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Assessment of biomass and carbon sequestration under Mahaneem based agro-forestry systems and sole cropping

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Abstract
Study shows the biomass and carbon sequestration under different plant geometries, *i.e.*, 10×20, 10×10, 10×6.5 and 10×5 m of Mahaneem based agro-forestry systems and sole cropping. Destructive sampling was used to calculate the biomass and carbon content of *A. excelsa* and carbon sequestration was also calculated. The total biomass of crops *viz.* wheat and mustard was calculated by adding biomass of all the components (grain, straw and root weight). It stated that the higher biomass (28.63 t/ha) and carbon sequestration (13.13 t/ha/yr) in *Mahaneem* was recorded under 10×5 m plant geometry, whereas, the maximum carbon sequestration (16.5 t/ha/year) was recorded in *Mahaneem* + wheat agro-forestry system under 10×5 m plant geometry closely followed by *Mahaneem* + Indian mustard agri-silviculture agro-forestry system with same plant geometry. It shows that wheat sequestered more carbon than Indian mustard.

Keywords: *Ailanthus excelsa*, biomass, carbon sequestration, Indian mustard, *Mahaneem*, wheat

Introduction

Agro-forestry practices have great potential for climate change mitigation through sequestration of atmospheric carbon dioxide. Agro-forestry systems are intensively managed and they produce far more biomass than the conventional forests. Its recent recognition as a greenhouse-gas mitigation strategy under the Kyoto Protocol has earned it added attention as a strategy for biological carbon sequestration (Nair *et al*., 2009) [2]. Fast-growing woody plants that can be grown under short rotation systems offer an alternative to food production on arable land, serve as a potential source of renewable energy as well as climate-change mitigation strategies. Other significant environmental benefits spurred by commercial agro-forestry establishment include soil organic carbon sequestration, long-term carbon storage in wood products manufactured from harvested biomass, and soil erosion control.

Agro-forestry systems reduce greenhouse gas emissions (GHG emissions) by storing carbon in the soils and woody biomass. All most all of the agro-forestry systems have the potential to sequester carbon, which may vary according to tree species (Prasad *et al*., 2012) [5] and management practices (Newaj *et al*., 2001) [3]. The CO_2 reduction in atmosphere can only be achieved by shifting from lower biomass land uses, *e.g*., grasslands, crop fallows, *etc*., to tree based systems such as agro-forestry, forests, and plantation forests (Roshetko *et al*., 2007) [6].

Material and Methods

The present study was carried out at the research area of CCS Haryana Agricultural University Regional Research Station, Bawal during winter, 2016-17. In which two winter season crops *viz.* wheat (*Triticum aestivum* L.) *cv*. WH-1105 and Mustard (*Brassica juncea* L.) *cv*. RH-50 were intercropped with three and half years old mahaneem (*Ailanthus excelsa*) plantation planted at different plant geometries, *i.e*., 10×20, 10×10, 10×6.5 and 10×5 m. The biomass and carbon sequestration of tree and crops were estimated.

The total biomass of tree was calculated using destructive sampling method. Three representative trees were selected under different plant geometry and were completely uprooted and the total fresh and dry weight was estimated by weighing stem, leaves, and root. After recording of fresh weight, all the samples were oven dried at 65 ˚C and the oven dry weight was used for determining the stand biomass on a hectare basis. . In crops, the above ground biomass was measured after harvesting and threshing.

The grain and straw/stover yield of crops (wheat and Indian mustard) were measured. The below ground biomass was estimated by excavation method. Three randomly selected one square meter quadrants were used under different plant geometry. Dry biomass was determined by drying the freshly harvested roots in hot air oven at 65°C.
Carbon sequestration (t/ha) was calculated by following formula:
Carbon Storage = Biomass of tree × 50% or Biomass/2 (Pearson *et al*., 2005) [4]
CO_2 sequestrated = carbon weight × 3.67
CO_2 sequestrated per year = CO_2 sequestrated/age of tree
Carbon sequestration in wheat and Indian mustard was estimated only considering the root biomass (below ground biomass) as the above ground biomass was removed from the system.

