Mitigation and Adaptation strategy to climate change: A case study of *Populus deltoides* based agroforestry system in Chhattisgarh, Central India

Speaker
Prof. S. L. Swamy
Director, Academic Staff College, Guru Ghasidas University,
Bilaspur (C.G.) 492 006 INDIA

Background

The fourth Assessment Report (AR 4) of IPCC emphasized to develop a strong rationale for mitigation and adaptation to climate change especially in developing countries of tropics, those are mostly vulnerable to climate change since the livelihoods and economy of majority of population is dependent on climate sensitive agriculture sector. There is need to evolve resilient agro-ecosytem to climate change.

Agroforestry systems which can help agro ecosystems to adapt to greater climate variability as well as mitigate greenhouse gases through sequestration and by buffering crops from the effects of temperature and precipitation variation. Fast growing tree plantations are considered highly efficient carbon sinks because of their relatively high rates of productivity. Poplars (*Populus* spp.) are one among the fast growing species produce large quantities of biomass per unit land gained considerable importance in plantation and agroforestry systems all over the world including India.

Poplars in India and Chhattisgarh

Populus deltoides Bartr., a native of North America was first introduced in North India above 28^0 N latitude in 1950s. Several promising clones of G series (Australian), D, Sc and St series (American) L and WSL series (India) have been identified and planted extensively in farm/agroforestry systems throughout Punjab, Haryana, Tarai region of U.P. and some parts of Bihar, West Bengal and Assam state.

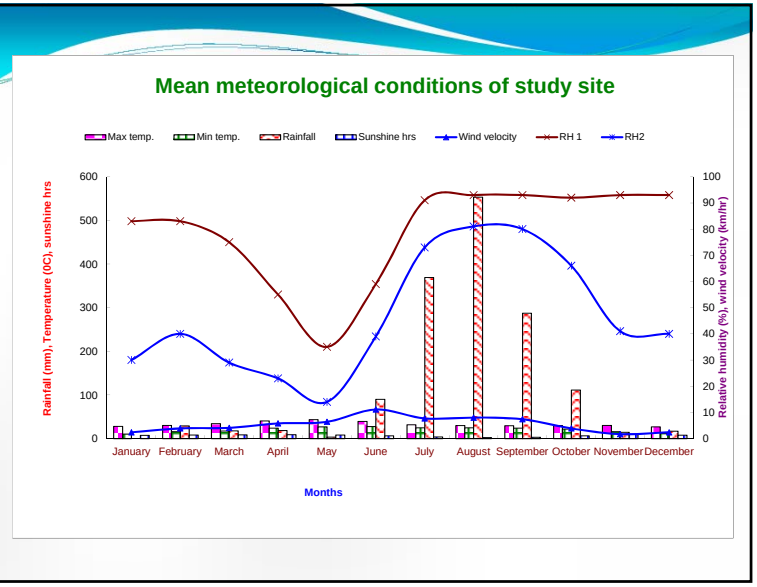
Fast growth rate, high biomass, diverse uses and easy adaptability prompted to extend poplar cultivation below 28^0 N latitude. Under All India coordinated research project on Poplar funded by ICFRE, it was first introduced in Chhattisgarh, Central India (21^0 N latitude) during 1997 (Puri et al., 2002). Hundred and twenty five promising clones were tested. Preliminary investigations showed that five clones *viz.* G3, G48, 65/27, D121 and S7C1 were found promising and emphasized the need of further evaluation for selecting clones with rapid growth and higher biomass production under agroforestry pratcices.

Objectives

1) To examine the clonal variations in allocation patterns of biomass and C in above ground and below ground components,
2) To study the productivity of soybean under poplar clones,
3) To investigate the eco-physiological variations in soybean under different poplar clones,
4) To assess the C storage in soil under different poplar clones.

Description of study site

Study site	:	**Forestry Research Farm of Indira Gandhi Agricultural University, Raipur , Chattisgarh India**
Geographical location	:	Latitude 21° 12' N; Longitude 81° 36' E
Topography & Elevation	:	Plains, 290 MSL
Climate	:	Sub-humid tropical
Annual Rainfall	:	1200-1400 mm (80% from July-October)
Temperature	:	Minimum 27° C - 13° C in December, Maximum 42° C - 28° C in May
Soil type	:	Vertisol (organic carbon - 0.43 ± 0.1%) 230 kg ha^{-1} N; 300 kg ha^{-1} K; 10.8 kg ha^{-1} P) with a pH of 7.5 ± 0.2



