plateau.

Materials and Methods

The study site is located in the Horticultural college farm (latitude 16 ^{0} 44 '92"N and longitude 77 ^{0}94'03" E), Wanaparty district, Telangana state, India. The average annual minimum temperature is 22.0 ^{o}C and maximum temperature is 33.4 ^{o}C. The average annual rainfall is 770.8 mm with approximately 50 rainy days. Relative humidity is extremely low in this region for major part of the year which ranges between 32 to 50%, while it is highest (72%) during south west monsoon period (July- September).

Establishment of Mother Block

During 2012 planting season, mango orchard with ten superior grafted varieties procured from Fruit research Station (FRS), Sangareddy belonging to different eco-geographical regions of India was established in the college farm. For each variety, 4 trees were planted at 10 m x 10 m spacing, 1m X 1m x 1m Pits were dug, filled with FYM, Vermicompost, Neem cake and recommended fertilizers. The details of mango varieties planted in the mother orchard, their eco-geographical origin, fruit ripening time, utilization aspects and special characteristics are briefly described in Table 1. The orchard site is slightly alkaline in pH 8.4 and EC: 2.2 dS m^{-1}, low in Organic matter, low in available major nutrients status 75.3 kg N ha^{-1} N, 3.9 kg P_2O_5 ha^{-1} and 88.5 kg K_2O respectively. In maintaining orchard good horticultural practices like minimum tillage, raining cover crops such as cowpea and Daincha, inter cropping with seasonal vegetables such cluster bean, okra, French bean and Dolichos bean were grown.

Table 1: Eco-geographical region of different mango varieties used in the study and their special characteristics

Eco-geographical region	Cultivar	Ripening time[$]	Purpose	Special characteristics
South India	Baneshan	Early	Table	Large sized fruit, obliquely oval in shape, golden yellow in colour; good keeping quality.
	Pedda rasam	Late	Juice	Regular bearer, fruit is juicy and aromatic with a lemon-yellow color, the pulp is fibrous. Mainly suitable for coastal area.
	Suvarna Rekha	Early	Table	Medium ovate oblong fruit, green in colour with prominent red blush on the shoulders; good keeping quality; Heavy bearer.
	Cheruku Rasam	Late	Juice	Cheruku literally means "sugarcane" and Rasalu means "juicy", It is sweetest and juiciest mango variety from Andhra Pradesh.
	Himayat	Late	Juicy	Also known as Imam Pasand. Fruit has thin outer skin, thin seed and abundant pulp inside.
North India	Dasheri	Mid season	Table	Fruit is small-medium size with yellow fruit colour, flesh is fibreless; good keeping quality, used for table purpose.
	Jehangir	Late	Table	Fruit shape resembles apple. It is best consumed when it looks green and 'tight' as inside, the fruit would be ripe and ready to eat. Once it turns orange on the outside, it is best used for juice or pulp. It has a strong flavour and fragrance that are typical to desi mango.
	Langra	Mid-season	Table	Langra is a famous variety originated from Varanasi, Uttar Pradesh. Alternate bearing Vigorous and spreading type; Fruit is medium, ovate in shape with light green colour; poor keeping quality; skin is very thin and pulp is very sweet.
Eastern India	Chausa	Late	Table	The chausa variety of mango was made popular by the Indian ruler Sher Shah Suri while commemorating his victory over Humayun at Chausa, Bihar. Variety had sweet pulp and bright yellow skin with long shelf life.
Western India	Alphonso	Mid-season	Table & Juicy (Dual)	Famous Variety from Konkan region, named after Portuguese general Afonso de Albuquerque, who helped to establish colonies in India (Ganeshamurty *et al*., 2019) []. Exported variety with firm flesh, varied skin color ranging from purple to yellow. Fruit is medium in size, ovate oblique in shape, Excellent keeping quality, used for pulping and canning;

[$]Early season: late January to early March; Mid season: mid March to May; Late season: June- early August;

Allometric measurements

Allometric parameters of standing trees such as collar diameter (mm), diameter below and above the graft union over bark (mm) were measured using tree caliper. Number of primary and secondary branches, diameter of primary and secondary branches was also determined. Tree height (H) in meters (m) was measured with Ravi Multimeter /Altimeter; Crown radius (m) was measured from the base of the tree in the four cardinal directions by sighting vertically to determine crown edge and then measuring the distance to the base of the tree. Light intensity under the canopy was estimated using LUX meter (Digital LUX meter, Model: TES 1332A) and the values were expressed as irradiance (W m^{-2}) by using a conversion factor of Lux*0.00795. Measurements taken on four cardinal directions were used to classify the canopy architecture in to circular or semi circular, symmetrical or asymmetrical spread types.

