International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 1499-1507

Received: 10-03-2019
Accepted: 12-04-2019

G Shial
Programme Assistant (Forestry), Krishi Vigyan Kendra, Ranital, Bhadrak, Odisha, India

TL Mohanty
Assistant Professor, College of Forestry, OUAT, Bhubaneswar, Odisha, India

AK Mohapatra
Professor, Department of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha, India

Correspondence
G Shial
Programme Assistant (Forestry), Krishi Vigyan Kendra, Ranital, Bhadrak, Odisha, India

Assessment of nutrient status of soil under different agroforestry systems in North Eastern coastal plain zone of Odisha

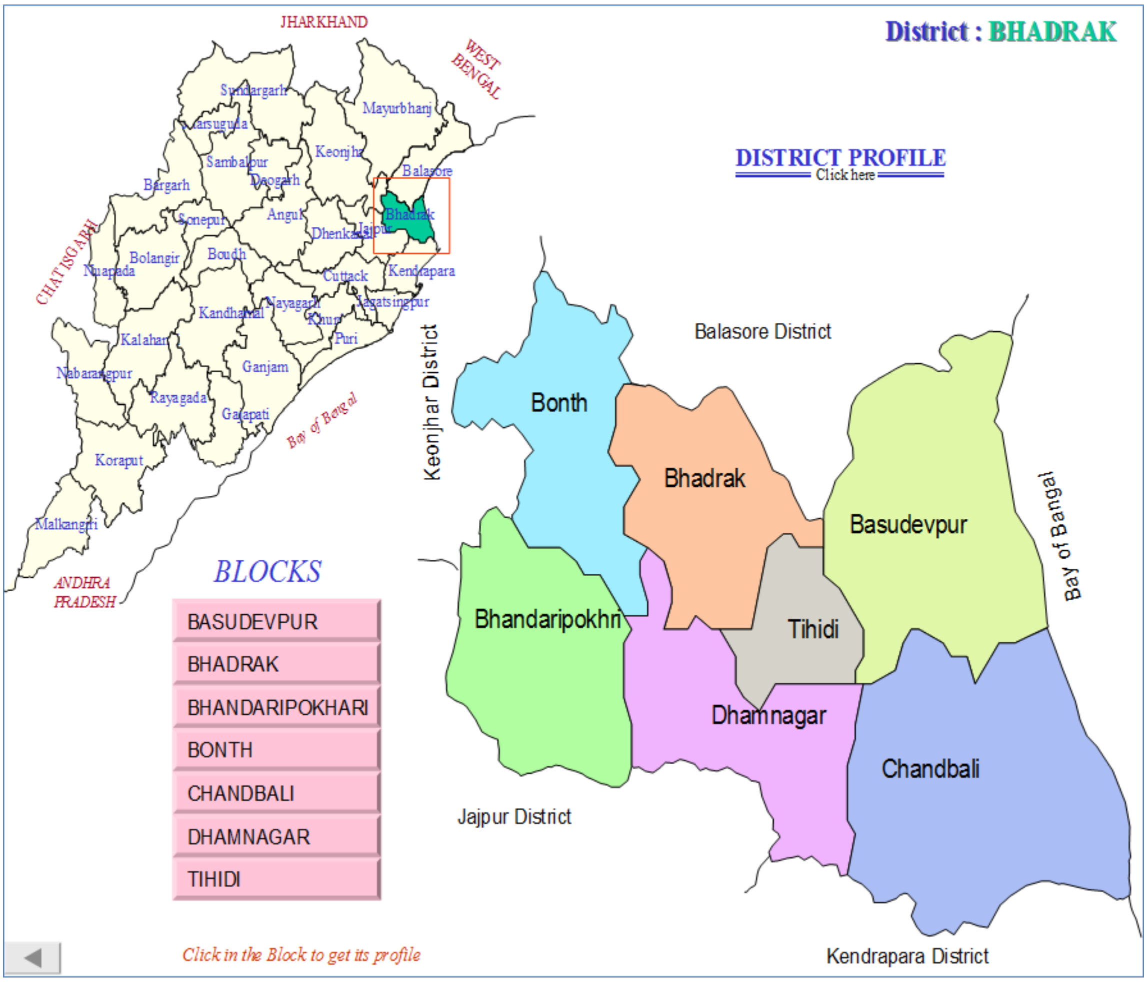
G Shial, TL Mohanty and AK Mohapatra

Abstract
Now-a-days India is self sufficient in terms of both food production and tree biomass to meet the needs of the future generation. Maintenance and enhancement of soil fertility plays a vital role in terms of sustainable food production and environmental security. This can be achieved through adopting suitable practices on farm lands. The planting of multipurpose trees along with agricultural crops improves soil fertility, provides fodder for livestock, agricultural implements etc. Agroforestry systems help in conservation of resources and promotes biomass production when grown on the field bunds along with food crops. The next green revolution aims to achieve doubling farm income by 2022.Indigenous and improved agroforestry systems are complementary to chemical fertilizers to increase nutrient status of soil. There is a great scope in the coastal Odisha to promote agroforestry for maintenance of productivity and sustainability in this region. Besides, Indigenous Agroforestry systems such as home gardens, Fodder trees for green fencing systems, scattered trees on crop land and *Acacia auriculiformis* based agroforestry systems, *Acacia mangium* based agroforestry systems are other kinds of Improved agroforestry systems are found in coastal districts of Odisha.

Keywords: Self sufficient, soil fertility, multipurpose trees, agroforestry systems doubling farm income

Introduction
With intensified agriculture soil fertility has emerged as a key problem in many parts of the world.
Soil is one of the most important natural resources, its protection is essential to enhance the productivity by adopting suitable agroforestry systems. The term agroforestry is not a new concept, it is an age old practice as agriculture itself and traditional. “Agroforestry is a collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between the trees and other components of the system”. In addition to timber, these species provide excellent fuel wood, small timber for agricultural implements, leaves for fodder, compost fertilizer etc. Tree roots generally extend deeper zone than crop roots and absorb soil nutrients and water unavailable to crops, lower soil horizons by tree roots and returned to the soil through leaf fall and enhance soil nutrient beneath them.