Experimental Details

Clones tested	:	**5 (G3- Australian, 65/27-Chilean, D121-American, G48-Australian and S7C1-American)**
Spacing	:	4 x 5 m
Density	:	500 trees ha^{-1}
Crops tested	:	Soybean (rainy) Wheat (Winter)
Design	:	Randomized complete Block Design (RCBD)
Replications	:	3
No of trees maintained of a clone per block	:	16

Observations recorded

Tree parameters

Growth parameters :

DBH, Height, clean bole and crown length and LAI

Biomass estimation:

Non linear allometric regression equations (Swamy et al., 2006)

Crop parameters

Yield parameters:

Grain yield, straw yield, root biomass and total biomass

C stocks in phytomass

C constitutes about 45 to 50 %of dry matter (Schlesinger,1991;Chan 1982), and it was estimated by simply taking a fraction of biomass as Magnussen and Reed , 2004):

C=0.475 x B

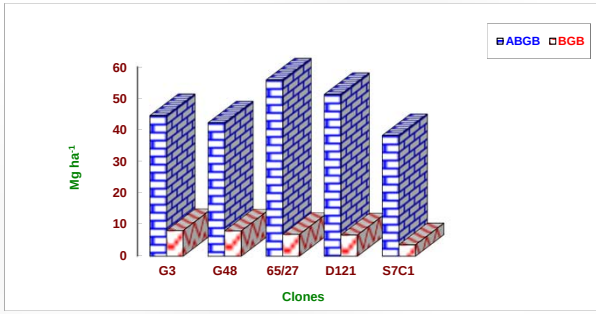
Where C is the carbon content and B is oven dry biomass

Growth variations in 6- year- old clones of *Populus deltoides* in agrisilviculture system at Raipur, Chhattisgarh, India

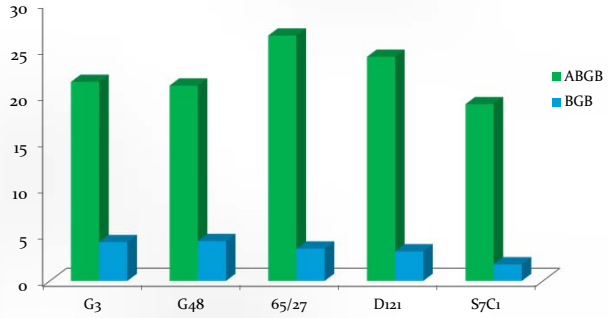
Clone	Dbh (cm)	Total height (m)	Clean bole (m)	Crown length (m)	LAI
G3	19.3	13.6	5.0	7.3	4.5
G48	19.7	14.5	5.3	8.2	4.1
65/27	21.6	14.3	5.6	9.4	4.2
D121	20.1	13.0	3.8	7.4	2.0
S7C1	13.3	11.2	3.9	8.2	2.5
LSD (P≤0.05)	3.57	1.85	1.03	0.84	0.5

Note : LSD- Least significant difference , Dbh- Diameter at breast height (1.37 m on trunk) ; LAI- Leaf area index

Clonal variation in aboveground and below ground biomass of *Populus deltoides* in agrisilviculture system at Raipur, Chhattisgarh, India



Clonal variation in aboveground and below ground C storage (Mg/ha) of *Populus deltoides* in agrisilviculture system at Raipur, Chhattisgarh, India



Biomass accumulation in *Populus deltoides* clones under agrisilviculture system at Raipur, Chhattisgarh, India

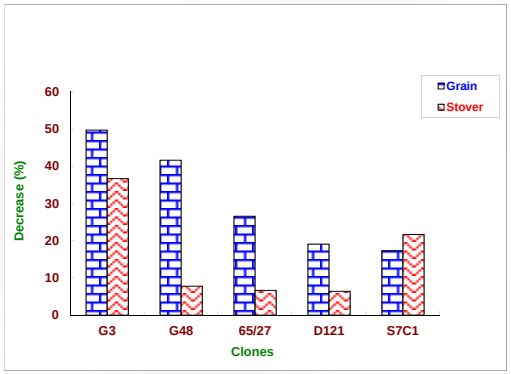
Clone	Stem (Mg ha^{-1} yr^{-1})	Branch (Mg ha^{-1} yr^{-1})	Foliage (Mg ha^{-1} yr^{-1})	Coarse root (Mg ha^{-1} yr^{-1})	Fine root (Mg ha^{-1} yr^{-1})	Total production (Mg ha^{-1} yr^{-1})
G3	11.3	2.62	0.97	1.54	0.5	16.93
G48	9.56	2.04	1.07	3.6	0.3	16.56
65/27	11.1	2.26	1.28	3.82	0.4	18.86
D121	13.1	2.52	0.41	2.46	0.3	18.79
S7C1	10.41	1.82	0.53	1.81	0.2	14.77
LSD (P≤0.05)	**1.2**	**0.26**	**0.35**	**0.9**	**NS**	**2.4**

