

# Carbon Sequestration in Poplar Agroforestry Systems in India with Wheat and other Crops at Different Spacing and Row Directions

R.S. Dhillon, R.S. Beniwal, G. von Wühlisch

Haryana Agricultural University, Thünen-Institute for Forest Genetics



Different age poplar plantations



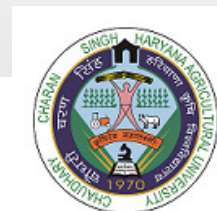
# Outline

**AFS (Agroforestry Systems) studied**

**C-sequestration**

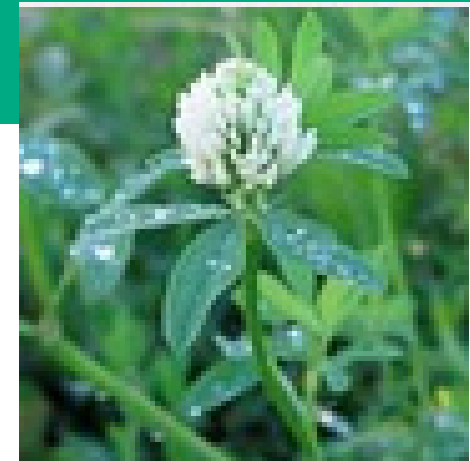
**SOC (soil organic carbon)**

**Effect of tree line – distance and direction**



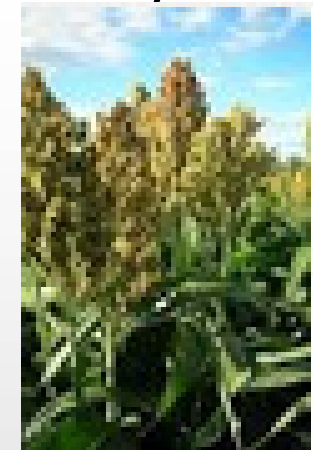
# Agroforestry Systems (irrigated)

Poplar as forest species  
combined with crops:



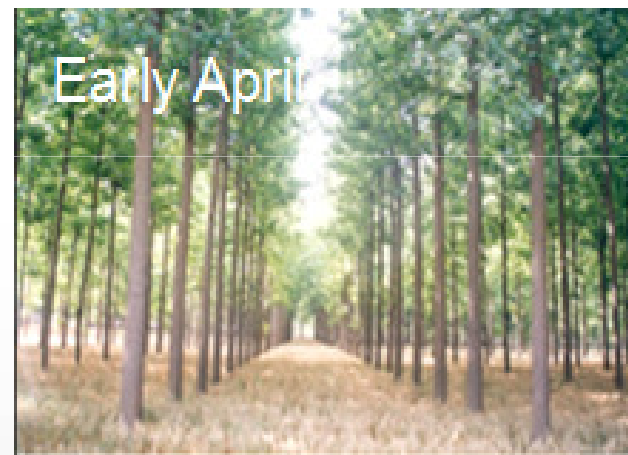
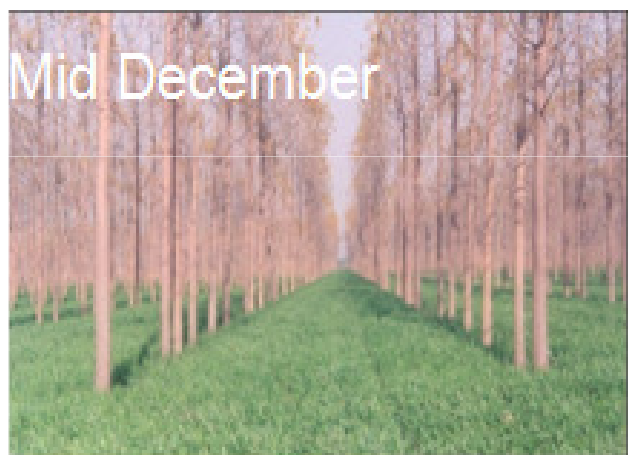
- Cowpea (*Vigna unguiculata*)
- Berseem (Egyptian clover; *Trifolium alexandrinum*)
- Sorghum (*Sorghum bicolor*)
- Wheat (*Triticum aestivum*)

