Biomass production carbon storage capacity and nutrient export in natural rubber

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Abstract

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Assessment of Biomass, nutrient accumulation and carbon stock are important in the cultivation of long duration plantation crops like rubber (*Hevea brasiliensis*) for beneficial managements in terms of economic and environmental sustainability of the ecosystem. Three rubber trees of clones RRII 105, RRII 203 & GT 1 at the age of 30 years, grown on a sandy clay loam Ultisol were destructively sampled to estimate the biomass production, nutrient export through the accumulated biomass and carbon storage. The trees were uprooted and fresh weight of each plant parts were recorded. A portion of the subsamples was oven dried to estimate the biomass and nutrient content. Results of the study indicated the total dry biomass (1140 - 2045kg/tree), carbon stock (479 - 860kg/tree) and carbon storage potential (148 -258T carbon/ha) for three rubber clones at the age of 30 years. The average nutrient export due to biomass removal was estimated and found to be N = 1555.4, P = 201.5, K = 1700.5, Ca = 3292.8, Mg = 573.2 and Zn = 5.89, Cu = 2.63, Fe = 108.07 & Mn = 17.67 kg/ha in each planting cycle of 30 years period. Timber yield in rubber ranged from 556 - 949kg/tree. Study reveals that the economic return in forms of timber and the environmental protection by higher carbon storage capacity are promising in rubber plantations. However, the nutrient export through biomass removal may be compensated with additional nutrition and proper management to sustain the soil productivity. Removal of potassium, calcium, magnesium and nitrogen was high as compared to phosphorous. Very less removal (178.6 - 226.5kg/ha) of phosphorous was observed in rubber. Among micronutrients, removal was more for Fe & Mn.

Key words: Rubber (*Hevea brasiliensis*), Biomass, nutrient export, carbon storage capacity

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Introduction

Biomass accumulation, carbon storage potential and nutrient uptake are the specific genetic factors of each plant species. Biomass studies are essential to understand the site productivity, nutrient requirement, nutrient drain, nutrient budgeting environmental impact etc., of the ecosystem to attain sustainable management strategies. Since biomass is the sink and source of carbon capturing, it is having an important role in the context of growing international concern over the increase of CO_2 in the atmosphere. Rubber, the important primary source of natural rubber is a quick growing tree species accumulating a good amount of biomass during its life span of about 25-30 years.

The commercial cultivation of rubber (*Hevea brasiliensis*), a native tree species of Brazil was started in 1902 and extended to a total area of 7.37 lakh hectare including traditional and non-traditional areas all over India. Since rubber is a long duration plantation crop covering large areas all around, the estimation of biomass, nutrients locked up and carbon stock assessment will help to understand the economic, social and environmental outcome of the ecosystem for adoption of necessary management practices to attain the sustainability of the cultivation system. Present study was undertaken to estimate biomass production, carbon stock and nutrient export in rubber trees in a 30 years old rubber plantation.

Materials and methods

30 year old rubber trees viz RRII 105, RRII 203 & GT 1 having different yield potential and timber production grown on sandy clay loam Ultisols at Central Experiment Station, Chethackal of Rubber Research Institute of India was selected for the study. Trees were destructively sampled and separated into different plant components viz trunk, branches, leaf & root. Fresh weight of each component was taken using standard field balance.

A portion of the components was collected and dried at 70 ºC for estimation of moisture content to calculate biomass and nutrients (macro & micro), to know the nutrient concentration in the tree. Using this, nutrient export for 300 trees was calculated to obtain nutrient drain per hectare of rubber plantation. Nutrient export was calculated based on the assumption that the leaf and root were not removed from the field and allowed to decompose in the field itself. Therefore, leaf and root was not included in the estimation of nutrient export.

