International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 10(5): 525-532, October 2017
DOI: 10.5958/2230-732X.2017.00065.1

HORTICULTURE

Growth Performance and Yield of Intercrops in Agri-horti-silvi System in Hill Zone of West Bengal, India

Bandhan Subba* and Pratap Kumar Dhara

Department of Soil and Water Conservation, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

*Corresponding author: bandhan_subba@rediffmail.com

Paper No. 610 Received: 15-7-2017 Accepted: 22-9-2017

ABSTRACT

The present investigation was conducted at Dalapchand Science Farm, Krishi Vigyan Kendra (KVK), Kalimpong, West Bengal, which aimed at analyzing the growth performance and yield of selected intercrops under one silvi, Alder (*Alnus nepalensis*) and two fruit trees, Mandarin and Asian pear (*Citrus reticulata* Blanco. and *Pyrus communis*) in agri-horti-silvi system. The experimental site is located at 27.06° N latitude and 88.47° E longitudes at an elevation ranging between 979.93 m. to 1257.30 m. above the mean sea level. The experiment was fitted in the randomized block design (RBD) with three replications. The fruit saplings were planted at a spacing of 10m × 10m and the silvi seedlings were planted in between the two fruit trees and boundary at 2.5 m spacing during *kharif* season of 2011. Suitable intercrops *viz.* maize, rice, french bean, pea and pumpkin during *kharif* and potato, cabbage, cauliflower, mustard and onion during *rabi* season of two consecutive years (2013-2015) were grown. The result revealed that the number of plants per m^2 was higher under sole crop. But, it was found reverse in case of the plant height (cm) and recorded taller plant Sunder intercropping with *Alnus nepalensis* + *Pyrus communis* followed by *Alnus nepalensis* + *C. reticulata* and in sole crop. Soil organic matter percent at (0-15cm, 15-30cm, 30-60cm) soil depth was found to significantly increase under the agri-horti-silvi situation resulting with a decrease in the soil bulk density ($gmcm^{-3}$) at the end of the study. *kharif* and *rabi* intercrops yield (t/ha) were found higher in sole crop. However, in the intercropping situation higher yield were recorded when intercropped with *Alnus nepalensis* + *C. reticulata* than *Alnus nepalensis* + *Pyrus communis.*

Highlights

- Plant population of both *kharif* and *rabi* intercrops were higher under sole crop followed by intercropping under horti-silvi plantation
- Growth of both *kharif* and *rabi* intercrops were higher under *Alnus nepalensis* + *Pyrus communis* plot followed by *Alnus nepalensis* + *Citrus reticulata* and least in sole crop plots
- In soil depth (0-15cm, 15-30cm, 30-60cm) an increasing effect in soil organic matter (%) under agri-horti-silvi system, resulted with a decreasing effect in the soil bulk density ($gmcm^{-3}$)
- There was no antagonistic effect on the yield of intercrops grown under agri-horti-silvi system
- Such agri-horti-silvi system could be profitably grown by both small and marginal farmers of the hill zone of West Bengal

Keywords: Mandarin, Asian pear, environment, soil health, agroforestry

In the hilly areas, undulating landscape constitutes the most fragile elements of the ecosystem and the traditional economy rests on the terrace cultivation with extremely limited feasibility for both expansion and modernization. Consequently, low economic return remains the characteristic feature of the agrarian landscape in the hill region. Along with fruit cultivation, tea garden practice and the cultivation of seasonal vegetables will boost up the regional economy (Sati 2004). The population density of this hill region is very low, but the per capita availability of land in this region is also low

because, vast portion of land could not cover with traditional agricultural crops presumably due to the practical difficulties experienced in the intensive cropping in such hilly terrains. For economic upliftment of the rural community inhabiting these hilly terrains, proper land use planning has to be done with different horticultural and plantation crops. With regard to soil conservation and in the ecological point of view, it is also desirable to cover the hills with perennial vegetation (Ghosh 1995). The rainfall is high in most of the hilly regions and fairly widespread. Though the soil and climate conditions are favourable for growing almost all the type of crops, in reality the organised cultivation practices in these hilly regions is relatively scanty compared to the plains.