Study area
Location
Bhadrak is one of the coastal districts coming under North Eastern Coastal Plain Zone (NECPZ) of Odisha. It is situated between 20° 45' and 21° 15' N latitude and 85 °15' and 87° E longitude and 17.2 m above mean sea level. The district shares its boundaries with Balasore district in the north, Jajpur district and river Baitarani in the south, Keonjhar district in the west and Bay of Bengal and Kendrapada district in the east. The district consists of seven blocks namely Basudevpur, Bonth, Bhadrak, Bhandaripokhari, Chandbali, Dhamnagar and Tihidi with 193 Gram Panchayats and 1311 villages. The total population of the district is 1,506,522 (2011 census) and the rural population constitutes 87.67 % of the total population.



District Profile

Material and Methods

Experimental Design

The experiment was carried out in a Randomized Block Design (RBD) with three replications. For this the district was divided into three regions, each region represented one replication. The region- 1 covered the Northern part of the Bhadrak district comprising two blocks such as Bonth and Bhandaripokhari. The region –11 covered the central part of the district comprising Bhadrak, Dhamnagar and Tihidi. The region - 111 covered the southern part of the district comprising Basudevpur and Chandabali. In each region different indigenous Agroforestry systems practiced by the local people, the different improved Agroforestry systems introduced and the adoptability of different systems with reference to their economic viability of 15 different sizes of Indigenous and improved Agroforestry practices were studied.

Treatments

There are 15 treatments as given below-

Treatments	Details
T_1	Indigenous and improved Agroforestry System of 0.2 acre
T_2	Indigenous and improved Agroforestry System of 0.4acre
T_3	Indigenous and improved Agroforestry System of 0.6 acre
T_4	Indigenous and improved Agroforestry System of 0.8 acre
T_5	Indigenous and improved Agroforestry System of 1. 0acre
T_6	Indigenous and improved Agroforestry System of 1.2 acre
T_7	Indigenous and improved Agroforestry System of 1.4 acre
T_8	Indigenous and improved Agroforestry System of 1.6 acre
T_9	Indigenous and improved Agroforestry System of 1.8 acre
T_{10}	Indigenous and improved Agroforestry System of 2.0 acre
T_{11}	Indigenous and improved Agroforestry System of 2.2 acre
T_{12}	Indigenous and improved Agroforestry System of 2.4 acre
T_{13}	Indigenous and improved Agroforestry System of 2.6 acre
T_{14}	Indigenous and improved Agroforestry System of 2.8 acre
T_{15}	Indigenous and improved Agroforestry System of 3.0 acre

The study areas were selected first on the revenue map on the basis of their central location in each region (replication). For replication-1, the area was the transitional point of the blocks of Bonth and Bhandaripokhari. The villages of Asinpur, Barahampur, Naripur, Suanpada of Ganijang, Purusandha, Anijo, Kadabaranga of Grampanchayats of Bont block were studied. In Bhandaripokhari block the villages of Guhalia, Parbati, Akhuapada, Patuli of Nirgundi, Ramachandrapur, Nerada, Patuli Gram panchayats respectively were covered., For application-II, the area was the transitional point of the block Bhadrak, Dhamnagar and Tihidi. The villages such as Pagada, Nalanga, Sarasatia, Sabranga of handigaon, Gelpur, Jagadalpur, Sabranga Patuli Grampanchayats of Bhadrak were covered. In, Dhamnagar block the villages of Hatiapada, Suryapur, Mirjapur, Sriganga of Panchayats of Asurali, Dhusuri, Radhaballavapur and Katasahi respectively were covered. The villages such as Dolasahi, Gadadharpur, Mangalpur, Budhapur of panchayats of Dolasahi, Talapada, Sindoland Mukundapur respectively were covered in Tihidi block. For replication –III, the area was the transitional point of the block Basudevpur and Chandabali. In Basudevpur block villages such as Balimunda, Bhatapada, Muladiha and Suan of panchayats of Balimunda, Nuagaon, Padhuan and Sudarshanpur respectively were covered. The villages such as Motto, Gobindpur, Kaithakola and Kherang of panchayats of Motto, Dhamara, Kaithakolha and Nalgunda respectively of Chandabali block were studied. From this cluster of villages in each replication Indigenous and improved Agroforestry practices of representative sizes were selected. From each replication 45 sample plots were selected (3 for each treatment) from four different villages located closely and made into 15 composite samples, one for each treatment. The selected Indigenous and improved agroforestry practices were visited i and required observations were recorded.

Soil Analysis: Soil samples of 500gm weight from each randomly selected indigenous and improved agroforestry fields were collected from 0-30cm. depth in the month of April- May, 2015. Collected samples were air dried under shade, finely dusted and passed through a 2 mm sieve and finally 250 gm. of such soil were taken from each treatment plots in polythene bag with proper label for analysis of pH, organic carbon, Nitrogen, Phosphorus and Potash. The methods used were mentioned below:

a) P^H : Soil P^H was determined in 1:2 soil and water suspension by using glass electrode P^H meter (Jackson, 1967)
b) Organic Carbon : Organic Carbon content of the soil sample was determined by Walkley and Black's rapid titration method (Piper, 1950) [25]
c) Available Nitrogen: Available nitrogen was determined by the method described by Subbiah and Asija (1956) [29]. Nitrogen released as ammonia during distillation of 20 gram soil with 100 ml 0.32 % of KMnO4 and 100 ml of 2.5 % NaOH was received in 2 % boric acid containing mixed indicator and ammonia was titrated against standard 0.02 NH2SO4.
d) Available phosphorous: It was determined by Bray's-I method with shaking 2 gram soil in 20 ml of extracting solution(0.03N NH4AF in 0.025N HCl) for 5 minutes. The filtrate was estimated by spectrophotometer for phosphorous after development of colour by SnC12 and measured at 660nm (Jackson, 1973) [14].
e) Available Potassium: It was determined by equilibrating 5 gram of soil in 25 ml neutral ammonium acetate (Jackson, 1973) [14] and reading of extract was taken in flame photometer.
f) Soil sampling depth: Most soil studies are limited to surface soils down to 20 or 30 cm depth. Sampling beyond the surface soil is important while studying tree-based systems such as agroforestry because tree roots extend to deeper soil horizons.

