CARBON SEQUESTRATION POTENTIAL OF RRII 400 SERIES CLONES OF *HEVEA BRASILIENSIS*

K. K. Ambily, T. Meenakumari, M. D. Jessy, A. Ulaganathan and N.Usha Nair.

Rubber Research Institute of India, Kottayam–686 009, Kerala, India

Received: 08 May 2012 Accepted: 21 July 2012

Ambily, K.K., Meenakumari, T., Jessy, M.D., Ulaganathan, A. and Nair, N.U. (2012). Carbon sequestration potential of RRII 400 series clones of *Hevea brasiliensis*. *Rubber Science,* **25**(2): 233-240.

Sequestering atmospheric CO_2 through tree cultivation is an environmentally acceptable option. Recently the Rubber Research Institute of India released several high yielding clones of *Hevea* (RRII 400 series) and the present study was taken up to determine the carbon sequestration potential of these clones by two methods *viz.* conventional tree felling and allometric equation without tree felling. The trees planted in a clone evaluation trial in RBD design with three replication at RRII, Kottayam were used for the study. The clones selected were RRII 414, RRII 417, RRII 422, RRII 429 and RRII 430 and RRII 105. In the first method, carbon stock per tree was determined using the carbon content of plant parts *viz.* trunk, branches, leaf and root and the carbon sequestration potential of clones at the plantation level was estimated. In the second approach, the biomass accumulation at different growth stages was estimated using allometric equation based on girth of the trees for a period of 17 years the carbon accumulated at each growth stage was estimated assuming the carbon content as 42 per cent of the biomass. The study showed that the clones varied in growth pattern, biomass accumulation and carbon sequestration potential. The carbon sequestration potential of RRII 429 was 113.73 t/ha and it was significantly superior to that of all the other clones. The clones RRII 414 and RRII 417 also had a significantly higher carbon sequestration potential than RRII 105.

Keywords: Biomass, Carbon sequestration potential, *Hevea brasiliensis*, RRII 400 series clones

Global warming due to green house gases (GHG) emission and associated climate change are important concerns. Reduction of GHG emissions limitting the temperature increase to 2 - 2.5 °C by 2050 is necessary (UNCTAD, 2009). Land use systems differ in their ability to sequester atmospheric CO_2 and perennial tree crops are better than annual crops since they can sequester carbon for longer time. *Hevea brasiliensis*, the primary source of natural rubber in the world, is a fast growing and high biomass producing perennial tree crop ecosystem and in general it attains 50 cm girth in the first 7 years. Rubber trees can stock large amounts of carbon in their standing biomass and the rubber wood used for making diverse long term products and rubber sheets used for tyre manufacture constitute an additional fixed carbon sink. Carbon sequestration potential of world's rubber plantations is to the tune of 0.0782 Pg C/yr (Jacob, 2003) and it reduces 2 per cent of the current rate of rise in atmospheric CO_2. In view of the importance of biomass estimates and carbon storage trees in the

Correspondence: K. K. Ambily (Email: ambili@rubberboard.org.in)

global C-cycle, the present study was aimed to estimate the carbon sequestration potential of recently evolved modern *Hevea* clones.

The sample trees were selected from a small scale clone evaluation trial established during 1985 in the experimental farm of Rubber Research Institute of India, Kottayam. Average daily temperature in this central zone of Kerala ranges from 28-32 °C and annual precipitation varies between 2000-2500 mm. The experiment design was RBD with 3 replications and four trees per plot. All cultural operations were carried out uniformly as recommended by the Rubber Board (Karthikakuttyamma *et al*., 2000). The assessment of carbon sequestration potential through biomass estimation carried out for five clones from RRII 400 series and RRII 105 as control. The RRII 400 series clones were resultant of a cross between RRII 105 (female parent) and RRIC 100 (male parent). RRIC 100 is a vigorous and high yielding clone from Sri Lanka. Five clones from the 400 series *viz*. RRII 414, RRII 417, RRII 422, RRII 429 and RRII 430 were high yielding than RRII 105 (Licy *et al*., 2003; Mydin and Mercykutty, 2007).