Instead of the traditional  
rice-wheat rotation



# Agroforestry Systems

## Rabi season crop (winter) wheat



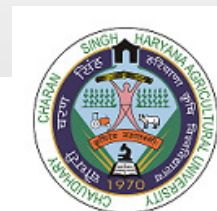
# Agroforestry Systems

Poplar spacings:

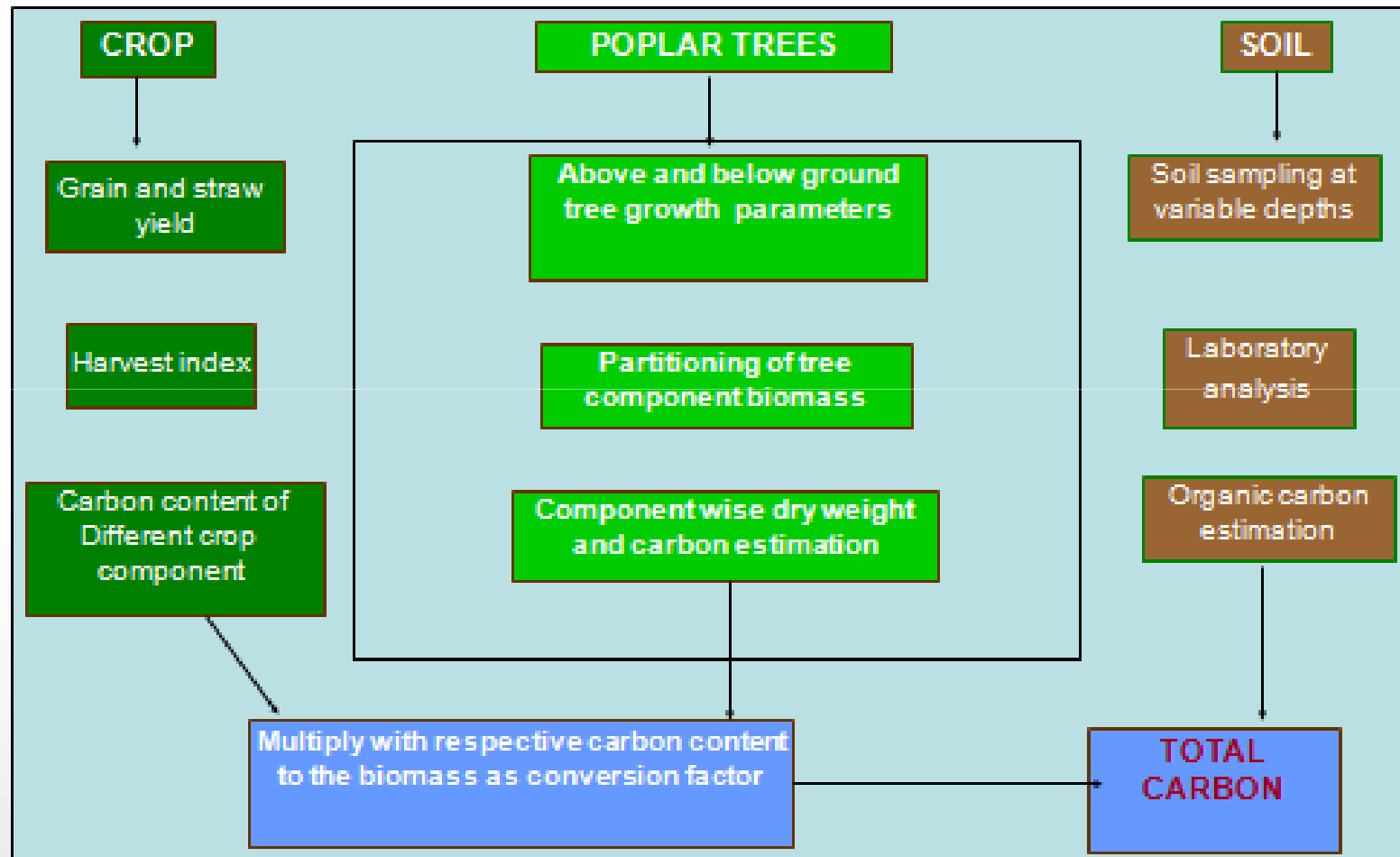
- a) 5 x 4 m
- b) 10 x 2 m
- c) 18 x 2 x 2 m (paired row)
- d) Sole crops