Statistical analysis: The quantitative data on various observations were analysed as per the procedure described i.e. SEm (±) and Critical Difference(C.D.) were calculated at 5 % level of significance for comparing the treatment means where 'F' test was found significant. The following formulae were used for estimation of SEm and CD.

$SE_m(\pm)$ =(EMS/R)
$CD_{(0.05)} = SE_m(\pm)x2xt(0.05)$ at error degree of freedom.

Where EMS= Error Mean Sum of square.
R = Number of replication.

Some prominent Indigenous Agroforestry practices in Bhadrak

Home gardens

It is the most ancient form of agroforestry system in coastal district of Bhadrak. It is also called Homestead Agroforestry/Gharbari Bagicha, Kitchen garden and Household garden. More intensive forms of this practice are seen commonly in rural areas. Home garden consists of on growing trees, shrubs, vines and herbaceous plants in or around the home stead, aiming mostly food production for house hold consumption. Coconut, areca nut, guava, mango, citrus, tamarind, jack-fruit, papaya, banana, moringa, custard apple and many multipurpose trees are the major trees found grown in home gardens.

Fodder trees for green fencing

In this system various fodder trees and shrubs are planted as live fence at closer Spacing to protect the crops from stray animals. They are maintained as hedges by regular pruning and the pruned materials are fed to animals. The plant species grown in this system are *Erythrina indica*, *Gliricidia sepium*, *Acacia nilotica*, etc.

Scattered trees on crop land

The practice of growing agricultural crops under scattered trees on farm lands is old and does not seem to have changed for centuries. Growing multipurpose trees on paddy field bunds while crops are grown along side or underneath has been adopted by farmers either by rotecting and managing the trees that are already there or by planting new trees. There are different spacing pattern and densities of placement depending on the type of tree selected and of grown. Among these are *Acacia nilotica, Azadirachta indica, Borassus flabellifer, Terminalia arjuna, Butea monosperma* etc. By growing only a few species of trees the farmers reduced the risk of crop competition with trees.

Some prominent Improved Agroforestry practices in Bhadrak

***Acacia auriculiformis* based Agroforestry systems**

Acacia auriculiformis is grown extensively with commercial production concentrated mainly in coastal regions of Bhadrak. Suitability of Acacia trees in coastal region in terms of biophysical and environmental considerations is very good.

Generally Acacia plantation in normal rice field bunds are found to be grown well.

***Acacia mangium* based Agroforestry practices**

Acacia mangium in the recent years. has achieved wide popularity in the Bhadrak, as a multipurpose fast growing species. In the irrigated as well non-irrigated areas, the farmers have the tendency to grow *Acacia mangium* trees on the paddy bunds. These plants are pruned regularly so that its shade does not affect the yield of rice. Again the pruned branches are usually used as staking materials for vegetable crops and also for fuel purposes. Abraham (1998) also stated that the nutrient contents varied with the tree species and season and the total nutrient return from the trees is more dependent on the total litter fall than on the nutrient contents of. A substantial portion of the nutrients accumulated in the plant biomass is returned to the soil through litter fall. According to Charley and Richards (1983), leaves accounted for most of the total litter fall and also for most of the nutrient inputs (nitrogen, phosphorus, potassium) that reached the floor in organic debris. The organic carbon, available phosphorus, and potassium status following the methods suggested by Jackson (1973) [14] and available nitrogen following the method of Subbiah and Asija (1956) [29].

Soil status under home gardens

Hazra and Tripathy (1986) [13] observed an increase of status of organic carbon, N,P,K, Ca and Mg and decrease of soil p^H under the plantation of *Leucaena leucocephala*, *Melia azadirachta* and *Eucalyptus tereticornis.*

Alexander (1989) [2] explored the potential of *Acacia albida* in ameliorating the soil mounds from opencast tin mining. Organic carbon, total nitrogen, P^H, percentage base saturation and exchangeable Ca, Mg and Na were all significantly higher in soils from beneath the canopy than in those from outside. The site under *Acacia albidia* was found to be better than site under eucalyptus.

Chakraborty and Chakraborty (1989) [6] studied the physic-chemical properties of soil under 4 years old *Acacia auriculiformis* plantation and reported an increase organic carbon, nitrogen, potassium, electrical conductivity and water holding capacity over the control plots. The values for these parameters in plantation plot were 2.70 percent, 0.504 percent, 7.1 mg lit^{-1}, 48.4 micro mho and 32.7 percent, respectively against the corresponding values of 0.81, 0.364, 27.2, and 22.9, respectively in control. Numerous studies has been demonstrated that plantations of native and exotic species adapted to harsh conditions of degraded sites can reverse degradation process by stabilizing soils increasing soil organic matter through enhancement of above and below litter production and improvement of soil status.

Sharma and Gupta (1989) [26] observed the effect of tree covers comprising *Acacia tortilis, Acacia senegal, Prosopis cineraria* and *Prosopis juliflora* on soil characteristics in Rajasthan. Under P. cineraria and organic carbon increased from 0.03 (in barren dunes) to 0.47 percent, total nitrogen from 0.007 to 0.43 percent and available nitrogen from 87.0 to 227.0 kg ha^{-1}. The soil P^H decreased from 8.58 to 8.34 under P. cineraria, but greater decrease occurred under *A senegal* (7.85). The overall fertility of soils under tree cover was improved with greatest overall improvement generally found under *P. cineraria* and least under *P juliflora*.