In the present study, there were two separate methods for the biomass estimation *viz*. conventional destructive method (above and below ground dry biomass) by tree felling and non-destructive method (total above ground standing tree dry biomass) using allometric equation. In the first method, 36 trees of 23 years age were felled and total height (m) and girth (cm) were recorded. The felled trees were separated into different parts *viz*. trunk, branches, leaf and root. Total fresh weight (kg) of each of these plant parts were recorded using field balance and a portion of each plant part of every tree were collected and fresh weights were recorded. Samples were dried in air oven at 70 °C for the estimation of total dry biomass (above ground and below ground). The carbon content in plant parts was estimated from the biomass using the carbon content of each plant parts separately (James, 2003) and from this the total carbon content of the trees was estimated. The carbon sequestration potential of clones per hectare was determined on the basis of 350 trees per ha, which is the approximate stand in mature plantation.

In the second method, carbon stock and carbon sequestration were determined by using the growth curve. Relationship of shoot weight with girth (cm) of trees at breast height (150 cm from bud point) in *Hevea* trees has already been proved (Shorrocks *et al*., 1965). The relationship is expressed as

$$\text{Shoot weight (kg)} = 0.002604\,(G)^{2.7826}$$

Shoot is defined as all above ground parts of the plant and 'G' is the girth in cm. This equation was used to estimate the above ground standing biomass and based on this the carbon stock of the tree was calculated with the carbon content as 42 per cent of the total above ground biomass. In the present experiment growth measurements were taken up to the age of 17 years for all clones and the data was used for preparing the growth curve. From the growth curve the carbon sequestration potential of clones was calculated directly with 350 trees per ha as in the first method.

Growth parameters of the clones studied are given in Table 1. Tree height ranged from 18-21 m and there was no significant difference between clones. Girth of the trees ranged from 65 to 98 cm. Among the RRII 400 series RRII 429 recorded the

Table 1. **Growth parameters of the clones.**

Clone	Height (m)	Girth (cm)	Total biomass Dry weight (kg)
RRII 414	20	92	736
RRII 430	18	75	419
RRII 429	19	98	793
RRII 422	18	65	377
RRII 417	21	89	713
RRII 105	19	68	407
CD(P=0.05)	NS	6.39	41.35

highest girth and was on par with RRII 414. Total dry biomass varied between clones and it ranged from 377 to 793kg/tree. The highest biomass accumulation was observed in RRII 429 (793 kg/tree) and the lowest biomass accumulated in RRII 422 (377 kg/tree) which was on par with RRII 105 (407.15 kg/tree). Biomass accumulation (kg) in plant parts varied among clones (Table 2) and the biomass partitioning per cent to woody tissues (trunk, branches and roots) and leaves were different for different clones (Fig.1). Among the plant parts, more biomass was distributed to branches in all clones followed by trunk, root and leaves. Leaves and roots recorded the lowest biomass. There was no significant difference in the trunk biomass between clones, but in clones with higher biomass the major share (about 70%) was distributed to branches.

