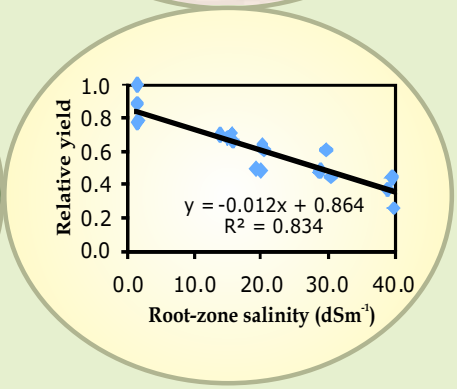
RESEARCH HIGHLIGHTS OF BIOSAFOR PROJECT

Biosaline (Agro) Forestry : Remediation of Saline Wastelands through Production of Renewable Energy, Biomaterials and Fodder



Mission

- To contribute to the development of biosaline agro-forestry systems for various saline environments (local/regional approach) and parallel to that
- To explore the potentials and options for biomass production in saline environments (globally).

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Biosaline agriculture (agro-forestry) seeks to change the problem of salinity into an opportunity. It uses the productivity of plants capable to grow under saline conditions that surpass the ranges of the classical crops and halophytes in combination with unconventional saline water resources and improved soil and water management. The main focus of the project is the remediation of saline wastelands through cultivation of biomass for energy production, bio-materials and fodder and focussing on the tree component of agroforestry systems. For example, in saline areas trees and salt-tolerant plants can be an alternative to conventional agriculture. Trees on saline wastelands produce timber for construction or for energy i.e. charcoal for cooking or electricity production through gassifires. They also function as windscreens, protect the soil against erosion, add organic matter and nitrogen in soil, help in breaking hard pans in alkali soils and above all sequester carbon helping in mitigating climate change.

Background & Status

BIOSAFOR research project is one of the first projects where knowledge from different disciplines in agricultural research from Agroforestry, Soil Science, Plant Sciences via GIS and policy making are combined in a research project on biosaline agriculture funded by European Union. The research focuses on tree species, largely from arid and semi-arid areas. Main thrust of the project was to select a number of salt-tolerant species with good production characteristics for saline environments and to produce relevant salinity data about these species through pot trials and field surveys. As no information or very little information is available on systematic evaluation of seedlings at juvenile stage for their salt tolerance hence pot studies were included in this project. For the first time extensive knowledge is generated regarding many forest tree species and salinity thresholds and curves are defined.

While traditional fresh water agriculture mainly focuses on preventing salinity in the soil and considers salinity levels of 8 dS/m (the classical USDA salinity classification ends at 16 dS/m), we are focussing on extremely saline and sodic soil and water conditions. Some of the pot trials, therefore, include high salinity ranges up to 40 dS/m. Innovative approaches for the economic reuse of saline wastelands offering agronomic opportunities, which are not competing with the traditional agriculture for food, are in the main focus of the project.

Current debate around bio energy and their relation to food security shows that there is a tremendous need for sustainable bio-fuels, which are not competing with traditional agricultural food crops. The production of woody biomass from land which is not suitable for any traditional agricultural production would therefore be a unique opportunity especially for countries like India and others. India being a fast growing economy with large import of crude oil makes it more important to develop such indigenous resources.

The overall objective of the BIOSAFOR project is two fold:

1) To contribute to the development of biosaline agro-forestry systems for various saline environments (local/regional approach) and parallel to that
2) To explore the potentials and options for biomass production in saline environments (globally).