Crop rotations:

- Cowpea-Wheat
- Sorghum-Berseem



# Agroforestry Systems



# Agroforestry Systems

Income ratio of poplar AGRF vs. pure crop

Rotation (Years)	AGRF	Pure crop
6	5.38	2.22
7	5.80	2.21
8	8.30	2.21

Poplar is a high value-added farm product





**Poplar (5x4m) with cowpea**



**Poplar (5x4m) with wheat**



**Poplar (10x2m) with cowpea**



**Poplar (10x2m) with berseem**





**Poplar paired row with wheat, 18 x 2 x 2**



**Poplar paired row with berseem**



**Poplar paired row with sorghum**



**Poplar paired row with cowpea**

# C-sequestration

Effect of spacing of poplar on yield (t/ha) of rainy and winter season crops during 2012-13.

Spacing (m)	Sorghum fodder yield	Cowpea fodder yield	Berseem fodder yield	Wheat grain yield
5 x 4	1.7	4.0	41.4	2.0
10 x 2	3.5	4.8	42.4	2.1
18 x 2 x 2	8.7	16.5	48.1	2.5
Control	28.3	20.1	55.1	3.6

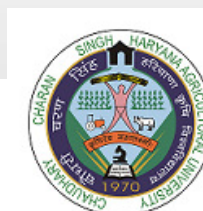
CD at 5%

1.9

1.4

5.2

0.4





# C-sequestration

**Leaf litter fall (t/ha), its NPK content and nutrient addition in soil at different spacings of poplar.**

Poplar Spacing (m)	Leaf litter fall (t/ha)	Leaf litter NPK Content (%)			NPK addition (kg/ ha) through leaf litter		
		N	P	K	N	P	K
5 x 4	5.4	1.230	0.100	0.565	65.2	5.3	30.0
10 x2	4.3	1.230	0.090	0.613	52.9	3.8	26.4
18 x 2 x 2	2.7	1.320	0.094	0.606	35.6	2.5	16.4



**Total carbon storage (t/ha) in poplar based agroforestry system and sole agriculture after six years of plantation.**

<b>System</b>	<b>Carbon storage (t/ha)</b>			
	<b>Poplar spacings (m)</b>			<b>Sole crops</b>
	<b>5x4</b>	<b>10x2</b>	<b>18x2x2</b>	
<b>Soil</b>	<b>12.6</b>	<b>12.6</b>	<b>12.8</b>	<b>12.0</b>
<b>Agric. crops (above ground)</b>				
<b>a). Sorghum-berseem</b>	<b>32.2</b>	<b>35.4</b>	<b>39.0</b>	<b>53.1</b>
<b>b). Cowpea-wheat</b>	<b>27.4</b>	<b>29.5</b>	<b>34.5</b>	<b>40.5</b>
<b>Poplar tree (below &amp; above ground)</b>	<b>70.6</b>	<b>62.0</b>	<b>51.4</b>	<b>-</b>
<b>Grand total =</b>				
<b>poplar+ sorghum- berseem</b>	<b>115.4</b>	<b>110.0</b>	<b>103.2</b>	<b>65.1</b>
<b>poplar + cowpea-wheat</b>	<b>110.6</b>	<b>104.1</b>	<b>98.7</b>	<b>52.5</b>
<b>Carbon storage rate / year/ ha</b>				
<b>Sole poplar</b>	<b>11.8</b>	<b>10.3</b>	<b>8.6</b>	<b>-</b>
<b>Poplar+ sorghum-berseem</b>	<b>19.2</b>	<b>18.3</b>	<b>17.2</b>	<b>10.8</b>
<b>Poplar+ cowpea-wheat</b>	<b>18.4</b>	<b>17.3</b>	<b>16.5</b>	<b>8.8</b>