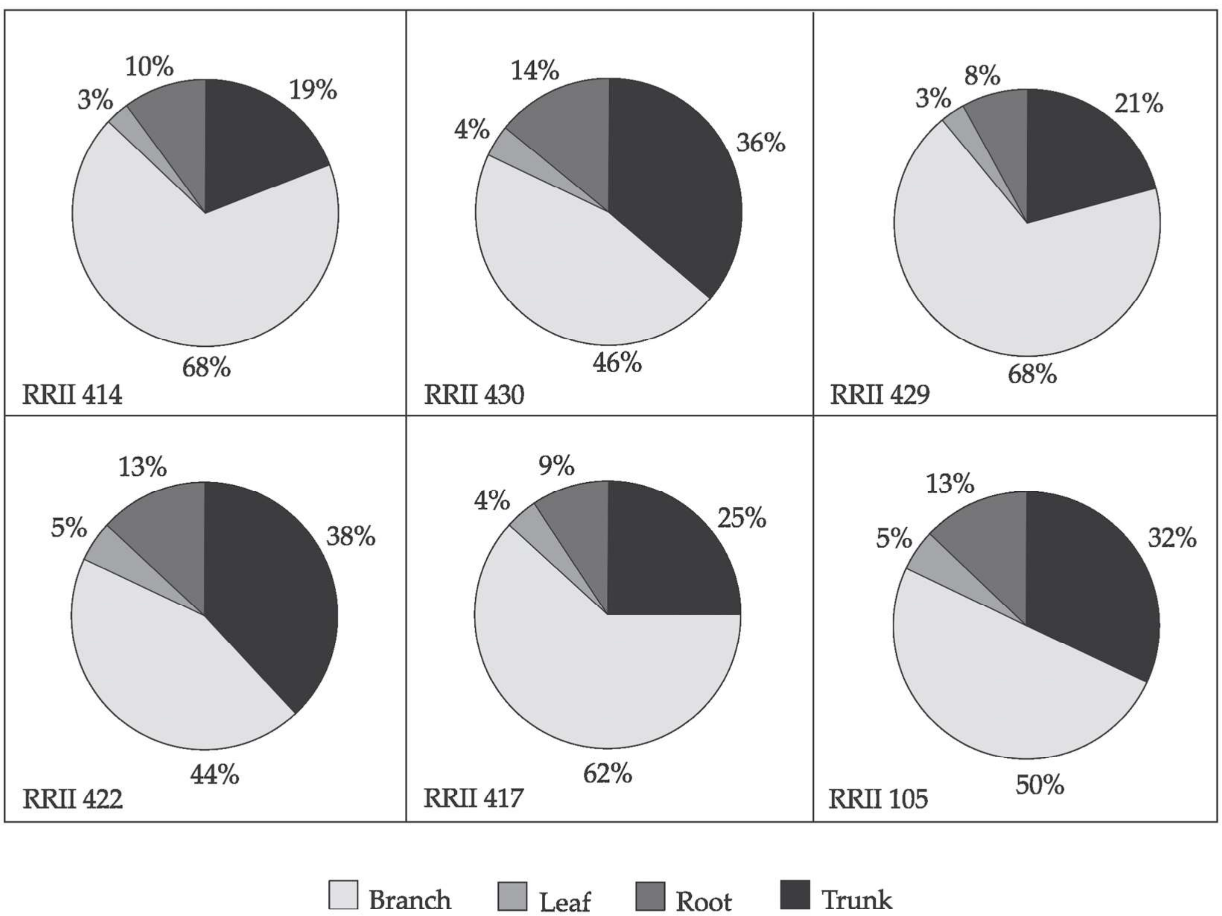

Fig.1. Biomass partitioning in different clones

Table 2. **Biomass distribution in different plant parts**

Clone	Dry Biomass (kg)			
	Trunk	Branches	Leaf	Root
RRII 414	1389 (19)	515 (68)	20 (3)	76 (10)
RRII 430	158 (36)	197 (46)	11 (4)	58 (14)
RRII 429	162 (21)	544 (68)	19 (3)	66 (8)
RRII 422	153 (38)	180 (44)	23 (5)	49 (13)
RRII 417	177 (25)	425 (62)	20 (4)	60 (9)
RRII 105	129 (32)	210 (50)	22 (5)	60 (13)
CD (P=0.05)	NS	53.61	0.73	3.18

Values in parenthesis are per cent distribution of biomass

Hence, the timber yield (trunk volume) was not compromised due to higher biomass accumulation in branches in the clones RRII 429, RRII 417 and RRII 414 which showed higher carbon sequestration potential.

Carbon stock in rubber trees

Generally, carbon content in plants ranges from 40-50 per cent of the total dry biomass. Cerrillo and Oyonarte (2006) reported that the amount of carbon sequestered in the above ground phytomass of each ecosystem was assumed to be of 50 per cent of the predicted biomass from its allometric equation. The carbon captured in the biomass of rubber clones was different (Table 3). The highest carbon stock (kg/tree) was in the clone RRII 429 (325) followed by RRII 414 (301) and RRII 417 (292) as compared to RRII 105 (163). Among the RRII 400 series clones lowest carbon stock was recorded by RRII 422 (154) followed by RRII 430 (172) which was on par with RRII 105 (163).