Agroforestry is a unique and common practice in the hill region of West Bengal, India. The agri-horticultural is a common practice followed by the farmers which includes the cultivation of agricultural crops in association with the forest trees. The arrangement of agri-horti-silvi culture (agricultural crops + horticulture tree + forest tree) system on the same piece of land provides stable and a better output to the farmers. It is worthwhile because in hilly regions the existence without agroforestry is difficult as the trees not only supplement timber, fodder, fuel, fruits etc. but also reduces the pace of land sliding in the fields, protects crop to adverse wind and climatic conditions, conserves the soil moisture, improves the soil quality through nitrogen fixation and organic matter in terms of leaf fall.

Agroforestry is a land use option that increases livelihood security and reduces vulnerability to climate and environmental change. Agroforestry systems play a great role in the conservation of natural resources, especially soil. The soils are protected from wind and water induced erosion. The adverse effects of temperature and wind on soil fertility, soil flora and fauna are ameliorated by agroforestry system. This system also helps to increase soil fertility through nitrogen fixing trees and increase nutrient uptake from deep soil horizons and it also reduces the nutrient leaching losses. On the other hand, recycling of nutrients through the decomposition of litter fall, pruning of twigs and dead root residues enhance nutrients build up in soil. Most of the studies have shown that the tree residues in agroforestry system have N, K and Ca in sufficient quantity to meet the requirements of the associated crop (Korwar 1992). Crop production on hills of West Bengal in particular results in low and unstable, and often uneconomic yields because the lands results in degradation due to soil erosion. These lands are not able to sustain arable crops particularly during the drought years. Therefore, to develop some alternative land used system for these lands has been the need of the day. The component rainfed area increases production and income, besides imparting stability to the farming system (CRIDA 1999). Fruit trees apart from the above advantages also yield valuable by products. It is also found that the agri-horti-silvi culture is an increasingly important component of highland cropping systems (Withrow and Robinson 1999). In view of the above, the present paper deals with the influence of selected agri-hoti-silvi based system on growth and yield of selected intercrops, along with improvement in addition of the soil organic matter percent.

MATERIALS AND METHODS

Study Site

Field experiment was conducted during the year 2013-2015 at the Dalapchand Science Farm, Krishi Vigyan Kendra (KVK), Kalimpong, West Bengal to evaluate the growth performance and the yield of intercrops in the fruit based agroforestry system in the hill zone of West Bengal. The experimental site is located at 27.06° N latitude and 88.47° E longitudes at an elevation ranging between 979.93 m. to 1257.30 m. above the mean sea level. The average annual rainfall of this area generally varies between 2000 and3000 mm, about 80% of which are usually precipitated between June and September (monsoon period). Within this short period, the rainfall may be unevenly distributed. In the month of July to August, the heavy rains are likely to occur. Rainfall is not certain from the month of November to March. Partial or even total crop failures are the usual feature of the rainfed agriculture in this region. In this area, mean annual maximum and minimum temperatures vary from 15 to 24°C and 7.5° C to 9°C respectively, during the whole period of the experimentation. The intensity of sunlight is low, particularly in the monsoon and winter months, which in addition to the altitude

lowers the temperature. The summer temperature is generally high and during winter temperature remains moderately low. The climate of the site varies from sub-tropical to temperate type. The crop season of this region are broadly classified as summer or *pre-kharif* (March to May), rainy season or monsoon *kharif* (June to October) and winter or *rabi* (November to February). The mean relative humidity was found to vary from 70 to 80% depending on the locality and the season of the year. The soils of the site are mostly categorized as red lateritic and brown forest soil. The soil consists of organic matter content (1.07-0.12%), is light and high sandy loam or clay textured,and porous with poor water holding capacity. It has low pH due to its strong (pH below 4.9) (moderately acidic pH 5.0-5.9) reaction, available with phosphorus (9.9-15.8 kg ha^{-1}), and potassium content (488-592 kg ha^{-1}).

Intercrops in established plantation

The experiment was fitted in the randomized block design (RBD) which was replicated thrice. The grafted saplings of two fruit species (*Citrus reticulata* Blanco and *Pyrus communis*) were planted at 10m × 10m and one year old silvi sapling of *Alnus nepalensis* D. Don. were planted in the third week of June 2011 when the monsoon started in the region. It was planted in between the fruits species and boundary at a spacing of 2.5 m. Suitable varieties of ten intercrops viz. Maize (var. RCM-I-I), rice (var. Kalimpong-I), french bean (var. RCMFB-I), pea (var. Pusa Pragati) and pumpkin (var. Pusa Vishwas) during *kharif* and potato (var. Kufri Jyoti), cabbage (var. Pusa Drumhead), cauliflower (var. Pusa Snow Ball K-I), mustard (var. Pusa mustard 27(EJ-17) and onion (var. Pusa White Round) during *rabi* season of two consecutive years (2013-2015) were grown in between the two fruit trees and different growth parameters of intercrops viz. number of plants per m^2, plant height(cm) and main vein length(cm) of intercrops were recorded for the consecutive two years. The entire field was given equal cultural practices and was raised under rainfed condition. The control plots were taken as the area devoid of trees and fruit trees. The *kharif* and *rabi* crops were harvested in the month of November and March respectively and the crops weight were recorded on plot basis and their yield was converted per hectare basis.