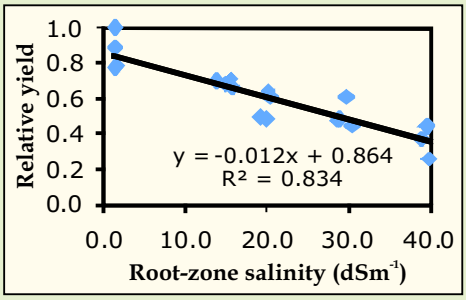
This consortium project funded by European Union has the following partners:

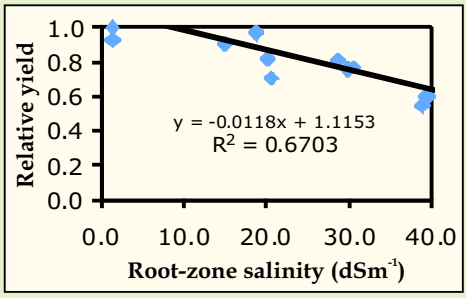
Various objectives of the consortium project were targeted to be achieved by working in different work packages 1 to 6 involving specific partners having specializations and track record. CSSRI Karnal contributed to the maximum number of packages and made significant contributions leading to success of this consortium project. Most significant achievements were in the pot trials and field studies on saline and sodic areas focusing on long-term plantations involving important multipurpose tree species.

Research Highlights

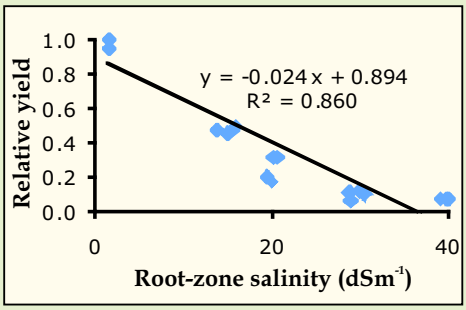
Results

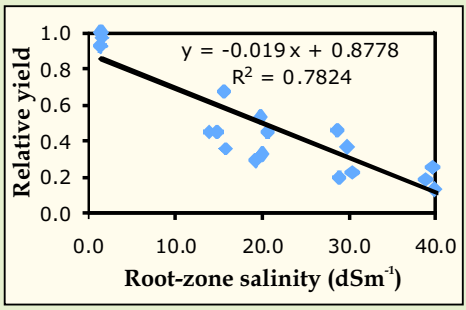
- Salinity tolerance of the locally available species : *Eucalyptus tereticornis, Prosopis juliflora, P. alba, and P. glandulosa, Acacia nilotica, Terminalia arjuna, Tamarix articulata, Pongamia pinnata, Jatropha curcas* and *Cassia siamea; and exotic germplasm (germplasm brought from other countries): Acacia salicina, A. ampliceps* and *Casuarina glauca* were worked out in pot trials and field studies.
- Mechanisms of tolerance and growth were studied and salt tolerance curves were developed
- Among local species /accessions, *Prosopis juliflora, P. alba* and *P. glandulosa* showed higher biomass. They also showed higher C_{50} and C_0 (22-36 dS/m) values, indicating that local species /accessions have high potential for bioforestry projects.
- Species that showed higher biomass and salinity tolerance include *Acacia ampliceps* accessions holds promise, with C_0 values varying from 21-41 dS/m.
- Among the exotic species *Acacia salicina, Acacia ampliceps and Casuarina glauca showed* good salinity tolerance and biomass production potential.
- *Acacia species, Casuarina, Eucalyptus, Prosopis* and *Tamarix* species/accessions (s/a) occupy the top positions among tree species that are salt tolerant and provide higher biomass.



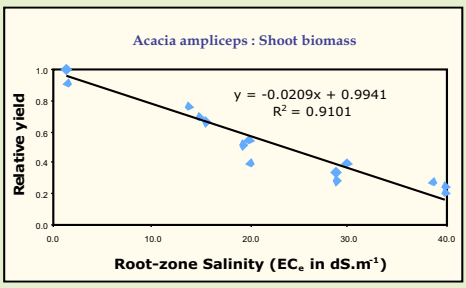


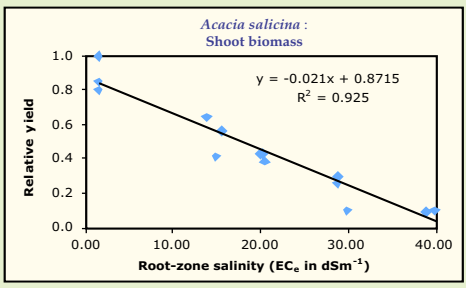
Pot studies and salinity response curves of Prosopis juliflora and Tamarix articulata showing higher tolerance to salinity stress.