# C-sequestration

## Annual soil organic carbon (%) accumulation in poplar-based AFS

Landuse	Tree age (years)		
	One	Three	Six
0–15 cm soil layer			
Agroforestry	0.55 (0.006)	0.65 (0.012)	0.77 (0.012)
Sole crop	0.40 (0.006)	0.43 (0.010)	0.41 (0.006)
LSD (0.05)	Land use (LU) = 0.04	Tree age (TA) = 0.05	LU × TA = 0.07
15–30 cm soil layer			
Agroforestry	0.48 (0.010)	0.50 (0.006)	0.59 (0.015)
Sole crop	0.36 (0.012)	0.37 (0.007)	0.36 (0.003)
LSD (0.05)	Land use (LU) = 0.02	Tree age (TA) = 0.02	LU × TA = 0.03

Values in parenthesis are the standard error of means of the three replications

Gupta et al. 2009



# C-sequestration

## Total soil organic carbon (SOC) pool (Mg ha<sup>-1</sup>)

Landuse	Tree age (years)		
	One	Three	Six
0–15 cm soil layer			
Agroforestry	12.4 (0.058)	14.6 (0.115)	15.8 (0.115)
Sole crop	9.00 (0.058)	9.67 (0.010)	9.22 (0.006)
LSD (0.05)	Land use (LU) = 1.6	Tree age (TA) = 1.1	LU × TA = 0.9
15–30 cm soil layer			
Agroforestry	10.8 (0.100)	11.3 (0.058)	13.3 (0.153)
Sole crop	8.10 (0.012)	8.32 (0.007)	8.10 (0.003)
LSD (0.05)	Land use (LU) = 1.1	Tree age (TA) = 0.9	LU × TA = 0.7

Values in parenthesis are the standard error of means of the three replications

Gupta et al. 2009



# C-sequestration

## Water stable aggregates >0.25 mm (%) in a poplar-based AFS at different tree age

Landuse	Tree age (years)		
	One	Three	Six
0–15 cm soil layer			
Agroforestry	3.60 (0.115)	11.4 (0.100)	19.9 (0.115)
Sole crop	0.25 (0.006)	0.35 (0.015)	0.31 (0.010)
LSD (0.05)	Land use (LU) = 1.52	Tree age (TA) = 1.86	LU × TA = 2.60
15-30 cm soil layer			
Agroforestry	2.40 (0.058)	6.93 (0.012)	12.3 (0.058)
Sole crop	0.17 (0.006)	0.33 (0.010)	0.16 (0.006)
LSD (0.05)	Land use (LU) = 1.04	Tree age (TA) = 1.28	LU × TA = 1.81

