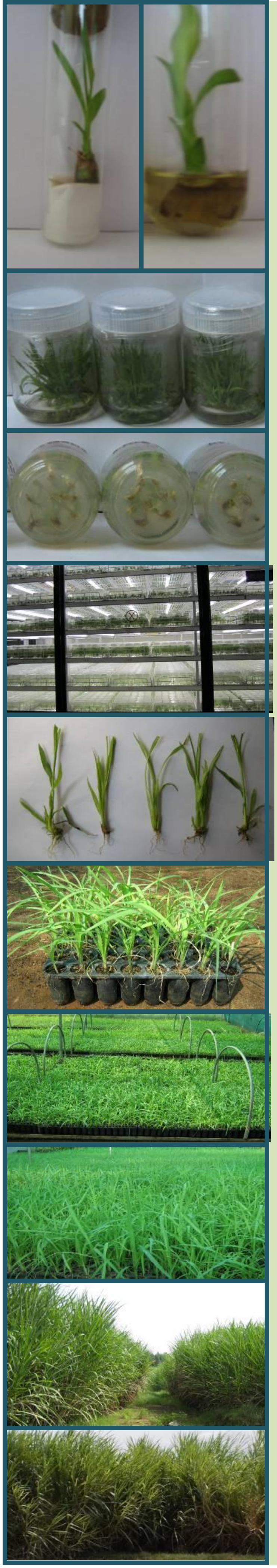

FINAL PROJECT REPORT FOR CESS FUNDED R & D PROJECT

ON

DEVELOPMENT OF HIGH FIBRE ERIANTHUS ARUNDINACEUS (WILD-CANE) CLONES AS ALTERNATE SOURCE OF FIBROUS RAW MATERIAL FOR PULP AND PAPER INDUSTRY

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INDIA

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1. **Title of the project**	:**Development of High Fibre *Erianthus arundinaceus* (Wild-cane) Clones as Alternate Source of Fibrous Raw Material for Pulp and Paper Industry**
2. Broad area of technology	: Alternate Raw Material Research
3. Project Duration	:3 Years
4. Organisation	:Tamilnadu Newsprint and Papers Ltd., (TNPL) Kagithapuram
5. Other interacting agencies	:Sugarcane Breeding Institute (SBI) Coimbatore
6. Actual location where the Project will be carried out	:Tamilnadu Newsprint and Papers Ltd. Kagithapuram
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1. INTRODUCTION

Forests in India are unable to meet the demand of fibrous raw materials for various forest and cellulose based industries due to increasing population, over exploitation of natural resources, shrinking forest cover and alternate use of forest products. On the other hand, agricultural based non wood fibrous raw materials are increasingly used for various other purposes like bio-energy (PACHISIA, 2011). Utilization biomass to green generate energy to reduce greenhouse gas emission is gaining importance, for example energy produced from *Miscanthus* emit 11-13 g of CO_2 per megajoule of fuel which is 80-90% lower than fossil fuel (www.environmentalresearchweb.org/cws/article/news/48511). These factors put Indian pulp and paper industry at great risk. The shortage of cellulose raw material is not only faced by Indian paper industry, but also around the world (RAYMOND AND GREAVES1997). Apart from that, growing awareness about environment at different levels, increasing demand for paper, rising cost of available pulp wood, low fiber supply are major constraints to paper industry and opened the way for competitive alternatives to the well established wood fiber stocks.

Shortage of agro- based and forest based fibrous raw material for papermaking forces the paper industry to look for alternate raw material resource. Shortage of fibrous raw material can be made-up by improving unit area productivity by introducing highly productive and improved pulpwood clones or by identifying and adopting new plant species having high biomass productivity (COTTERILL and MACRAE 1997, ASSIS *et al.,* 2004). Annual and perennial grasses belong to non wood plant species and give promising hope to work and develop them as new source of fibre for paper industry. Since, from the ancient days. It is reported that non-wood fibres were used for papermaking. For example, during 3000 BC in Egypt, pressed pith tissue of *Cyperus papyrus* L was used as printing material. Ts Ai Lun discovered the actual paper in China during 105 AD from Hemp rags and Mulberry. Straw was used as raw material for papermaking in 1800 and the first commercial operation of pulp mill started in the year 1927 in USA. After the invention of chemical pulping process, wood is being used increasingly in many part of the world, as a paper making raw material in the 20th century. However, in many regions of the world, wood is not sufficiently available for papermaking due to increased paper production (ATCHISON 1987A, JUDT 1993) and also wood is being utilized for many other purposes including fuel and other value added products. The shortage of woody fibrous raw material for papermaking and growing demand for paper forced many papermakers to look for alternate raw materials, such as, non-wood for papermaking. The world paper and board consumptions increased from 78 million tones per annum in 1961 to 335 million tones in 2004 and it is around 400 million in 2011. Since 1990 consumption in the developed regions as whole did not increase. In contrast, growth in developing region especially in Asia is increasing at the rate of 6.5% per annum due to higher literacy and income (ADRIAN WHITEMAN, 2005). Commercial non wood pulp production has been estimated to be around 6.5% of total global pulp production and it is expected to rise in the future.