Table 3. **Carbon stock/tree and C- sequestration potential at 23 years**

Clone	Carbon stock (kg/tree)	C-seq.pot. (t/ha)
RRII 414	302	106
RRII 430	172	60
RRII 429	325	114
RRII 422	154	54
RRII 417	292	102
RRII 105	163	57
CD(P=0.05)	14.47	5.06

Carbon sequestration potentiel

The carbon sequestration potential of clones at plantation scale is given in Table 3. Carbon sequestration potential of RRII 400 series clones was 44-49 per cent higher than the current popular clone RRII 105 except the clone RRII 422 and RRII 430. Carbon sequestration of rubber plantation within 30-year life period investigated in Hainan Island, China was 272 t/ha (Cheng *et al.*, 2007) which was higher than the rain forest (234 t/hm^2) unit and secondary rain forest (150 t/hm^2). The carbon sequestration potential of teak plantation was found to be 120 t/ha (Kraenzel *et al.*, 2003). In the earlier study the carbon sequestration potential of *Hevea* plantations was 142 t C/ha (Jacob, 2003). Kaou and Panwar (2008) reported that the potential of carbon storage can be further increased using improved planting materials. By using improved planting materials and increasing the number of trees per unit area without compromising the yield along with appropriate management practices will help in increasing the carbon storage in lesser time on the same land management unit.

Traditionally, biomass of trees was estimated through direct methods (destructive or extractive), including both