Data recording

Observation on crop growth parameters *viz.* number of plants per m^2, plant height (cm) and main vein length (cm) was made on the intercrops and the sole crops plot. For determining the number of plants, an area of one sq. m. was demarcated for each of the intercrops, their number counted and their average values were also calculated. The heights of the intercrops were measured by a linear metric scale from the ground level of the plant to the auricle/ scar of the highest leaf. The average length of the plants was obtained from the length of all the plants within the demarked area of one square meter area. The *kharif* and *rabi* crops productivity was measured after each harvest in the month of November and March respectively. Initial depth wise composite soil samples were taken (0-15cm, 15-30cm and 30-60 cm depth) for the determination of the soil organic matter status of the experimental site.

At the end of the experimentation, plot wise soil organic matter dynamics under different agri-horti-silvi combinations were also observed by determining the percent soil organic carbon content at different soil depth (0-15 cm, 15-30 cm and 30-60 cm). The organic carbon status of the soil was determined by wet digestion method as proposed by Walkey and Black, and as described by Jackson (1967). Organic matter was calculated by multiplying the organic carbon percent by the value of Von Bemmelen factor 1.724. The bulk density of soil samples of the experimental plot was determined by Keen Raczkowski Box method. All the data generated in this experiment have been analyzed following the method of analysis for RBD. All main effects have been tested by F test. Critical difference (CD at 5%) has been calculated for mean comparison.

RESULTS AND DISCUSSION

Intercrops growth

Number of plants per m^2

The study revealed that the effect of one silvi (*Alnus nepalensis*) and two fruit trees (*Citrus reticulata* Blanco and *Pyrus communis*) on the number of plants per m^2 of intercrops during *kharif* and *rabi* were found significant at 5% level of significance (Table 1 & 2). Irrespective of the years of intercropping

Table 1: Number of plants per m^2 of intercrops during *kharif* season in 1st and 2nd year of study

Cropping System	*Kharif* Season									
	Maize		Rice		French bean		Pea		Pumpkin	
	2013-14	2014-15	2013-14	2013-2015	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Alnus nepalensis (T) + *C. reticulata* (F_1)	33.25	32.82	97.15	96.51	25.20	24.21	32.73	32.42	4.64	4.49
Alnus nepalensis (T) + *Pyrus communis* (F_2)	31.73	30.98	96.36	95.80	24.40	23.92	32.18	31.83	4.34	4.25
Sole crop	35.03	34.08	98.41	97.41	26.34	25.99	33.66	33.33	4.96	4.84
Mean	33.34	32.62	97.31	96.57	25.31	24.70	32.85	32.53	4.65	4.53
SEm(±)	0.12	0.26	0.11	0.08	0.05	0.26	0.03	0.07	0.10	0.08
CD (P=0.05)	0.38	0.86	0.36	0.26	0.17	0.83	0.11	0.21	0.33	0.26

Table 2: Number of plants/m^2 during *rabi* season in 1st and 2nd year of study in different crops

Cropping System	*Rabi* Season									
	Potato		Cabbage		Cauliflower		Mustard		Onion	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Alnus nepalensis (T) + *C. reticulata* (F_1))	31.58	30.75	13.22	13.09	13.13	12.99	22.62	22.50	37.78	37.64
Alnus nepalensis(T) + *Pyrus communis* (F_2)	30.68	30.27	12.30	12.18	12.36	12.24	22.34	22.20	37.54	37.41
Sole crop	32.50	31.43	14.00	13.84	13.63	13.48	23.27	23.14	38.30	38.20
Mean	31.59	30.82	13.17	13.04	13.04	12.90	22.74	22.61	37.88	37.75
SEm(±)	0.13	0.15	0.08	0.09	0.04	0.05	0.03	0.03	0.03	0.02
CD (P=0.05)	0.44	0.50	0.26	0.28	0.14	0.18	0.09	0.08	0.09	0.05