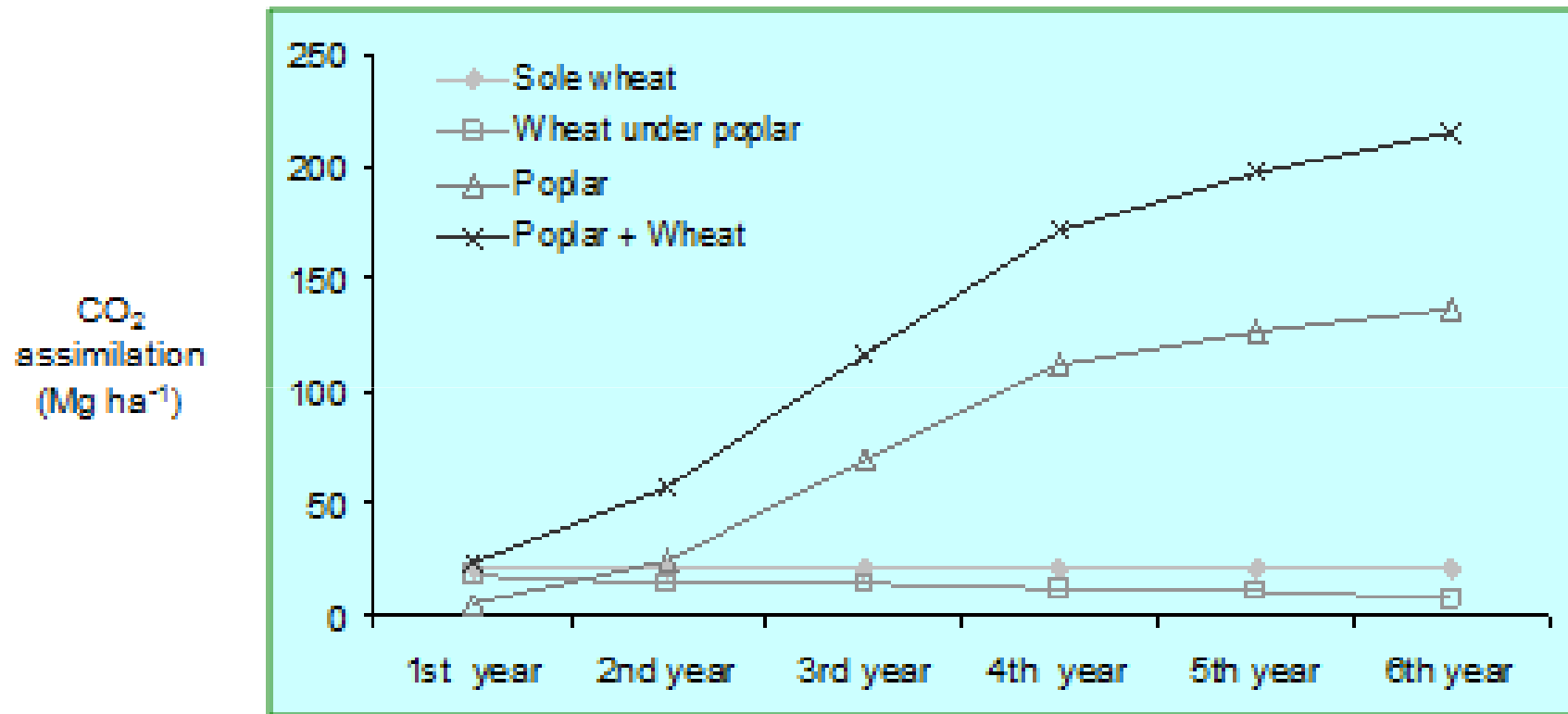
Values in parenthesis are the standard error of means of the three replications

Gupta et al. 2009





# C-sequestration



Total CO<sub>2</sub> assimilation in poplar and wheat agroforestry

Chauhan et al. 2011

# Effects of poplar tree lines

## Effect of boundary planted poplar tree lines and row direction on the yield of agricultural crops

Year of start: 2006-07

### Treatments:

A. **Tree species:** (i) Poplar

B. **Row direction:** (i) North-south (ii) East-west

C. **Crop rotation:** Poplar:- sorghum-wheat,

D. **Distance from the tree row:** 0-3m, 3-6m, 6-9m, 9-12 m, 12-15 m and 15-18 m

Design: RBD      Replications: Three

Chauhan et al. 2012



**Effect of row direction and distance from the row of East-West bund planted poplar on the green fodder yield (t/ha) of sorghum and Wheat during 2012-13.**