Murthy *et al*. (1990) incorporated the leaves of *Albizia lebbek, Leucanea leucocephala* and *Azadiratchta indica* combination with inorganic N-fertilizers, in order to study changes in soil fertility. Leaf meal incorporation in combination with fertilizers improved the soil fertility status in terms of organic carbon and available nitrogen contents. *Albizialebbek* was found to be superior to other leaf meals in this respect.

Laskar and Datta (1992) reported the improvement of soil fertility under 3-years old tree cover. Soil under tree cover showed an increase in P^H by 0.25-0.60, with the greatest decrease in exchangeable acidity occurring under *Albizia lebbek*. Soil electrical conductivity increased slightly under *Dalbergia sissoo, Leucaena leucocephala, Acacia auriculiformis* and *Albizia lebbek*. Soil organic carbon increased from 0.54 to 0.63 percent under *Dalbergia sissoo*. In general, tree cover improved the nutrient available and water retention capacity in undulating, soils of Tripura.

Piters and Freco (1995) examined the variations in yields within the same environmental context through an analysis of the variability of fields and the diversity of households and farmers in the village of Gaban, Northern Cameroon.

John and Nair (1999) studied the soil fertility aspects of coconut-based homestead farming. A field investigation was conducted to monitor the changes of soil properties of a 0.50 ha coconut-based homestead in southern Kerala, India, from 1994-96. Soil fertility aspects were assessed.

Solomon and Lehman (2000) evaluated loss of phosphorus from soil in semi-arid northern Tanzania, the native woodland is being rapidly cleared and replaced by low input agriculture. This has resulted in pronounced environmental degradation, and in particular loss of phosphorus (P) from the soil.

Dutta and Iftekar (2004) noticed a perception analysis on the effect of soil salinity on the homestead gardens of the worst salinity affected district Satkhira. It was found that people have recognized salinity as a problem and construction of shrimp enclosures and maritime influence as the reasons. Salinity increase results in reduction of crop production 92.50% per year), tree growth (2% year) and vegetation coverage (1.87% per year). Tree species were disappearing due to salinity.

Bhola (1995) has also reported the increase of available N, P, and K status in soil under tree canopy in comparison to open area. Alexander (1989) [2] reported a higher amount of total N, exchangeable Ca, Mg and Na in the soil under canopy of *Acacia albida* than the soil of outside area. Lasker and Datta (1992) also observed an improvement of nutrient status of soil under 3-year old tree cover *of Dalbergia sissoo. Leucaena leucocephala, Acacia auriculiformis and Albizia lebbek.* Jensen (1993) estimated that the nutrients circulated internally in a Javanese home garden were as much as 223 kg N, 38 kg P, 373 kg K, 135 kg Ca, and 50 kg Mg ha-1 yr-1. Similar findings were supported by Hazra and Tripathy (1986) [13], Sharma and Gupta (1989) [26]. Mafongoya, P.L, Giller, K.E and Palm, C.A. 1998) studied decomposition and nitrogen release patterns of tree pruning and litter.

The soil status under homestead agroforestry system of different sizes varied significantly. The organic carbon % content varied remarkably in different unit sizes. Holdings of 0.2 acre and 0.4 acre registered the highest value of 0.52% while 1.6 holding registered the lowest value of 0.40%. The organic carbon % content decreased with increase of holding size (Table 1).

The available nitrogen status in soil was found significantly different under different home garden sizes. It varied from 304.12 to 273.45 kg ha^{-1} among the various holding sizes. The maximum amount was found in 0.2 acre and minimum in 1.6 acre holding. The content of available nitrogen per hectare gradually decreased with increase of home garden size.

Table 1: Soil status under home gardens

Treatment	O. C. (%)	Available N(kg ha⁻¹)	Available P (kg ha⁻¹)	Available K (kg ha⁻¹)
T_1(0.2 acre)	0.52	304.12	32.75	151.49
T_2(0.4 acre)	0.52	300.16	32.10	150.27
T_3(0.6 acre)	0.50	296.82	31.15	145.17
T_4(0.8 acre)	0.48	291.45	28.08	143.39
T_5(1.0 acre)	0.46	285.31	26.25	140.18
T_6(1.2 acre)	0.45	284.11	25.31	138.22
T_7(1.4 acre)	0.43	286.30	25.00	135.16
T_8 (1.6 acre)	0.40	273.45	24.7	131.11
T_9(1.8 acre)	0	0	0	0
T_{10}(2.0 acre)	0	0	0	0
T_{11}(2.2 acre)	0	0	0	0
T_{12}(2.4 acre)	0	0	0	0
T_{13}(2.6 acre)	0	0	0	0
T_{14}(2.8 acre)	0	0	0	0
T_{15}(3.0 acre)	0	0	0	0
SE_m(±)	0.0355	21.612	2.130	10.578
$CD_{(0.05)}$	0.071	6.492	2.326	3.195

The phosphorus content in the soil varied significantly among the treatments. The home garden of 0.2 acre size registered significantly higher phosphorus content of 32.75 kg ha^{-1} over the rest of the home garden sizes. The lowest amount of phosphorus content (24.7 kg ha^{-1}) was estimated under home garden of 1.6 acre size. The phosphorous content gradually decreased with increase in home garden size.

The available potassium also significantly varied among the home gardens of different sizes. It ranged from 151.49 to 131.11 kg ha^{-1}. The small home garden of 0.2 acre size recorded the highest amount of available potassium among the home gardens while the home gardens of 2.6 acre size recorded the lowest amount. The potassium content gradually decreased with increase in home garden size.