From the total biomass obtained, the carbon stock in the tree is calculated considering the carbon composition of rubber tree as 42 per cent, that is derived from the carbon content in various plant parts of rubber trees (Jacob 2003). Using this, the carbon storage potential of rubber plantation was calculated for 300 trees per hectare area, which is the general stand per hectare in old mature rubber plantation.

Results and discussion

General characteristics of the trees selected for this study as per the approved cultivars classification of RRII is given in Table 1. RRII 105, RRII 203 &GT1 are classified as category I & II clones

Table 1. General characteristics of clones (approved cultivars classification)

Clone	Classification	Yield potential kg/ha/year	Area of cultivation
RRII 105	Category - I	2210	Traditional region
RRII 203	Category - II	1818	Non-traditional region
GT 1	Category - II	1420	Traditional & non-traditional region

Table 2. Height, girth & biomass production in 30 year old rubber clones

Clone	Height (m)	Girth (cm)	Dry biomass (kg/tree)
RRII 105	10	102	1254
RRII 203	15	105	1140
GT 1	15	132	2045
Mean ± SE	13.33 1.66	113 9.54	1479.66 285.03

respectively. The yield potential of these trees is different (Approved cultivars 2012). Among this RRII 203 & GT1 are classified as latex-timber clone. Clones with above average yield and high timber volume was classified as latex-timber clone. The popular clone RRII 105 is a latex clone. RRII 105 is widely cultivated in the traditional area and RRII 203 is spreading in non-traditional areas.

Height, Girth and biomass production of the clones are given in Table 2. Girth and biomass produced varied among the trees. Height of the trees did not vary much. Higher girth of about 132cm was recorded by GT I. Mean height and girth of the tree were 13.33m and 113cm respectively. Highest dry biomass was recorded in GT I (2045kg) and lowest by RRII 203 (1140 kg). The biomass production of three trees was in the range of 1140-2045kg with a mean value of 1479.66kg/tree. Karthikakuttyamma (1997) reported the total biomass of 1303 kg/tree for clone RRII 105 at the age of 20 years. Jessy (2004) reported the total biomass of 1049.92kg/tree for the clone PB 217 at the age of 19 years. The biomass allocation into the tree components showed different pattern (Table 3). Generally more

Table 3. Distribution of biomass in tree components (kg DW)

Clones	Tree components				
	Trunk	Branches	Leaf	Root	Total
RRII 105	556 (44.31)	504 (40.13)	56 (4.46)	138 (11.1)	1254
RRII 203	738 (64.13)	298 (26.14)	17 (1.49)	87 (7.63)	1140
GT I	949 (46.4)	926 (45.28)	37 (1.8)	133 (6.5)	2045
Mean ± SE	748 113.55	576 184.83	37 11.26	119 16.23	1480 81.46

Table 4. Nutrient export through biomass in rubber trees (kg/ha)

Clone	Nutrient export (kg/ha)								
	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn
RRII 105	1052.4	178.6	1436.2	4410.1	307.2	5.4	1.76	42.48	17.17
RRII 203	1219.8	199.6	1993.8	2897.8	421.1	4.04	2.85	109.85	8.88
GT 1	2393.6	226.5	1670.7	2568.9	991.3	8.1	4.49	171.87	26.97
Mean ± SE	1555.4 421.94	201.5 45.47	1700.5 343.08	3292.8 566.92	573.2 211.6	5.89 1.19	2.63 1.14	108.07 37.36	17.67 5.23

biomass was accumulated in trunk and branches (85 - 91.7 %) than leaf and root (8.3 - 15 %). Among the trees the two timber trees viz.. GT 1 & RRII 203 recorded more biomass allocation in the trunk (738 & 949kg) respectively than RRII 105 (556kg).

Clear bole volume is an indicator of the timber yield of a clone since the clear bole contributes 60 per cent of the timber recovered from a rubber tree (Mydin *et al.*, 2007). When three clones compared, the allocation of leaf biomass (4.46 %) and root biomass (11.1%) was found to be more in RRII 105 than other trees. Root biomass was around 10 per cent in all trees.