during both *kharif* and *rabi* season under horti-silvi plantation revealed that the number of plants per m^2 of all intercrops was higher under sole cropping followed by intercropping with *Alnus nepalensis* + *Citrus reticulata* and *Alnus nepalensis* + *Pyrus communis*. Further, the numberof plants per m^2 of all intercrops were found to slightly decrease in the second year of intercropping as compared with the first year of intercropping.Of the two fruit species, intercropping with *Alnus nepalensis* + *C. reticulata* plot showed higher number of plant per m^2 than intercropping with *Alnus nepalensis* + *Pyrus communis*. This may be due to the canopy architecture of *Citrus reticulata*, in which the soil is more exposed to sunlight. As a result, soil temperature was high and moisture in the surface soil was relatively low. These conditions of the above ground environment and soil might be responsible for better crop growth in *Citrus reticulata* plot Tripathi *et al.* (2009).

Height and main vein length (cm)

The study revealed that the effect of one silvi (*Alnus nepalensis*) and two fruit trees (*Citrus reticulata* Blanco and *Pyrus communis*) on height and main vein length (cm) of *kharif* and *rabi* intercrops were significant at 5% level of significance (Table 4&5). It was observed that the height and the main vein length (cm) of both *kharif* and *rabi* intercrops under one silvi (*Alnus nepalensis*) and two fruit tree (*Citrus reticulata* Blanco and *Pyrus communis*) revealed taller height (cm) and longer main vein length (cm) which was later found in *Alnus nepalensis* + *Pyrus communis* plot followed by *Alnus nepalensis* + *C. reticulata* plot and shorter in sole crops plot. The effect of shade was caused more by *Pyrus communis* trees which were relatively taller and had more canopy area than *C. reticulata* trees. This shade effect of trees might be the reason for taller crop height and longer vein length in *Alnus nepalensis* + *Pyrus communis* plot. All intercrops height was found to significantly increase over the years. This may be due to more litter production and subsequent litter decomposition under trees favouring higher soil moisture and nutrients retention that require better crop growth Vanlalhluna (2007).

Table 3: Number of plants/m^2 of *kharif* and *rabi* intercrops over two years of study (pooled)

Cropping System	*Kharif* crops						*Rabi* crops			
	Maize	Rice	French bean	Pea	Pumpkin	Potato	Cabbage	Cauliflower	Mustard	Onion
Alnus nepalensis (T) + *C. reticulata* (F_1)	33.04	96.83	24.70	32.57	4.57	31.17	13.16	13.06	22.56	37.71
Alnus nepalensis (T) + *Pyrus communis* (F_2)	31.35	96.03	24.16	32.01	4.30	30.47	12.34	12.30	22.27	37.48
Sole crop	34.55	97.91	26.16	33.49	4.90	31.84	13.92	13.55	23.21	38.25
Mean	**32.98**	**96.94**	**25.01**	**32.69**	**4.59**	**31.16**	**13.11**	**12.92**	**22.68**	**37.81**
SEm(±)	0.18	0.09	0.13	0.04	0.09	0.10	0.08	0.05	0.03	0.02
CD (P=0.05)	0.60	0.29	0.42	0.14	0.29	0.33	0.27	0.16	0.08	0.07

Table 4: Plant height (cm) and main vein length (cm) of intercrops during *kharif* season of 1st and 2nd years of study

Cropping System	*Kharif* Season									
	Height(cm)				Main vein length(cm)					
	Maize		Rice		French bean		Pea		Pumpkin	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Alnus nepalensis (T) + *C. reticulata* (F_1)	132.45	134.12	67.72	68.83	124.23	125.25	92.15	93.06	184.58	185.49
Alnus nepalensis (T) + *Pyrus communis* (F_2)	134.85	136.60	69.11	69.92	125.28	126.47	93.18	94.13	185.31	186.08
Sole crop	130.14	131.78	66.32	67.46	122.96	124.06	91.04	92.09	184.20	185.23
Mean	**132.48**	**134.16**	**67.72**	**68.74**	**124.16**	**125.26**	**92.12**	**93.09**	**184.70**	**185.60**
SEm(±)	0.29	0.43	0.23	0.27	0.07	0.12	0.13	0.07	0.07	0.14
CD (P=0.05)	0.93	1.39	0.74	0.87	0.24	0.41	0.42	0.22	0.21	0.45