Soil status under Fodder trees for green fencing systems

The soil status under Fodder trees for green fencingagro forestry system of different sizes varied significantly (Table 2). The organic carbon % content decreased with increase of holding size. This might be due to more litter accumulation in smaller holding. Similar findings were supported by Hazra and Tripathy (1986) [13], Sharma and Gupta (1989) [26]. The available nitrogen status in soil was found significantly different under different Fodder trees for green fencing sizes. The content of available nitrogen per hectare gradually decreased with increase of size fodder trees for green fencing system.

The phosphorus content in the soil varied significantly among the treatments. The fodder trees for green fencing of 0.2 acre size registered significantly higher phosphorus content 38.42 kg ha^{-1} over the rest of the fodder trees for green fencing sizes. The lowest amount of phosphorus content (25.88 kg ha^{-1}) was estimated in 1.6 acre. Bhola (1995) has also reported the increase of available N, P, and K status in soil under tree canopy in comparison to open area. Hazra and Tripathy (1986) [13] and Mishra *et al*., (1992) observed an increase of status of organic carbon, N,P,K, Ca and Mg and decrease of soil p^H under the plantation of *Leucaena leucocephala*, *Melia azadirachta* and *Eucalyptus tereticornis*.

The available potassium also found significantly variation among the Fodder trees for green fencing of different sizes. It ranged from160.81 to147.88 kg ha^{-1}. The smaller holdings of 0.2 acre size recorded highest amount of available potassium among the Fodder trees for green fencing agroforestry system. While the larger holdings of 2.6 acre size recorded the lowest amount. The potasium content gradually decreased with increase in Fodder trees for green fencing sizes of agroforestry practices. Similar study was held In Malawi and Zambia by planting the shrubs *Tephrosia vogelii, Sesbania sesban, Gliricidia sepium* or *Cajanus cajan* in fallows for two years, cutting them back, then following them with two to three years of maize cultivation increased maize yields compared with planting continuous unfertilized maize (Phiri, R. and F.K. Akinnifesi, 2001) Some of the fodder trees are leguminous and in addition to providing fodder, may have additional benefits for soil fertility.

Table 2: Soil status under fodder trees for green fencing systems

Treatments	O. C. (%)	Available N(kg ha⁻¹)	Available P (kg ha⁻¹)	Available K (kg ha⁻¹)
T_1(0.2 acre)	0.56	315.15	38.42	160.81
T_2(0.4 acre)	0.56	311.21	37.45	160.08
T_3(0.6 acre)	0.56	305.17	34.15	158.12
T_4(0.8 acre)	0.54	299.11	30.19	155.49
T_5(1.0 acre)	0.52	294.19	30.11	152.67
T_6(1.2 acre)	0.48	291.20	28.78	150.11
T_7(1.4 acre)	0.43	281.37	28.91	148.05
T_8 (1.6 acre)	0.42	277.4	25.88	147.88
T_9(1.8 acre)	0	0	0	0
T_{10}(2.0 acre)	0	0	0	0
T_{11}(2.2 acre)	0	0	0	0
T_{12}(2.4 acre)	0	0	0	0
T_{13}(2.6 acre)	0	0	0	0
T_{14}(2.8 acre)	0	0	0	0

T_{15}(3.0 acre)		0	0	0
SE_M(±)	0.0383	22.095	2.405	11.478
$CD_{(0.05)}$	0.033	81.581	1.186	1.640

The phosphorus content in the soil varied significantly among the treatments. The fodder trees for green fencing of 0.2 acre size registered significantly higher phosphorus content 38.42 kg ha^{-1} over the rest of the fodder trees for green fencing sizes. The lowest amount of phosphorus content (25.88 kg ha^{-1}) was estimated under fodder trees for green fencing of 1.6 acre size. The phosphorous content gradually decreased with increase in fodder trees for green fencing.

The available potassium varied significantly among the Fodder trees for green fencing of different sizes. It ranged from160.81 to147.88 kg ha^{-1}. The smaller holdings of 0.2 acre size recorded highest amount of available potassium among the Fodder trees for green fencing, while the larger holdings of 2.6 acre size recorded the lowest amount. The potassium content gradually decreased with increase in fodder trees for green fencing sizes of agroforestry practices.

Soil status under scattered trees on crop land

The practice of growing scattered trees on farmlands is quite old. These trees are multipurpose, used for shade, fodder, A large number of indigenous scattered trees such as Neem, Babul, Palm etc are found in agricultural field bunds and played a significant change in micro-climate, plant, animal, micro-organism composition and recycling of mineral elements (Shukla, 2009; Manjur *et al.*, 2014). Trees can improve the nutrient status of soil through nitrogen fixation and increased biological activities by providing biomass and suitable microclimate (Clement and Olusegun, 2010). Practice of agroforestry also improves soil productivity by planting of selected trees and food crops on the same farm fields (Kassa *et al*., 2010). Crop yield and soil nutrient improvement can be obtained under tree canopy cover (Boffa, 2000). It was found that holdings having more no of Babul trees registered more available nitrogen, phosphorus and potassium per hectare in holdings of 1.4 acre,1.6 acre and 1.8 acre. Similar studies were made by Nair 1993, Chander, S. Goyal, D.P. Nandal and K. K. Kapoor 1998,

The soil status under scattered trees on crop landindigenous agroforestry practices agroforestry system of different sizes varied significantly. Holdings of 1.4 acre registered the highest value of 0.50 % while 2.6 acre holding registered the lowest value of 0.32 %.

The available nitrogen status in soil was found significantly different under different holdingsizes. It varied from 253.41 to 277.11 kg ha^{-1} among the various holding sizes. The maximum amount was found in 1.4 acre and minimum in 2.6 acre holding. It was found that holdings having more no of Babul trees registered more available nitrogen status per hectare.