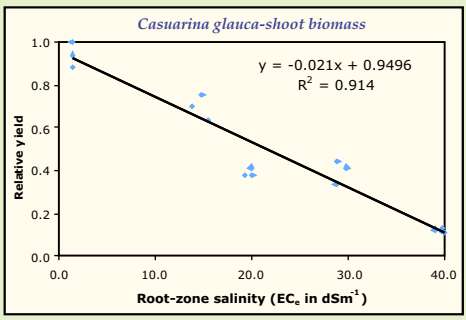


Pot studies and salinity response curves of Eucalyptus tereticornis and Pongamia pinnata showing moderate tolerance to salinity stress.





Pot studies and salinity response curves of Acacia ampliceps and Acacia salicina species showing tolerance to salinity stress.



Pot studies and salinity response curves of Casuarina glauca showing tolerance to salinity stress.

Work Package 2

Objective of this work package was to acquire specific information on saline sites where the trees do prevail naturally and the performance of these trees in various – saline environments thereby enabling conclusions on best practices. Studies at the eight case study sites having plantations on saline and sodic lands were conducted in India: five by CSSRI and three by CAZRI. These sites were monitored providing very useful data to establish relationship between growth and biomass of the test species based on real long-term data on plantations on saline and sodic lands. CSSRI, Karnal conducted studies at five sites, namely Saraswati, Shivri (Lucknow) and Karnal on sodic soils and Hisar and Sampla for saline soils to measure and estimate the potential of mature salt tolerant trees in various saline environments.

Biomass of trees grown on a highly alkali soil at Shivri farm, Lucknow

These studies were carried out at Shivri farm located 20 km away from Lucknow, Uttar Pradesh (26^0 47' 58" N and 80^0 46' 24" E) at an elevation of 100 m. The annual rainfall varies from 700 to 1000 mm (average 800 mm), 80% of which occurs during the months of July to

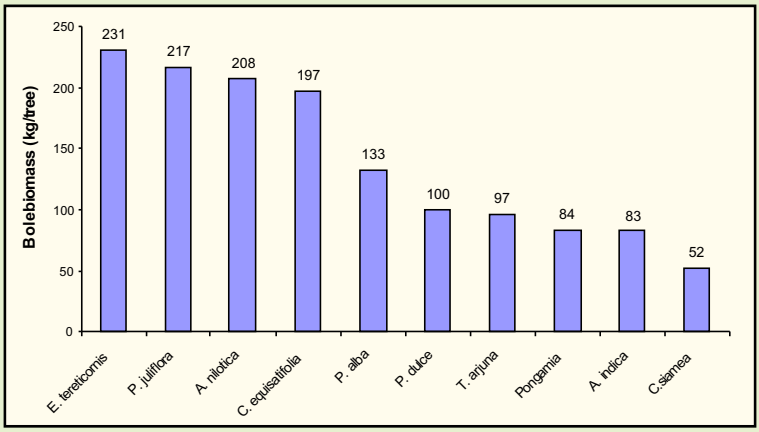
September. The mean monthly temperature varies from 21^0 C in January to 40.5^0 C in June. The evaporation exceeds the rainfall for all the months except July and August. The ground water table fluctuates seasonally between 5-7 m.

Examination of the profiles revealed the soil as alkali in nature, fine loamy, mixed, hypothermic and classified as Sodic Ustochrept. The soil contained around 40 cm thick $CaCO_3$ concretion layer at about 80 to 120 cm. At the time of planting, soil pH at the surface was 10.6 and ranged from 10.0 to 10.6 in different layers up to the depth of 1 m with ESP values of 89- 92.