Carbon sequestration potential measurements

a) Diameter over bark (D): Above and below ground biomass of trees were estimated using non destructive methods. Grafted mango varieties tend to form more than one trunk or main branches and there is no possibility to measure diameter at breast height (DBH). In such cases, the diameter over bark (D) of such trees was computed by taking the square root of the sum of all squared stem diameters of primary and secondary branches (Nimbalkar *et al*., 2017) [9].

$$D = \sqrt{(a)^2 + (b)^2 + (b)^2 + (d)^2}$$

Where,
a, b, c, d are the diameters of individual branches.

b) Tree volume over the bark (VOB): This was estimated by using the regression equation for multi branched trees as suggested by Bohre *et al*., 2013 [1].

$$VOB = -0.017 + 0.003\ D + 0.0014H + 1.899 \times 10^{-5}\ D^2H$$

(Coefficient of Determination R^2=0.986; Standard Error (SE) = 0.00497)

VOB = tree volume over the bark in m^3;
D = diameter of the tree in cm;
H = height of the tree in meter;

c) Above ground biomass (AGB): Above ground biomass (AGB) was calculated by multiplying wood volume, wood density and biomass expansion factor (BEF)

$$AGB = VOB \times WD \times BEF \times 1000$$

Where,
AGB = Above Ground Biomass;
VOB = Volume of the tree over bark;
WD = Wood density g cm^{-3}; Wood density of the mango was taken as 0.68 from the online data base (https://www.wood-database.com/mango/)
BEF = Biomass expansion factor that includes leaves, twig and branches. Biomass expansion factor varies with stand age *i.e* at 3 years old it was 0.93 and gradually increased to 1.63 at the age of 8 years followed by gradual decline towards 1.12 at the age of 20 years (Ganeshamurthy *et al*., 2016) [2]. However constant biomass expansion factor is used in forestry and agroforestry studies. We used constant biomass expansion factor of 1.5 to account for these component biomasses as suggested by Nimbalkar *et al*., 2017 [9].

d) Below ground biomass (BGB): The below ground biomass (BGB) has been calculated by multiplying above-ground biomass taking 0.26 as the root to shoot ratio (Ganeshamurthy *et al*., 2019) [4].

$$BGB = AGB \times 0.26$$

e) Total Biomass: Total Biomass was determined by adding the above and below ground biomass of respective tree.

$$\text{Total Biomass} = AGB + BGB$$

f) Total carbon content: Based on published values, the carbon content is approximately 50% of the total biomass based on dry weight (Paladinic *et al*., 2009) [10].

$$\text{Total carbon} = \text{Total biomass} \times 0.50$$

g) Carbon sequestration potential: Total carbon sequestration potential of trees was expressed in terms of equivalent CO_2 $tree^{-1}$ by multiplying with a factor 3.67 (Molecular weight of CO_2 to molecular weight of Carbon ratio).

$$\text{Carbon sequestration potential (e- } CO_2 \text{ tree}^{-1}) = \text{Total carbon} \times 3.67$$

Allometric data and carbon sequestration potential values of trees of the same variety were averaged (sample size = 4) and presented in this research.