The phosphorus content in the soil varied significantly among the treatments. The holdings of 1. 4 acre size registered significantly higher phosphorus content 25.19 kg ha^{-1} over the rest of the holding sizes. The lowest amount of phosphorus content of 15.04 kg ha^{-1} was found in2.6 acre size.

The available potassium also found significantly variation among the different holding sizes. It ranged from minimum 132.11 kg ha^{-1}in holdings of 2.6 acre and maximum 150.75 kg ha^{-1} in 1.4 acre.

Table 3: Soil status under scattered trees on crop land

Treatments	**O. C. (%)**	**Available N (kg ha^{-1})**	**Available P (kg ha^{-1})**	**Available K (kg ha^{-1})**
T_1(0.2 acre)	0.42	263.41	23.41	135.32
T_2(0.4 acre)	0.45	265.82	22.45	134.11
T_3(0.6 acre)	0.44	261.44	21.11	140.10
T_4(0.8 acre)	0.44	263.43	22.10	145.17
T_5(1.0 acre)	0.42	260.41	19.16	142.11
T_6(1.2 acre)	0.40	258.30	18.01	140.71
T_7(1.4 acre)	0.50	277.11	25.19	150.75
T_8 (1.6 acre)	0.48	270.41	24.04	148.32
T_9(1.8 acre)	0.45	263.49	23.00	145.41
T_{10}(2.0 acre)	0.43	260.01	19.92	137.11
T_{11}(2.2 acre)	0.38	259.11	17.21	135.11
T_{12}(2.4 acre)	0.35	255.41	16.17	132.11
T_{13}(2.6 acre)	0.32	253.41	15.04	132.31
T_{14}(2.8 acre)	0.38	260.45	18.42	144.11
T_{15}(3.0 acre)	0.41	261.11	23.11	144.11
SE_m(±)	0.0075	0.872	0.466	0.7036
$CD_{(0.05)}$	0.045	68.356	1.679	3.372

Soil status under *Acacia auriculiformis* based agroforestry systems

The soil status under *Acacia auriculiform* is based agroforestry systems of different sizes varied significantly. The organic carbon content % decreased with increase of holding size. This might be due to more litter accumulation in smaller holding. Similar findings were supported by Hazra and Tripathy (1986) [13], Sharma and Gupta (1989) [26] and Murthy *et al.,* (1990).

The content of available nitrogen per hectare gradually decreased with increase of holding size. The content of available nitrogen per hectare gradually decreased with increase of holding size. Garcia-Moya and McKell (1970) showed that nitrogen was concentrated in the soil under the canopy of shrubs. A dense stand of *A. mearnsii*in South Africa was reputed to have fixed 180 kg N/ha annually (Orchard and Derby 1956). *A. auriculiformis* produces profuse bundles of nodules, which suggests a good nitrogen-fixing potential (Domingo, 1983). Concentrations of N, P, S and K were significantly higher in acacia litter than in eucalyptus litter (Gil. Et.al 1987).

The phosphorus content in the soil varied significantly among the treatments *Acacia auriculiformis* based agroforestry practices. Holding size of 0.2 acre registered significantly higher phosphorus content 19.94 kg ha^{-1} over the rest of the holding sizes. The lowest amount of phosphorus content (10.11 kg ha^{-1}) was estimated in 2.6 acre to 3.0 acre size. (Bosma *et al*., 2003). Bhola (1995) has also reported the increase of available N, P, and K status in soil under tree canopy in comparison to open area. Hazra and Tripathy (1986) [13] and Mishra *et al*., (1992) observed an increase of status of organic carbon, N,P,K, Ca and Mg and decrease of soil p^{H} under the plantation of *Leucaenaleuco cephala*, *Melia azadirachta* and *Eucalyptus tereticornis*.

The available potassium also found significantly variation among *the Acacia auriculiformis* based agroforestry practices land holding sizes. It ranged from144.12 to125.10 kg ha^{-1}. The smaller holdings of 0.2 acre size recorded highest amount of available potassium among Acacia based agroforestry practices. while the larger holdings of 3.0acre size recorded the lowest amount. The potasiumcontent gradually decreased with increase in holding size. It was seen that through introduction of *Acacia Auriculiformis* improved soil fertility and enhancing farm income compared with conventional crop production (Kang and Akinnifesi, 2000). Young 1986), (Jamaludheen and Kumar, 1999; De Costa and Sangakkara, 2006) found similar results. Osman *et al*. (2001) observed that soils under Acacia auriculiformis plantations had significantly higher organic carbon, total N, available K and Mg. Chakraborty and Chakraborty (1989) [6] conducted an experiment to study the charges in soil properties under Acacia auriculiformis and was directly related to organic carbon content. (Mongi and Huxley, 1979) focuses on the role of trees and shrubs in maintaining soil fertility in forest/agricultural ecosystems.

Table 4: Soil status under *Acacia auriculiformis* based agroforestry systems

Treatments	O. C. (%)	Available N(kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1(0.2 acre)	0.42	260.11	19.94	144.12
T_2(0.4 acre)	0.41	258.10	19.90	142.18
T_3(0.6 acre)	0.40	256.15	17.51	142.15
T_4(0.8 acre)	0.38	252.35	17.11	140.31
T_5(1.0 acre)	0.37	250.11	16.31	138.11
T_6(1.2 acre)	0.35	248.15	16.27	137.75
T_7(1.4 acre)	0.34	248.11	16.11	137.15
T_8 (1.6 acre)	0.32	241.35	14.32	135.21
T_9(1.8 acre)	0.30	235.71	13.11	135.11
T_{10}(2.0 acre)	0.28	234.89	11.20	133.38
T_{11}(2.2 acre)	0.27	233.11	10.45	133.11
T_{12}(2.4 acre)	0.27	230.15	10.15	132.11
T_{13}(2.6 acre)	0.27	230.11	10.11	130.71
T_{14}(2.8 acre)	0.27	228.21	10.11	125.12
T_{15}(3.0 acre)	0.27	225.11	10.11	125.10
SE_M (±)	0.0089	1.717	0.534	0.886
$CD_{(0.05)}$	0.050	2.052	1.144	3.225

Soil status under *Acacia Mangium* based agroforestry systems

The soil status under *Acacia mangium* based agroforestry practices of different sizes varied significantly. The organic carbon content % decreased with increase of holding size. This might be due to more litter accumulation in smaller holding. Similar findings were supported by Hazra and Tripathy (1986) [13], Sharma and Gupta (1989) [26] and Murthy *et al.*, (1990).