Six to nine months old seedlings of 10 multipurpose tree species were planted in auger holes (45 cm diameter at the surface and 20 cm at the bottom) 120 cm deep. Row to row and plant to plant distances were 4 m x 3 m. The auger holes were filled with a mixture of original soil, 4 kg Gypsum, 10 kg Farm Yard manure and 20 kg silt. These plants were irrigated in the initial two years period.

Survival of *Prosopis juliflora, Terminalia arjuna, Pongamia pinnata, Acacia nilotica, Casuarina equisetifolia* and *Pithocellobium dulce* was > 95% after 10 years of planting. Maximum plant height after 10 years of planting was observed in *Eucalyptus tereticornis* followed by *Casuarina equisetifolia* and *Prosopis juliflora*. However, maximum diameter at breast height was recorded in Acacia nilotica, *Eucalyptus tereticornis* and *Prosopis juliflora.* These studies also suggested that in addition to reclaiming these sodic soils, the tree-based systems also increased microbial biomass, microbial N and C in otherwise very low or dead mass of degraded sodic soils.

Out of the ten species planted and harvested after 14 years growth on these highly deteriorated sodic soils maximum biomass production was achieved in the *Eucalyptus tereticornis, Acacia nilotica, Prosopis juliflora* and *Casuarina equisetifolia giving 231, 217, 208 and 197 kg bole weight per plant respectively*, whereas *Prosopis alba*, *Pithocelbium dulce*, *Terminalia arjuna, Pongamia pinnata, Azhadirachta indica* and *Cassia siamea* species provided relatively lower bole weight of 133, 100, 97, 84, 83 and 52 kg per plant, respectively. Thus these four species, namely *Eucalyptus tereticornis, Acacia nilotica, Prosopis juliflora* and *Casuarina equisetifolia* can be helpful in reclamation and productive utilisation of these soils. These studies provided very useful data to establish relationship between growth and biomass of the test species based on real long-term data on plantations on saline and sodic lands.



Biomass Production (kg/tree) by 14 years old trees on a highly sodic soil at Shivri farm, Lucknow (Biomass figures represent biomass at the final harvest and does not include lopped biomass over the previous years)

Harvested boles of 14 years old tree species in highly sodic soils at Shivri farm, Lucknow

Fourteen years old plantation of forest tree species in a highly sodic field at Shivri farm of CSSRI RRS, Lucknow

Research Highlights of Work Package 2

- Actual data on biomass production potential of 5, 10 and 14 years old field plantations grown on severely affected saline and sodic soils at five study areas were generated. These plantations were also monitored in terms of plant growth parameters and their contribution towards soil physical, chemical properties and environmental amelioration
- Regression equations for biomass calculation of trees based on actual harvested total biomass (kg/tree), girth at breast height (cm) and total height (m) were developed to predict biomass in similar situations and age of the plants without harvesting the trees
- These 5, 10 and 14 years old plantations resulted in significant reclamation of highly deteriorated soils and improvement in physical and chemical properties. Upper surface soils (0-30 cm) pH was reduced from initial 10.6 to ~8.0
- Regression curves relating harvested biomass, girth and plant height were developed and validated. These curves have been used in estimation of biomass production potential of these species on saline and sodic soils thus enabling non-destructive estimates at regional and global levels for similar saline and sodic lands
- A database was established in MS Access to link the different subsets of field data and be able to assess and evaluate case study data.
- These equations and data have helped to make non-destructive projections on biomass production at regional and global levels for similar species in saline and sodic lands
- The work carried out by CSSRI was highly appreciated by all the partners as it provided very useful data to establish relationship between growth and biomass of the test species based on real long-term data on plantations on saline and sodic lands.

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