Productivity (Mg ha^{-1}) of soybean under different clones of *Populus deltoides* in agrisilviculture system at Raipur, Chhattisgarh, India

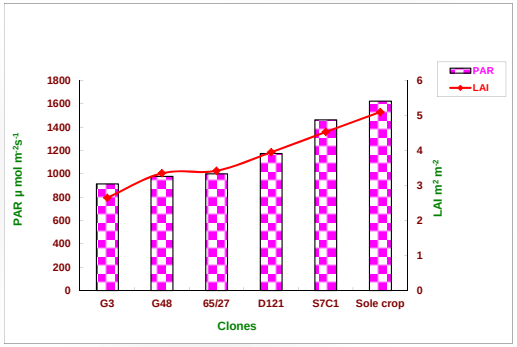
Clone	Grain yield	Stover Yield
G3	0.93	2.48
G48	1.02	3.32
65/27	1.27	3.36
D121	1.40	3.36
S7C1	1.44	3.23
Sole crop	1.73	3.60
LSD (P≤0.05)	0.13	0.40

Note : LSD- Least significant difference test; Total crop biomass – (grain+stover+root biomass)

Yield losses in soybean under different clones of *Populus deltoides* in agrisilviculture system at Raipur, Chhattisgarh, India



Variation in PAR and LAI in sole and intercropped soybean under poplar clones in agrisilviculture system at Raipur, Chhattisgarh, India



Variation in eco-physiology of soybean under *Populus deltoides* based agrisilviculture system at Raipur, Chhattisgarh India

Clone	Leaf temperature (^{0}C)	Relative humidity (%)	Stomatal conductance (mol m^{-2}s^{-1})	Transpiration (m mol m^{-2}s^{-1})
G3	32.5	28.6	0.9	18.4
G48	31.6	29.2	1.5	20.4
65/27	32.5	27.8	1.4	18.9
D121	33.7	27.2	1.5	18.7
S7C1	34.1	22.2	2.4	22.0
Sole crop	34.9	18.5	3.4	28.0
LSD (p<0.05)	1.6	1.5	0.42	2.6

Available nutrients in the soil (at 0-20cm and 20-40cm) under different clones of *Populus deltoides* in agrisilviculture system at Raipur Chhattisgarh India

Clone	Organic C (%)		Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
G3	0.63	0.61	270.9	263.3	14.55	13.6	373.4	366.4
G48	0.60	0.56	262.7	251.7	14.39	13.01	369.2	364.7
65/27	0.62	0.58	269.4	260.1	13.94	10.39	363.4	357.5
D121	0.65	0.61	275.2	263.5	14.50	12.33	373.6	365.3
S7C1	0.66	0.62	285.4	269.8	14.42	13.17	375.6	368.6
Control	0.56	0.54	230.1	226.8	11.8	9.85	352.5	350.8
LSD (P≤0.05)	**0.05**	**0.06**	**16.4**	**14.1**	**0.42**	**2.1**	**3.2**	**3.2**

Note : LSD- Least significant difference, NS- Non significant

Conclusion

Several clones of *Populus deltoides* are commonly grown in north Indian states above 28° N latitude, however our study showed that it is possible to grow clones 65/27, D121, G3, G48 and S7C1 economically in Central India, particularly in Chhattisgarh (21° N latitude). Clone 65/27 of Australian origin (derived from cross with Chilean semi-evergreen *P. deltoides*) showed consistently superior growth and higher biomass followed by clone D121 (American selection) and clone G3 (Australian origin).. Based on biomass and C accretion clones were ranked in the order: 65/27 > D121 > G48 > G3 > S7C1. .

Eco-physioogical studies demonstrated that leaf temperature and transpiration rates were significantly lower in soybean crop under clones 65/27 and D121 demonstrating buffering influence of these clones on the intercrop, which can be utilised as adaptive mechanism to drought in the scenario of climate change. The two outstanding clones 65/27 and D121 were suggested for agroforestry practices in Chhattisgarh, however further evaluation and understanding of eco-physiological aspects crops are needed for recommending these clones for large scale plantations in the region.