The content of available nitrogen per hectare gradually decreased with increase of holding size. The content of available nitrogen per hectare gradually decreased with increase of holding size. Garcia-Moya and McKell (1970) showed that nitrogen was concentrated in the soil under the canopy of shrubs. A dense stand *of A. mearnsii*in South Africa was reputed to have fixed 180 kg N/ha annually (Orchard and Derby 1956). *A. auriculiformis s*produces profuse bundles of nodules, which suggests a good nitrogen-fixing potential (Domingo, 1983a).

The phosphorus content in the soil varied significantly among the treatments *Acacia mangium* based agroforestry practices. The phosphorous content gradually decreased with increased inbased agroforestry practices land holding sizes. The lowest amount of phosphorus content (10.11 kg ha^{-1}) was estimated in 2.6 acre to 3.0 acre size. (Bosma *et al*., 2003).Bhola (1995) has also reported the increase of available N, P, and K status in soil under tree canopy in comparison to open area. Hazra and Tripathy (1986) [13] and Mishra *et al*., (1992) observed an increase of status of organic carbon, N,P,K, Ca and Mg and decrease of soil p^{H} under the plantation of *Leucaena leucocephala, Meliaazadirachta* and *Eucalyptus tereticornis*.

The potassium content gradually decreased with increase in holding size. The smaller holdings of 0.2 acre size recorded highest amount of available potassium among Acacia based agroforestry systems. While the larger holdings of 3.0acre size recorded the lowest amount. It was seen that through introduction of *Acacia Auriculiformis* improved soil fertility and enhancing farm income compared with conventional crop production (Kang and Akinnifesi, 2000). Young 1986), (Jamaludheen and Kumar, 1999; De Costa and Sangakkara, 2006) found similar results. Osman *et al*. (2001) observed that soils under *Acacia auriculiformis* plantations had significantly higher organic carbon, total N, available K and Mg. Chakraborty and Chakraborty (1989) [6] conducted an experiment to study the charges in soil properties under *Acacia auriculiformis* and was directly related to organic carbon content. (Mongi and Huxley, 1979) focuses on the role of trees and shrubs in maintaining soil fertility in forest/agricultural ecosystems

It was seen that through introduction of *Acacia spp* improved soil fertility and enhancing farm income compared with conventional crop production (Kang and Akinnifesi, 2000). Young 1986), (Jamaludheen and Kumar, 1999; De Costa and Sangakkara, 2006) found similar results. Osman *et al*. (2001) observed that soils under *Acacia auriculiformis* plantations had significantly higher organic carbon, total N, available K and Mg. Chakraborty and Chakraborty (1989) [6] conducted an experiment to study the charges in soil properties under

Acacia auriculiformis and was directly related to organic carbon content. (Mongi and Huxley, 1979) focuses on the role of trees and shrubs in maintaining soil fertility in forest/agricultural ecosystems.

Table 5: Soil status under *Acacia mangium* based agroforestry systems

Treatments	O. C. (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1(0.2 acre)	0.45	265.17	22.41	145.32
T_2(0.4 acre)	0.43	262.10	20.11	143.21
T_3(0.6 acre)	0.41	262.11	18.37	140.11
T_4(0.8 acre)	0.40	260.18	18.11	144.19
T_5(1.0 acre)	0.38	255.75	18.87	138.47
T_6(1.2 acre)	0.38	250.81	16.75	134.52
T_7(1.4 acre)	0.36	245.11	16.31	133.32
T_8 (1.6 acre)	0.37	245.11	15.21	130.72
T_9(1.8 acre)	0.37	240.92	14.32	128.45
T_{10}(2.0 acre)	0.37	238.11	13.11	125.11
T_{11}(2.2 acre)	0.35	236.72	12.30	125.32
T_{12}(2.4 acre)	0.36	235.11	11.31	125.12
T_{13}(2.6 acre)	0.36	234.11	11.20	124.11
T_{14}(2.8 acre)	0.33	233.24	11.10	123.11
T_{15}(3.0 acre)	0.32	233.11	10.11	122.20
SE_M(±)	0.0060	1.707	0.562	1.217
$CD_{(0.05)}$	0.141	60.835	4.838	35.023

Conclusion

Indigenous and improved agroforestry systems in Bhadrak, Odisha found to be immense importance not only for importance in supporting livelihood of rural poor but also for its role in soil enrichment. Agroforestry systems have positive effects for increasing organic carbon content, available N, P and K. Study shown that Soil status under fodder trees for green fencing indigenous agroforestry systems have highest O.C %, available NPK than other indigenous and improved agroforestry systems. Smaller land holding sizes have highest O.C %, available NPK than larger sizes. In recent times however, the loss of soil fertility and biodiversity, frequent occurrence of natural calamities among others threaten the farming communities and leads to commercialization of improved agroforestry practices such as. *Acacia auriculiformis* and *Acacia mangium* based agroforestry practices in Bhadrak district. The contribution of the trees in the farming systems certainly added nutrients to the soil. Apart from the *Acacia auriculiformis* and *Acacia mangium,* there is much scope to cultivate many other multipurpose trees (MPTs) suitable for the agroforestry system in this agro-climatic region