Table 5: Plant height (cm) of intercrops during *rabi* season of 1st and 2nd years of study

Cropping System	*Rabi* Season									
	Potato		Cabbage		Cauliflower		Mustard		Onion	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Alnus nepalensis (T) + *C. reticulata* (F_1)	28.55	29.76	30.28	31.62	35.61	35.87	38.76	39.50	40.83	41.83
Alnus nepalensis (T) + *Pyrus communis* (F_2)	29.66	30.41	31.49	32.67	36.42	36.81	39.09	39.78	41.35	42.01
Sole crop	27.87	28.72	29.76	30.68	35.26	35.37	38.61	39.30	40.47	41.51
Mean	**28.69**	**29.63**	**30.51**	**31.66**	**35.76**	**36.02**	**38.82**	**39.53**	**40.88**	**41.78**
SEm(±)	0.15	0.16	0.11	0.16	0.07	0.06	0.01	0.02	0.03	0.05
CD (P=0.05)	0.50	0.54	0.36	0.53	0.24	0.2	0.02	0.08	0.09	0.15

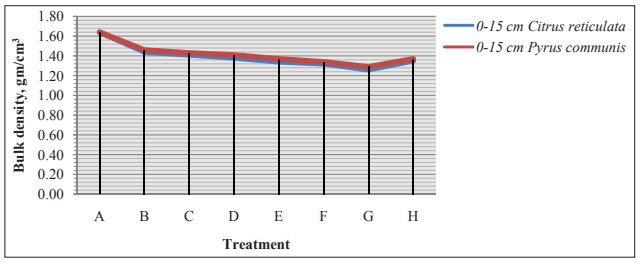
Table 6: Plant height (cm) and main vein length (cm) of *kharif* and *rabi* intercrops over two years of study (pooled)

Cropping System	*Kharif* season					*Rabi* season				
	Plant height(cm)		Main vein length (cm)			Plant height(cm)				
	Maize	Rice	French bean	Pea	Pumpkin	Potato	Cabbage	Cauliflower	Mustard	Onion
Alnus nepalensis (T)+ *C. reticulata* (F1)	133.28	68.27	124.74	92.61	185.04	29.15	30.95	35.74	39.13	41.33
Alnus nepalensis (T) + *Pyrus communis* (F2)	135.73	69.52	125.87	93.66	185.70	30.04	32.08	36.62	39.44	41.68
Sole crop	130.96	66.89	123.51	91.57	184.72	28.29	30.22	35.32	38.96	40.99
Mean	**133.32**	**68.23**	**124.71**	**92.61**	**185.15**	**29.16**	**31.10**	**35.89**	**39.17**	**41.33**
SEm(±)	0.33	0.25	0.27	0.10	0.08	0.15	0.13	0.07	0.01	0.04
CD (P=0.05)	1.07	0.80	0.89	0.31	0.26	0.50	0.42	0.22	0.03	0.12

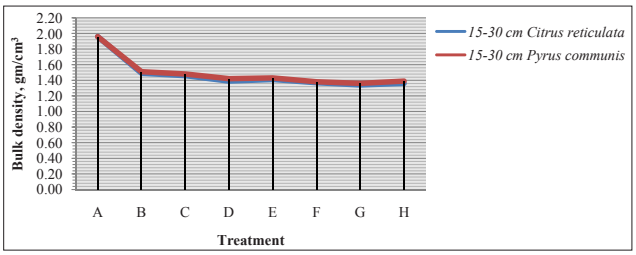
Soil health status

Bulk density

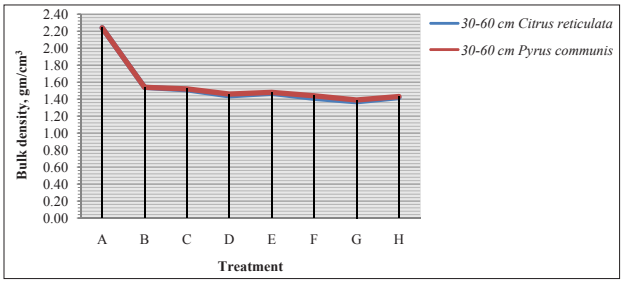
The results revealed that the effect of agri-horti-silvi system on soil bulk density was found significant (Fig.1.a.b.c) in all soil depth. It shows a decreasing effect in the soil bulk density under agri-horti-silvi system as compared to the initial value in all soil depths.