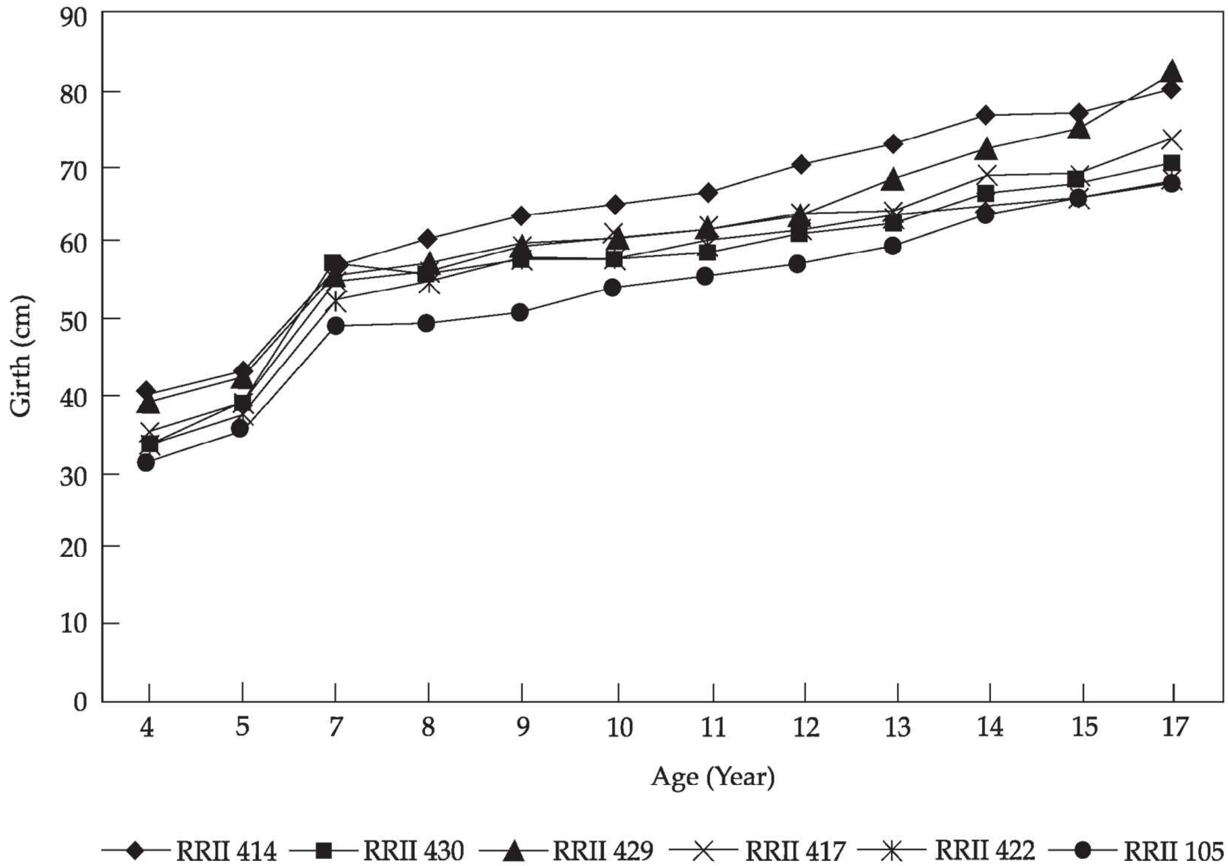

Fig.2. Growth curve of clones

above ground and belowground biomass, but the extraction of large number of tree samples especially for mature trees well established root system is very laborious and costly (Uresket *et al.*, 1977). Indirect method using allometric equation with easily measurable basal growth parameters like girth of plants gives estimates that can equal the prediction level of the conventional method. In addition, it permits a large number of observations at a relatively low cost at any time and at any age (Uso *et al.*, 1977; Montes *et al.*, 2000). Understanding the relationship between the age of a tree stand and its biomass accumulation is essential for estimating the carbon storage in the standing biomass. This information is further essential especially for farmer's benefit if the carbon crediting is to be implemented. The growth curve (Fig. 2) showed that the girths of the trees of different clones are different and the initial growth patterns up to 7 years are similar for all clones. The biomass accumulation pattern (Fig. 3) showed similar trend till 12 years and after this period, the pattern diverged and RRII 414 and RRII 429 accumulated more biomass than RRII 417, RRII 430, RRII 422 and RRII 105. Carbon storage potential (Fig. 4) of the clone RRII 414 and RRII 429 were found to be higher than RRII 417, RRII 430, RRII 422 and RRII 105. Alexandrov (2007) reported that the growth pattern of a forest stand is species specific and site-specific and