Results and Discussion

The northern, southern, western and eastern regions of India have distinct mango varieties and adaptation to the local climatic conditions. The carbon sequestration potential in fruit trees are influenced by latitude, water availability, nutrients, temperature, atmospheric gases, plant age and variety, etc factors. All the grafted trees were shown ground level branching and maximum number of branches was formed in Jehangir variety and forking habit was observed in Suvarana Rekha variety (Table 2). Under wider spacing options, early stage - branch pruning was not practiced in mango orchards. Consequently genotypes adjust to the climatic conditions present their natural growth habit. The mean diameter of trees varied across varieties, the lowest diameter was for the cherukurasam variety (16.02 cm) and the highest for Jehangir variety (33.03 cm) followed by Langra (30.47 cm), which shows trees robustness and the dominance of North Indian varieties.

East coast of Andhra Pradesh is home to many juicy type of mangoes known as 'Rasalu' types, *viz*., Cheruku rasam and pedda rasam varieties had similar allometric parameters that of Alphonso variety from the West coast Konkan region. These varieties are adapted to high rainfall with tropical hot and humid climatic conditions in contrast to the low rainfall and dry climatic conditions of Deccan plateau. The North Indian varieties Jehangir and Langra had put forth robust growth compared to the Dasheri variety and often these varieties tend to bear in alternate years. In North India, climate subtropical temperate climatic conditions prevail in

contrast to the semi-arid tropical climate of Deccan plateau. The baneshan, popular variety that widely grown in Telangana was comparatively dwarfed in stature than north Indian varieties. In the present study, Langra, Dasheri, Alphonso varieties with circular crown and dense foliage needs regular pruning or centre opening so as to enable light penetration on to the lower branches.

Tree canopies vary by spacing, pruning and climatic conditions. The variations in plant stature traits such as dwarfness or robustness, branching pattern and other morphological traits may be related to the genotypic differences which in turn evolved due to a wide range of environmental conditions prevailing in this country.

Table 2: Allometric parameters of different mango varieties

Variety	Primary branches	Mean diameter (cm)	Tree height (m)	Crown radius (m)	Irradiance values (W m^{-2})	Tree habit
Baneshan	2.3	18.89	2.9	1.95	4.412	Circular crown, erect and dense foliage
Pedda rasam	2.3	24.17	2.3	1.60	14.493	Circular crown, erect and sparse foliage
Suvarna Rekha	2.0	20.53	2.6	1.60	13.443	Circular crown, erect and sparse foliage
Cheruku Rasam	2.3	16.08	2.1	1.40	14.334	Circular crown, erect and sparse foliage
Himayat	3.3	23.14	3.0	2.95	7.155	Semi-circular Spreading crown dense foliage
Dasheri	2.8	19.39	2.6	2.80	6.750	Semi-circular Spreading crown dense foliage
Jehangir	3.3	33.02	2.4	2.70	9.484	Circular crown erect and sparse foliage
Langra	3.5	30.47	3.2	3.00	5.899	Circular crown, erect dense foliage
Chausa	2.8	18.20	2.4	2.30	15.319	Semi circular crown, sparse foliage
Alphonso	2.5	18.60	2.7	2.50	5.342	Circular crown, erect dense foliage

Table 3 provides information on biomass compartmentalization and total carbon content of trees derived by using standard empirical formulae. There was a marked difference in the biomass compartmentalization and carbon sequestration potentials of varieties. Carbon-credit systems allow agricultural producers to earn extra revenue through selling their surplus of carbon credits to producers who emit higher amounts of greenhouse gases (GHGs).

Unlike seed origin mango trees, grafted mangoes are dwarf statured and commercial productivity begins at the age of 6 years and declines after 40 years. At the age of 10 years, varieties with low carbon sequestration potential (<1.5 e- CO_2 metric ton tree $^{-1}$) were Cheruku rasam, Alphonso and High carbon sequestration potential (> 3.0 e- CO_2 metric ton tree $^{-1}$) were Jehangir and Langra respectively. The varieties with moderate carbon sequestration potential were Baneshan, Pedda rasam, Suvarna Rekha, Himayat and Dasheri. The newly established orchard growers and horticulturists may use this information to claim the carbon credits for the benefit of dryland farmers.

Table 3: Variation in biomass production (kg $tree^{-1}$) and carbon sequestration potential (e- CO_2 metric ton tree $^{-1}$) of different mango varieties.