1(a)



1(b)



1(c)

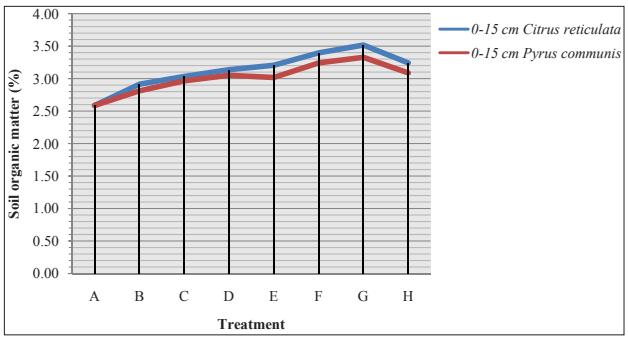
Where, A=Initial value, B= Sole Fruit Tree, C= Silvi + Fruit tree, D=Silvi + Fruit tree +Maize (kharif) + Potato (rabi), E= Silvi +Fruit tree + Rice (kharif) + Cabbage (rabi), F= Silvi + Fruit tree + French bean (kharif) + Cauliflower (rabi), G= Silvi + Fruit tree + Pea (kharif + Mustard (rabi), H= Silvi + Fruit Tree + Pumpkin (kharif) + Onion (kharif).

Fig. 1.a.b.c Influence of agri-horti-silvi system on soil bulk density ($gm \cdot cm^3$) at the end of experimentation

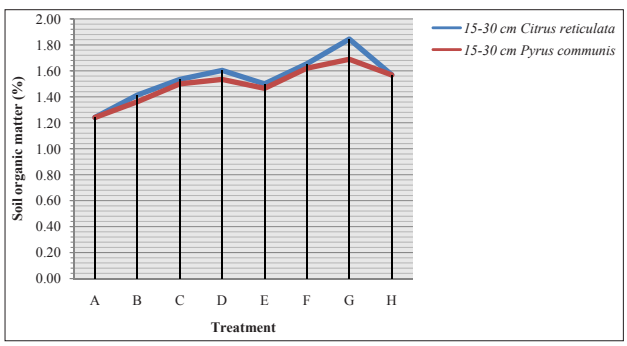
At soil depth 0-15cm, sole fruit tree system does not show it's that effective as compared to silvi (*Alnus nepalensis*) + fruit tree (*C. reticulata* & *Pyrus communis*) + intercrops (*kharif* and *rabi*) system. Similar trend was observed in other depth of soil. In all the soil depths higher decrease in soil bulk density was recorded under *Alnus nepalensis* + *Citrus reticulata* + pea (*kharif*) + mustard (*rabi*) followed by *Alnus nepalensis* + *Pyrus communis* + pea (*kharif*) + mustard (*rabi*) and least in sole fruit tree. It was recorded that at initial (before establishment) the soil bulk density gm cm^{-3} found at soil depth 0-15cm, 15- 30cm and 30-60cm were 1.64, 1.96 and 2.24 gm cm^{-3}, respectively. The decrease in bulk density is corroborating with tillage operation during crop cultivation during the establishment of agroforestry system. The soil compaction is phenomenal as it involves significant interrelationship between physical and biological properties of the soil. This improved in bulk density of the top soil as a result of tillage operation, intercultural operation and leaf litter accumulation under agroforestry system (Ngunji and Siemens, 1993). Under this system bulk density increases significantly with soil depths (Rong Mao and De Hui Zeng, 2013).

Soil organic matter (%)

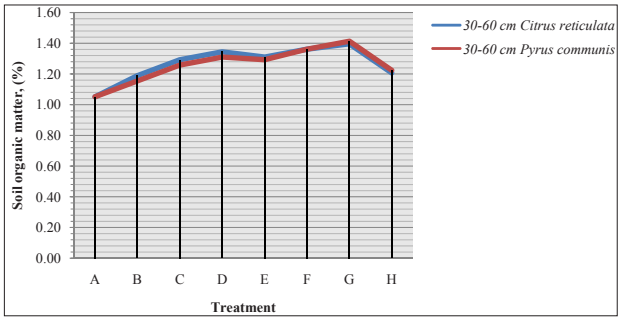
The results revealed that the effect of agri-horti-silvi system on soil organic matter was significant (Fig.2.a.b.c).