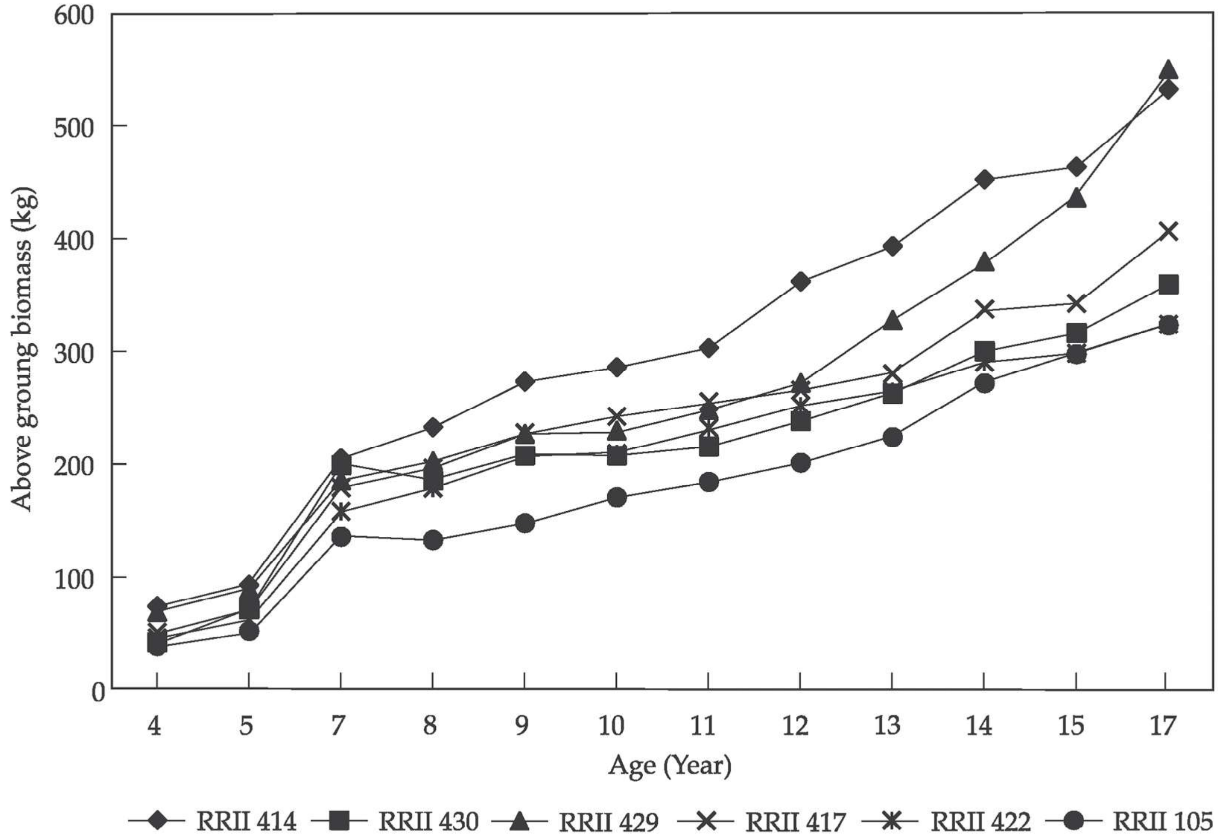

Fig.3. Biomass accumulation of clones

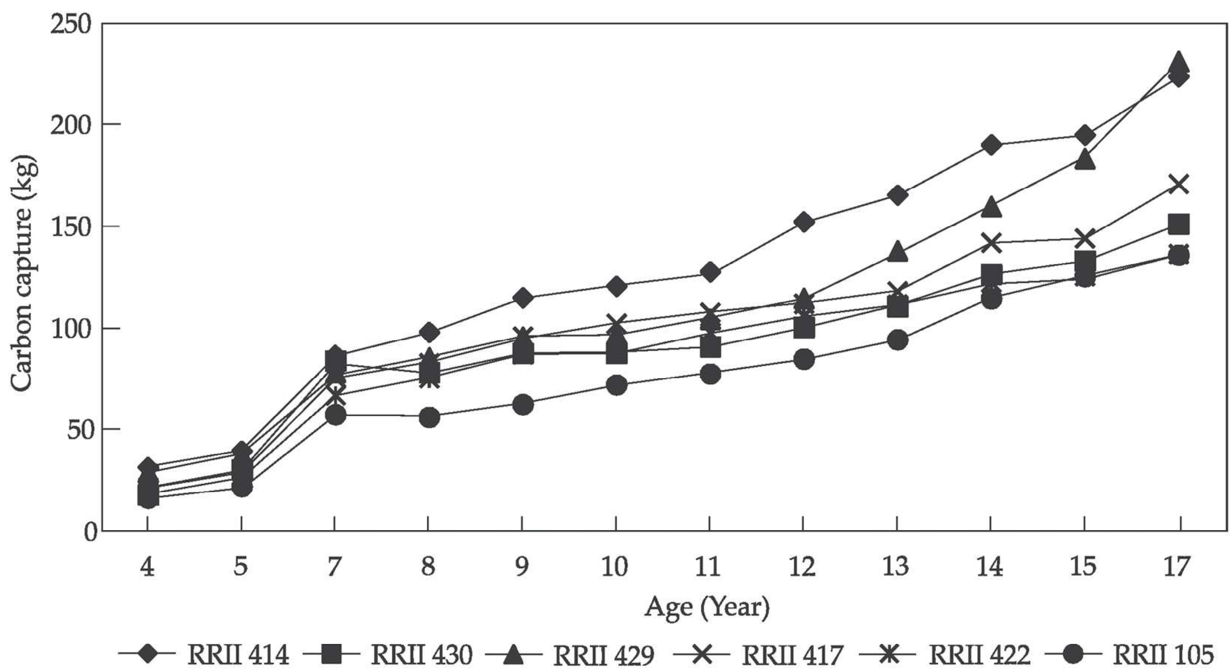

Fig.4. C- stock per tree of clones

understanding the relationship between the age of a forest stand and its biomass is essential for managing the forest component of the global carbon cycle. Since biomass increases with stand age, the carbon sequestration capacity can be quantified by suggesting a default rule to link carbon stock and stand age. The above ground carbon stocks using allometric equation for the tropical land use systems in three main tropical continents was reported by Noordwijk *et al.* (2002) also.

Evolving indigenous high yielding clones of rubber continues to be a major area of research. The development and release of RRII 105, the yield potential of which has been unprecedented in the history of rubber cultivation, has placed India in the forefront of NR producing countries in terms of its highest productivity. In the context of RRII 105 occupying more than 90 per cent of the area under rubber, the modern RRII 400 series clones are potential candidates for biomass accumulation and carbon sequestration, not withstanding yield *per se*.