References

1. Abraham Joise. Nutrient cycling and soil productivity studies of homestead agroforestry systems of Southern Kerala. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 1998.
2. Alexander MJ. The effect of Acacia albidaThe effect of *Acacia albida* on tin-mine spoil and their possible use in reclamation. Landscape and Urban Planning. 1989; 17(1):61-71.
3. Barbara W, Holm T. Organic Matter Turnover in Light Fraction and Whole Soil Under Silvopastoral Land Use in Semiarid Northeast Brazil. Rangeland Ecology & Management. 2008; 61(3):275-283.
4. Bhola N. Studies on Relative Growth Performance and Soil Enrichment Potential of Some Nitrogen Fixing Trees. MSc. Thesis. Dr. Y. S. P. University of Horticulture Forestry, Solon, India, 1995.
5. Boffa JM. Field Scale Influence of Karite Sorghum Production in Burkina Faso. International J Agroforestry Systems. 2000; 6:19-35.
6. Chakraborty RN, Chakraborty D. Change in soil properties under *Acacia auriculiformis* plantations in Tripura. Indian Forester. 1989; 115(4):272-273.
7. Charley JR, Richards BN. Nutrient allocation in plant communities, mineral cycling in terrestrial ecosystems. In Physiology Plant Ecology IV (eds.), 1983.
8. Clement O, Olusegun A. Soil Fertility Status under Different Tree Cropping System in a Southwestern Zone of Nigeria, Notulae Scientia Biologicae, 2010.
9. Domingo I. Nitrogen fixation in Southeast Asian forestry research and practice. In J.C. Gordon and C.T. Wheeler (eds.), Biological nitrogen fixation in forest ecosystems: foundations and applications. The Hague: Nijhoff/Junk, 1983.
10. Edmondo Garcia-Moya, Cyrus McKell M. Contribution of Shrubs to the Nitrogen Economy of a Desert-Wash Plant Community Ecological Society of America. 1970, 81-88.
11. Franzel Phiri, Kwesiga. Valuing Agroforestry Systems: Methods and Applications, 2002.
12. Gill HS, Abrol IP, Sharma JS. Nutrient cycling through litter production in young plantations of *Acacia nilotoca* and *Eucalyptus tereticornis* in a highly alkaline soil Forest Ecol Management. 1987; 22:57-69.
13. Hazra R, Tripathi SB. Soil Properties, Micrometeorological Parameters, Forage Yield and Phosphorus-Uptake of Berseem as Influenced by Phosphate Application under Agroforestry System of Production Journal of agronomy and crop science. 1986; 156(3):145-152.
14. Jackson ML. Soil Chemical Analysis. Prentice Hall of India, Pvt.Ltd. New Delhi. 1973, 1-498
15. Jensen M. Productivity and nutrient cycling of a Javanese homegarden. Agroforestry Systems. 1993; 24(2):187-201.
16. John J, Nair MA. Socio economic characteristics of homestead farming in south Kerala. Journal of Tropical Agriculture. 1999; 37(1/2):107-109.
17. Kassa H, Kindeya G, Yamoah C. Balanites aegyptiaca, a potential tree for Parkland agroforestry systems with sorghum in Northern Ethiopia. J. Soil Sci. and Environ. Manage. 2010; 1(6):107-114.

18. Chander K, Goyal S, Nandal DP, Kapoor KK. Soil organic matter, microbial biomass and enzyme activities in a tropical agroforestry system. 1998; 27(2):168–172.
19. Laskers S, Datta M. Tree cover improves soil fertility and water retention. Indian Farming. 1992; 4(10):17.
20. Mafongoya PL, Giller KE, Palm CA. Decomposition and nitrogen release patterns of tree prunings and litter. Agroforestry Systems. 1998; 38:77-97.
21. Manjur B, Abebe T, Abdulkadir A. Effects of scattered F. albida (Del) and *C. macrostachyus* (Lam) tree species on key soil physicochemical properties and grain yield of Maize (Zea Mays): a case study at Umbulo Wacho watershed, Southern Ethiopia. Wudpecker J Agric. Res. 2014; 3(3):063-073.
22. Nair PKR. An introduction to Agroforestry. ICRAF, Nairobi, Kenya, Kluwer Academic Publishers, 1993, 243.
23. Orchard ER, Derby GD. Fertility changes under continued wattle culture with special reference to nitrogen fixation and base status of the soil. Proceedings of 6^{th} International Soil Congress, Paris. 1956; 4:305-310.
24. Phiri R, Akinnifesi FK. Farmer Perceptions of Two Agroforestry Species and Their Contributions to Soil Fertility Replenishment in Malawi. In: Phiri, I.M.G., A.R. Saka and E.H.C. Chilembwe (Eds.). Agriculture Technologies for Sustainable Development in Malawi. Annual Science Proc., Lilongwe, Malawi, 2001, 108-119.
25. Piper CS. Soil and Plant Analysis. Inter Science Publisher, Inc. New York. Piters, B. D. S; Freco, L.O.; Breemer, J. P.M. V. and Van den, B. J. P. M. 1995. Farmers managing their most scarce natural resource an example of local level soil fertility management in Northern Cameroon. Local resource management in Africa. 1950, 65-76.
26. Sharma BD, Gupta LC. Effect of tree cover on soil fertility in Western Rajasthan. Indian Forester. 1989; 115:348-354.
27. Shukla PK. Nutrient dynamics of teak plantations and their impact on soil productivity-A case study from India. Proceedings of the 8thWorld Forestry Congress, 2009; 23:1-11.
28. Solomon D, Lehmann J. Loss of phosphorus from soil in semi-and-northern Tanzania as a result of cropping: evidence from sequential extraction and 31p-NMR spectroscopy. European Journal of Soil Science. 2000; 51(4):699-708.
29. Subbiah BV, Asija VL. Rapid procedure for the estimation of available nitrogen in soils Curro Sci. 1956; 25:259-260.
30. Walkley A, Black IA. An examination of the Degtjareff method for determinating soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 34:29-38.