Nutrient export through biomass was calculated (Table 4). Nutrient export was in the range of N=1052.4 - 2393.6, P = 178.6 - 226.5, K = 1436.2-1993.8, Ca=2568.9 - 4410.1, Mg=307.2-991.3 and micronutrients Zn=5.4-18.1, Cu=1.76-4.49, Fe=42.48-171.87 & Mn=8.88-26.97kg/ha. Since the branching habit and biomass accumulation is different in different clones nutrient export varied widely between clones.

More difference is noted in the case of calcium. This may be due to that the percent calcium content was more in plant parts especially in trunk and branches which contribute major parts of biomass removed from the field. Calcium is an immobile element in the plant and hence it is continuously accumulating when age is advancing. Higher Ca, K, and N removal when compared to other nutrients from the soil is observed after 30 years period. P removal was very less in rubber.

Among the micronutrients, Fe and Mn recorded higher removal than Zn and Cu. Removal of copper is less in rubber and Ulaganathan et al 2010 reported that accumulation of copper in soil in successive cycles of rubber cultivation. Biomass accumulation of rubber trees was earlier reported by Karthikakuttyamma (1997) and Jessy (2004) for the clone RRII 105 for macronutrients and PB 217 for both macro and micronutrients respectively. Nutrient loss per hectare (300 trees) for RRII 105 (Karthikakuttyamma (1997) was 1800 kg N, 210 kg P,1500 kg K, 2700 kg Ca and 1050 kg Mg with a biomass accumulation of 1303

Table 5. Carbon stock and carbon storage potential in rubber trees

Clone	Carbon stock (kg/tree)	Carbon storage potential (T carbon /ha)
RRII105	527	158
RRII203	479	148
GT I	860	258
Mean ± SE	622 119.95	188 31.84

kg per tree at the age of 20 years. The nutrient accumulation per tree (Jessy, 2004) was 8.071 kg N, 0.807kg P, 5.642kg K, 16.9kg Ca, 2.498kg Mg , 0.193kg Fe, 0.0458kg Mn, 0.036kg Zn and 0.176kg Cu for the clone PB 217 with a biomass accumulation of 1049.92kg per tree at the age of 19 years.

Higher accumulation of Ca followed by N and K was reported in these studies also. Concentration of Ca in older leaves and woody tissues were much greater than those in the other parts of the tree. Ca accumulated the greatest amount of nutrient in citrus tree followed by N and K (Mattos *et al* ., 2003). Biomass production and nutrient uptake was different for different species of viz., bamboo (Kumar *et al*., 2005) and sweet orange (Mattos *et al*., 2003)

The Ca and Fe content in three other tree species viz., Pollalesta discolor and Inga densiflora (Davidson *et al*., 1999) and beech (Fagus sylvatica L) trees (Ljungstrom *et al*., 1993) is least which was the opposite pattern as we found in rubber. However a similar nutrient uptake was reported in apple trees (Sharma *et al*., 1995)

The carbon stock calculated is given in Table-5 Carbon accumulation in rubber tree is in the range

of 479-860kg/tree with a mean value of 622kg/tree for three clones studied. Trees having higher total biomass recorded more carbon locked up in its components.

The carbon storage potential of the clones viz., RRII 105, RRII 203, and GT1 were 158T, 148T and 258T carbon / ha respectively with an average value of 188 T carbon/ha. Thus the carbon storage potential of rubber plantation is comparatively higher and promising.

Conclusion

Biomass production, nutrient export and carbon storage capacity is different in rubber clones. Due to higher removal of Ca, K and N, necessary input and management practices have to be included in the recommendations for maintaining the soil productivity.

Economic benefits through timber yield are high in rubber trees. Higher carbon sequestration capacity of rubber trees is the additional advantage in the international scenario of reduction of CO_2 in the atmosphere to protect the environment.

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