2(a)



2(b)



2(c)

Where, A=Initial value, B= Sole Fruit Tree, C= Silvi + Fruit tree, D= Silvi + Fruit tree +Maize (kharif) + Potato (rabi), E= Silvi +Fruit tree + Rice (kharif) + Cabbage (rabi), F= Silvi + Fruit tree + French bean (kharif) + Cauliflower (rabi), G= Silvi + Fruit tree + Pea (kharif + Mustard (rabi), H= Silvi + Fruit Tree + Pumpkin (kharif) + Onion (kharif).

Fig. 2.a.b.c Influence of agri-horti-silvi system on soil organic matter (%) at the end of experimentation

It shows an increasing effect in soil organic matter percent under agri-horti-silvi system when compared tothe recorded initial value (before establishment) in all three soil depths (0-15,15-30,30-60 cm). Sole fruit tree system does not seemthat effective as compared to silvi (*Alnus nepalensis*) + fruit tree (*C. reticulata* & *Pyrus communis*) + intercrops (*kharif* and *rabi*) system. Similar trend was observed in the other depth of soil. In all the soil depth, higher increase in soil organic matter percent was recorded under *Alnus nepalensis* + *Citrus reticulata* + pea (*kharif*) + mustard (*rabi*) followed by *Alnus nepalensis* + *Pyrus communis* + pea (*kharif*) + mustard (*rabi*) and least in sole fruit tree. It was recorded that at initial the soil organic matter percent found at soil depth 0-15cm, 15-30cm and 30-60cm were 2.59, 1.24 and 1.05 percent respectively. Higher soil organic matter content was found in top soil under agroforestry than the open area (Trouve *et al.* 1994). Agroforestry remains as a vital instrument to conserve soil organic carbon to increase the fertility status of the hill region Lal (2002).

Yield of crops (t/ha)

The yield attributes of all the intercrops grown during *kharif* (viz. maize, rice, french beans, pea, pumpkin) and *rabi* seasons (viz. potato, cabbage, cauliflower, mustard, onion) were recorded and presented in Fig. 3 & 4. The main objective of taking these parameters wasto observe any synergistic or antagonistic effects on the yield of the intercrops when grown under one silvi (*Alnus nepalensis*) and two fruit trees plantation.

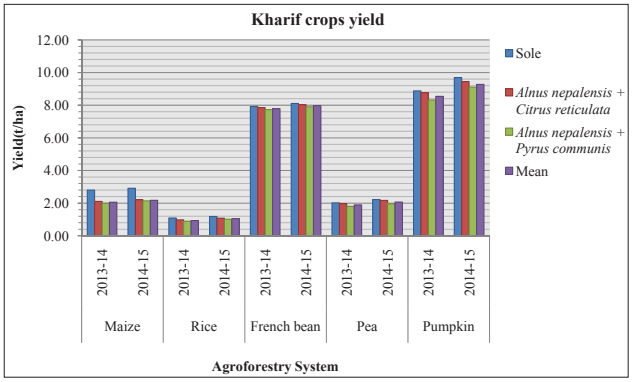


Fig. 3: Yield (t/ha) of *kharif* intercrops in agri-horti-silvi system during study period

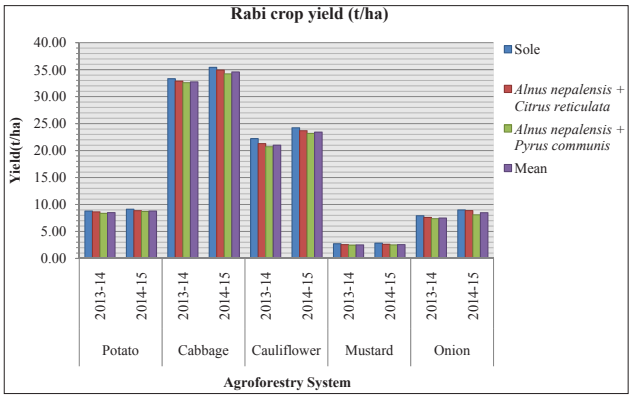


Fig. 4: Yield (t/ha) of *rabi* intercrops in agri-horti-silvi system during the study period

It was observed that there were significant differences in the yield of the intercrops during the second year. This could be due to the increased fertility of the soil or due to the addition of fertilizers to the fruit trees as well as the decomposition of the organic matter or both from the trees as well as the intercrops when compared to the initial land condition. The yield of intercrops was recorded higher in sole crop than intercropping situation. In an agroforestry system, the agricultural crop production is generally lower due to the competition with trees, but the biomass production is adequately compensated due to the overall productivity (tree+ crop) which is generally greater than sole agricultural system (Newaj *et al.* 2003). The reduction in crop yield under agroforestry systems was mainly due to the competition for the light, water, nutrients and allelopathic effect etc. The competition may be interspecific or intraspecific (Carnell 1990). Shading was found to be more

important than below ground competition in an intercropping study (Wiley and Raddy 1981). The nutrient status in agroforestry system was shared by agriculture and forest components.