Tree row distance (m)	Sorghum			Wheat		
	Northern aspect	Southern aspect	Mean	Northern aspect	Southern aspect	Mean
0-3	3.3	5.0	4.1	2.5	2.7	2.6
3-6	7.4	8.9	8.1	3.4	3.6	3.5
6-9	19.2	24.8	22.0	3.8	3.7	3.7
9-12	31.3	32.5	31.9	3.7	3.7	3.7
12-15	31.6	32.8	32.2	3.9	3.9	3.9
15-18	32.0	33.3	32.7	3.8	3.9	3.8
Mean	20.8	22.9	-	3.5	3.6	-

CD at 5% Distance: 2.0  
Aspect: 1.1  
Distance x aspect: NS

Distance: 0.5  
Aspect: NS  
Distance x aspect: NS

Chauhan et al. 2012



**Effect of row direction and distance from the row of North - South bund planted poplar on the green fodder yield (t/ha) of sorghum and grain yield of Wheat during 2012-13.**

Tree row distance (m)	Sorghum			Wheat		
	Eastern aspect	Western aspect	Mean	Eastern aspect	Western aspect	Mean
0-3	7.8	7.7	7.7	2.7	2.6	2.6
3-6	15.7	15.1	15.4	3.4	3.3	3.3
6-9	19.3	18.3	18.8	3.6	3.6	3.6
9-12	31.0	30.2	30.6	3.5	3.6	3.5
12-15	31.2	30.4	30.8	3.6	3.7	3.6
15-18	31.1	30.5	30.8	3.7	3.7	3.7
<b>Mean</b>	<b>22.7</b>	<b>22.0</b>	-	<b>3.4</b>	<b>3.4</b>	-

CD at 5%

Distance: 1.8

Aspect: NS

Distance x aspect: NS

Distance: 0.4

Aspect: NS

Distance x aspect NS

Chauhan et al. 2012





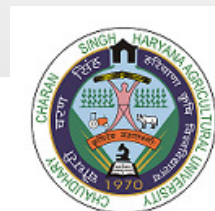
**Boundary planted poplar with wheat**



**Boundary planted poplar with sorghum**

# Salient results

- ❑ After six years of plantation, poplar has been found to attain significantly more girth at 5x4m and 10x2m spacing than paired row planting (18x2x2m).
- ❑ Sorghum and cowpea grown for fodder during the kharif (summer) season and wheat and berseem (fodder) grown during the rabi (winter) season produced significantly higher yield in paired row planting than at 5x4m and 10x2m spacing.
- ❑ Poplar based agroforestry system at 6years age was found to sequester 82 percent more carbon than sole agriculture. The rate of carbon storage was found to be 17.8t/ha/year in Poplar based agroforestry system and 9.8t/ha/year in sole agriculture.
- ❑ Water stable aggregates (> 0.25 mm) were found up to 64 times more frequently under agroforestry systems than under sole crops.
- ❑ Six years old poplar planted on field boundaries has been found to affect the green fodder yield of sorghum up to 9 m distance and wheat grain yield up to 3 m distance from the tree line .



# References

Chauhan SK, Gupta N, Walia R, Yadav S, Chauhan R, Mangat PS (2011): Biomass and Carbon Sequestration Potential of Poplar-Wheat Inter-cropping System in Irrigated Agro-ecosystem in India *Journal of Agricultural Science and Technology A* 1 (2011) 575-586

Chauhan SK, Sharma R, Sharma SC, Gupta N, Ritu (2012): Evaluation of Poplar (*Populus deltoides* Bartr. Ex Marsh.) Boundary Plantation Based Agri-silvicultural System for Wheat-Paddy Yield and Carbon Storage. *International Journal of Agriculture and Forestry* 2012, 2(5): 239-246

Gupta N, Kukal SS, Bawa SS, Dhaliwal GS (2009) Soil organic carbon and aggregation under poplar based agroforestry system in relation to tree age and soil type. *Agroforestry Systems* 76: 27-35.

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