RRII 400 series clones differed in their growth, biomass accumulation and carbon sequestration potential. Among the clones, RRII 429, 414 and 417 recorded higher carbon sequestration potential. The biomass accumulation pattern of the clones showed similar trend till 12 years and after this period, the pattern diverged and the clones RRII 429, RRII 414 and RRII 417 were found to accumulate more carbon than RRII 422 and RRII 430. The carbon sequestration potential of the clone RRII 429, RRII 414 and RRII 417 at an age of 23 years is 113.73, 105.53 and 102.28 t/ha respectively. Compared to the popular clone RRII 105, carbon sequestration potential of the new clones was 44 – 49 per cent higher except RRII 422 and RRII 430. Mitigation of global warming through CO_2 absorption is an added advantage of rubber plantations

REFERENCES

Alexandrov, G. A. (2007). Carbon stock growth in a forest stand: the power of age. *Carbon Balance and Management*, **2**: 2-4.

Cerrillo, N.R.M. and Oyonarte, B.P. (2006). Estimation of above-ground biomass in shrubland ecosystems of southern Spain. *Investigacian Agrarria: Sistemas y Recursos Forestales*, **15** (2): 197-207.

Cheng, C.M., Wang, R. and Jiang, J. (2007). Variation in soil fertility and carbon sequestration by planting *Hevea brasiliensis* in Hainan Island, China. *Journal of Environmental Sciences*, **19** (3): 348-352.

Jacob, J. (2003). Carbon sequestration potential of Natural Rubber plantations, in: *Proceedings of IRRDB Symposium on "Challenges for Natural Rubber in Globalization"*, 15-17 September 2003, Chiang Mai, Thailand.

Kaou, N.D. and Panwar, P. (2008). Prioritizing land-management options for carbon sequestration potential. *Current Science*, **95** (5): 658-663.

Karthikakuttyamma, M., Joseph, M. and Nair, A.N.S. (2000). Soils and Nutrition. In: Natural Rubber: Agromanagement and Crop Processing. (Eds. P.J. George and C. Kuruvilla Jacob). Rubber research Institute of India, Kottayam, India, pp.170-198.

Kraenzel, M., Castilo, A., Moore, T. and Potvin, C. (2003). Carbon storage of harvest-age Teak (*Tectona grandis*) plantations, Panama. *Forest Ecology and Management*, **173**: 213-225.

Licy, J., Saraswathyamma, C. K., Premakumari, D., Meenakumari, T., Meenattoor, R.J. and Nazeer, M. A. (2003). Genetic parameters and heterosis in rubber (*Hevea brasiliensis*) Muell Arg.: 5. Hybrid vigour for yield and yield components among the RRII 400 series clones in small scale evaluation. *Indian Journal of Natural Rubber Research*, **16** (1&2): 75-80.

Montes, N., Gauquelin, T., Badri, W., Bertaudiere, V. and Zaoui, Y.E. (2000). A non-destructive method for estimating aboveground forest biomass in threatened woodlands. *Forest Ecology and Management*, **130** (1-3): 37-46.

Mydin, K.K. and Mercykutty, V.C . (2007). High yield and precocity in the RRII 400 series hybdrid of rubber. *Natural Rubber Research*, **20** (1-2): 39-49.

Noordwijk, V.M., Rahayu, S., Hairiah, K., Wulan, Y.C., Farida, A. and Verbist, B. (2002). Carbon stock assessment for a forest –to-coffee conversion landscape in Sumber- Jaya (Lampung, Indonesia (from allometric equation to land use change analysis. *Science in China (Series C)*, 45p.

Shorrocks, V.M., Templeton, J.K. and Iyer, G.C. (1965). Mineral nutrition, growth and nutrient cycle of *Hevea brasiliensis*: 3. Relationship between girth and shoot dry weight. *Journal of Rubber Research Institute of Malaya*, **19**: 85-92.

UNCTAD (2009). Mitigation of climate change: a process of structural change.UNCTAD/PRESS/PR/209/038/07/09/09.*http://www.unctad.org*

Uresket, D., Gilbert, R. and Menke, J. (1977). Sampling big sagebrush for pytomass. *Journal of Range Management*, **30** (4): 311-314.

Uso, J.L., Mateu, J., Karjalainen, T. and Salvador, P. (1977). Allometric regression equations to determine aboveground biomass of Mediterranean shrubs. *Plant Ecology,* **132:** 59-69.