Results and Discussion

Biomass and carbon sequestration under agro-forestry system increased with increase in number of trees per ha. The data presented in Table 1 stated that the significantly higher biomass, *i.e*., 28.63 t/ha was recorded under 10×5 m plant geometry in association with crops which further decreased with the increase in the plant geometry of *Mahaneem*. Similar results were also obtained for carbon sequestration under different plant geometry in agro-forestry system. It was observed that maximum carbon (14.31 t/ha), carbon sequestration (52.54 t/ha) and carbon sequestration (13.13 t/ha/yr) was recorded under 10×5 m plant geometry in association with crops which further decreased with the increase in the plant geometry. It may be due to higher number of trees (200 trees/ha) in 10×5 m plant geometry. The increase in biomass and carbon sequestration under narrow plant geometry may be due to increase in number of trees per ha thereby increasing the total biomass produced by tree component. The carbon sequestration potential of trees in agro-forestry systems varies with age and spatial distribution (Dhyani *et al*., 2016) [1].

Table 1: Biomass and carbon sequestration (CO_2 t/ha/yr) by *Mahaneem* under agro-forestry and sole plantation

Plant geometry (m)	Biomass (t/ha)		Carbon (t/ha)		CO_2 Sequestration (t/ha)		CO_2 Sequestration (t/ha/year)	
	With Crops	Without Crops	With Crops	Without Crops	With Crops	Without Crops	With Crops	Without Crops
10x20	7.33	7.27	3.66	3.64	13.45	13.35	3.36	3.34
10x10	14.43	14.18	7.22	7.09	26.48	26.02	6.62	6.51
10x6.5	21.59	21.08	10.80	10.54	39.63	38.68	9.91	9.67
10x5	28.63	27.83	14.31	13.91	52.54	51.06	13.13	12.77
CD at 5% level of significance								
Crop	N.S.		N.S.		N.S.		N.S.	
Plant geometry	0.85		0.43		1.55		0.38	
Crop x plant geometry	N.S.		N.S.		N.S.		N.S.	

It was observed that significantly maximum carbon sequestration (16.5 t/ha/yr) was recorded in Mahaneem + wheat agro-forestry system under 10×5 m plant geometry closely followed by Mahaneem + Indian mustard agro-forestry system (14.3 t/ha/yr) under same geometry, i.e., 10×5 m (Table 2). In general, agro-forestry systems sequestered higher carbon than the sole plantation may be due slightly better growth in agro-forestry than sole planting. The carbon sequestered by each system differed greatly may be due to type of crop (wheat and Indian mustard in our case), system, geometry and previous land-use (Dhyani *et al.*, 2016) [1]. The carbon sequestered largely depends on the type of agro-forestry systems, the structure and function, which largely determined by environmental and socio-economic factors. The carbon sequestration potential for agro-forestry systems is variable, depending on the tree spacing, objective of production, system components and productivity, etc. (Prasad *et al.*, 2012 and Newaj *et al.*, 2001) [5, 3].

Table 2: Carbon sequestration of *Mahaneem* based agro-forestry systems (t/ha/year)

Plant geometry (m)	*A. excelsa*	*A. excelsa* + wheat	*A. excelsa* + Indian mustard	Mean B
10×20	3.3	7.2	4.9	5.13
10×10	6.5	10.2	7.9	8.20
10×6.5	9.7	13.3	11.1	11.37
10×5	12.8	16.5	14.3	14.53
Mean A	8.08	11.80	9.55	
CD at 5% level of significance				
AFS	0.25			
Plant geometry	0.28			
AFS x plant geometry	N.S.			

Conclusion

Maximum carbon sequestration (16.5 t/ha/year) was recorded in *Mahaneem* + wheat agro-forestry system under 10×5 m plant geometry closely followed by *Mahaneem* + Indian mustard agri-silviculture agro-forestry system with same plant geometry.

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