CONCLUSION

From the study it may be concluded that the yield of arable intercrops was higher under sole cropping system compared to the agri-horti-silvi based system. Silvi and fruit trees did not greatly suppress growth and the yield performance of intercrops. The soil health status was found better under agri-horti-silvi system than sole cropping system. High increase in the level of organic matter in the surface soil increases the infiltration capacity. Thus, it directly helps to check land degradation through soil erosion in heavy rainfall hilly areas. Besides, intercropping of arable crops during both *kharif* and *rabi* seasons allows better cash flow during the early growth period of the silvi and fruit trees when the return from the silvi and fruit trees is not forthcoming. Therefore, above all the benefits suitable agri-hort-silvi based models could be grown profitably by small and marginal farmers in the entire hilly region without deteriorating the soil health and the environment.

ACKNOWLEDGEMENTS

The authors are thankful to the University Grant Commission, New Delhi (India) for providing financial support to conduct the present investigation.

REFERENCES

Carnell, J.H. 1990. "Apparent verses real"competition in plants. In: Grace, G.B. and Tilman, D (eds), Prospective on plant competition, Academic Press, New York, USA, pp. 9-26.

CRIDA, 1999. Annual Reports of Central Research Institute for Dry land Agriculture, Hyderabad.

Ghose, S.P. 1985. Horticulture in North-East India. Associated Pub Co, New Delhi, pp. 230.

Korwar, G.R. 1992. Influence of cutting height of Leucaena hedgerows on alley cropped sorghum and pearl millet. *Indian Journal of Dryland Agriculture Research. & Development*, **7**: 57-60.

Lal, R. 2002. The Potential of soils of the tropics to sequester carbon and mitigate the Green house effect. *Advances in Agronomy,* **76:** 1-3.

Mao, R. and Zeng, D. 2013. Effect of land-use change from cropland to poplar-based agroforestry on soil properties in a semiarid region of northeast china. *Fresenius Environmental Bulletin*, **22**: 4a.

Newaj, R., Bhargava, M. K., Yadav, R.S., Ajit, and Shanker, A. K. 2003. Tree-crop interaction in *Albziaprocera* based agroforestry system in relation to soil moisture, light and nutrient. *Indian Journal of Agroforestry,* **5** (1&2): 17-29.

Ngunijiri, G. M. and Siemens, J.C. 1993. Tractors Wheel Traffic Effects on Corn Growth. ASAE Paper No. 93-110. ASAE, St. Joseph, MI.

Sati, V.P. 2004. Horticultural Development in hills-A case for the Alanknanda Basin. Mittal Pub., New Delhi, pp. 123.

Tripathi, O.P., Pandey, H.N. and Tripathi, R.S. 2009. Litter production, decomposition and physico-chemical properties of soil in 3 developed agroforestry systems of Meghalaya, Northeast India. *African Journal of Plant Science,* **3**(8): 160-167.

Trouve, C., Mariott, A., Schwartz, D. and Gguillet, B. 1994. Soil organic carbon dynamics under *Eucalyptus Eucalyptus* and *Pinus* planted on savannas in the Congo. *Soil Biology and Biochemistry,* **26**: 287-295.

Vanlalhluna, P.C. 2007. Studies of tree-crop compatibility and growth performance of field crops and soil moisture conservation as affected by different mulches under hilly terrain of Mizoram. Ph.D. Thesis. Mizoram University, Aizawl (unpublished).

Wiley, R.W. and Raddy, M.S. 1981. A field technique for separating above and below ground interaction in intercropping: An experiment with pearl millet/ groundnut. *Exp. Agric*., **17**: 257-264.

Withrow, B. and Robinson, 1999. A preliminary classification of fruit-based agroforestry in a highland area of northern Thailand, Kluwer Academic Publisher, *Agroforestry Systems*, **42**: 195–205.