Variety	AGB (kg $tree^{-1}$)	BGB (kg $tree^{-1}$)	Total Biomass (kg $tree^{-1}$)	Total Carbon (kg C $tree^{-1}$)	Carbon sequestration Potential (e- CO_2 metric ton tree $^{-1}$)
Baneshan	653	169	822	411	1.510
Pedda rasam	862	224	1087	543	1.995
Suvarna Rekha	732	732	922	515	1.693
Cheruku Rasam	463	120	584	292	1.072
Himayat	928	241	1169	584	2.146
Dasheri	657	170	828	414	1.520
Jehangir	1510	392	1903	951	3.493
Langra	1393	362	1755	877	3.223
Chausa	568	147	715	358	1.314
Alphonso	615	160	775	388	1.422

Conclusion

Mango orchards rose by the small and marginal farmers with integration of horticultural crops area expansion or rural employment guarantee scheme are less recognized for their carbon sequestration potential. Irrespective of the eco-geographical region of the varieties, crown spread, light penetration to the ground level varied that can be attributed to the normal cultivar growth habit. At the age of 10 years, grafted mango varieties had mean carbon sequestration potential ranged between 1.072 to 3.493 e- CO_2 metric ton tree $^{-1}$. This study demonstrated that mango based tree farming benefit the small holder's livelihoods as well as mitigating the climate change.

References

1. Bohre P, Chaubey OP, Singhal PK. Biomass accumulation and carbon sequestration in Linn and *Gmelina arborea* Roxb. International Journal of Bio-Science and Bio-Technology. 2013;5(3):153-174.
2. Ganeshamurthy AN, Ravindra V, Venugopalan R, Mathiazhagan M, Bhat RM. Biomass distribution and development of allometric equations for non-destructive estimation of carbon sequestration in grafted mango trees. Journal of Agricultural Science. 2016;8(8):201.

3. Ganeshamurthy AN, Kalaivanan D, Rajendiran S. Carbon sequestration potential of perennial horticultural crops in Indian tropics. In Carbon Management in Tropical and Sub-Tropical Terrestrial Systems. Springer, Singapore; c2020. p. 333-348.
4. Ganeshamurthy AN, Ravindra V, Rupa TR. Carbon sequestration potential of mango orchards in India. Curr Sci. 2019;117(12):2006-2013.
5. Horticulture Statistics Division, DAC & FW, Department of Agriculture and cooperation, Farmers Welfare; c2021.
6. Kishore K, Singh HS, Kurian RM, Srinivas P, Samant D. Performance of certain mango varieties and hybrids in east coast of India. Indian Journal of Plant Genetic Resources. 2015;28(3):296-302.
7. Mukherjee SK. The varieties of mango (*Mangifera indica* L.) and their classification. Bull. Bot. Soc. Bengal. 1948;2:101-133.
8. National Horticultural Board. National horticulture board. Department of agriculture and cooperation; c2022.
9. Nimbalkar SD, Patil DS, Sharma JP, Daniel JN. Quantitative estimation of carbon stock and carbon sequestration in smallholder agroforestry farms of mango and Indian gooseberry in Rajasthan, India. Environment Conservation Journal. 2017;18(1&2):103-107.
10. Paladinić E, Vuletić D, Martinić I, Marjanović H, Indir K, Benko M, Novotny V. Forest biomass and sequestered carbon estimation according to main tree components on the forest stand scale. Periodicum Biologorum, 2009;111(4):459-466.
11. Singh Gill M, Navprem S, Singh N, Gill PPS. Performance of mango cultivars under sub-mountane zone of sub-tropics of India. In Global Conference on Augmenting Production and Utilization Of Mango: Biotic and Abiotic Stresses. 2011;1066:27-33.
12. World Bank. State and Trends of Carbon Pricing 2022. State and Trends of Carbon Pricing. Washington, DC: World Bank. © World Bank; c2022. https://openknowledge.worldbank.org/handle/10986/37455 License: CC BY 3.0 IGO.
13. Kaur C, Selvakumar G, Ganeshamurthy AN. Acid tolerant microbial inoculants: a requisite for successful crop production in acidic soils. InPhyto and Rhizo Remediation. Springer, Singapore; c2019. p. 235-247.