China and India are the major users of non-wood fibre for papermaking. The main sources of non-wood raw materials are agricultural residues from the monocotyledons, such as, Rice Straw, Wheat Straw, Bagasse, and Bamboo (PAAVILAINEN *et al.,* 1998). Other most common energy and fibre crops like *Mischanthus*, Giant Reed, Reed Canary Grass, Hemp, Kenaf, Sisal and Jute are also used to certain extent for papermaking. The improved exploitation of agricultural residues and huge potential of nonfood crops can partially resolve the current dilemma between the increasing paper consumption and the diminishing forest resources. Beside agricultural residues, non-food plants offer a very attractive opportunity to utilise excess land for the cultivation of energy and fibre crops (SAMSON *et al.,* 2005).

However, utilization of fibre crops or agricultural residues for renewable energy generation became internationally popular in the post Kyoto regime especially bagasse in the sugar industry through co-generation for the production renewable energy. This offers additional benefit like carbon credits through Clean Development Mechanism projects. Apart from above international efforts, preferential tariffs for renewable energy, Renewable Purchase Obligations (RPO) and a variety of subsidies and incentives are given to make biomass as attractive feedstock for renewable energy generation (ANURADHA and SUMITI YADAVA 2012 MNRE , 2009). All the aforesaid schemes created new challenges for paper industry to look for other captive fibre sources for papermaking with improved productivity in the unit area.

Perennial grasses, such as, wild sugarcane (*Saccharum sp., Erianthus sp.)* Switchgrass (*Panicum virgatum*), *Miscanthus* (*Miscanthus sinensis*) are known for their high productivity due to its C_4 photosynthetic cycle, when compared to other C_3 plants and mainly used as bio-energy crops in many parts of the world (KLASS, 1999, MISLEVY *et al.,* 1995, MISLEVY and FLUCK, 1992, FUENTES and TALIAFERRO, 2002). An ideal fibre crop should have a sustained capacity to capture and convert the available solar energy into harvestable biomass with maximal efficiency and with minimal inputs and environmental impacts (Box 1).

Biomass cropping systems must have a highly favorable resource balance, i.e. low resource input versus output, since, resource input usually represents use of fossil fuel and emission of carbon to the atmosphere. Cultivation, harvest and especially nitrogen fertilization, represent large financial and fossil fuel inputs. Consideration of energy balances has driven a shift from annuals to perennials, primarily short rotation coppice like poplars, willows and perennial grasses, in particular *Phalaris, Miscanthus, Erianthus* and *Panicum* (VENENDAAL *et al.,* 1997). In contrast to annual crops, these perennials require only one cultivation activity, i.e. preparation for planting, over a 10- to 20-year duration, and minimal nitrogen inputs because of mutable ratooning.

The economic yields and energy efficiency of biomass crops will be determined predominantly by the amount of biomass that can be formed per unit area and per unit of investment of other resources, notably nitrogen. The potential limit on biomass yield will be set by the amount of light available, and the efficiency with which light is converted into biomass. Conversion efficiency depends on the duration, size and architecture of the canopy. A crop having closed canopy throughout the year or at least throughout crop season will clearly have highest productivity. C_4 photosynthesis is the most efficient form of photosynthesis known, largely due to the elimination of the wasteful process of photorespiration. Because of this, C_4 photosynthesis has the highest potential for converting sunlight energy into biomass energy and estimated to be 40% greater than that of C_3 photosynthesis (LONG, 1999, KLASS, 1999, MCLAUGHLIN, 1999). C_4 photosynthesis also allows plants to have higher efficiencies of nitrogen and water use (EHLERINGER and MONSON, 1993).

BOX –1: Modified from SAMSON *et al.*, (2005)

Objectives	Required characters
1. Efficient conversion of sunlight into plant material 2. Efficient water use moisture is one of the primary factors limiting biomass production in the world 3. Sunlight interception during as much of the growing season as possible 4. Minimal external inputs in the production and harvest cycle (i.e., seed, fertilizer, machine operations and crop drying).	1. There are two main photosynthetic pathways for converting solar energy into plant material: the C_3 and C_4 pathways. The C_4 pathway is approximately 40% more efficient than the C_3 pathway in accumulating carbon 2. C_4 species use approximately 1/2 the water of most C_3 species 3. Perennial crops do not have annual establishment costs (seed, tillage, etc.) and some species of warm-season species and have excellent stand longevity 4. C_4 species of grasses contain less nitrogen (N) thanC_3 species and can be more N-use efficient because N is cycled internally to the root system in the fall in temperate zones) and significant N fixation can occur in the tropics in some warm-season grasses

Utilization of these highly productive grasses as raw material for pulp and paper industry is a new concept developed recently to overcome raw material shortage in the developing countries like India where mostly non-wood fibrous raw material are used to manufacture paper. Another major advantage of these perennial grasses is that they contain less lignin when compared to woody plants. Lower lignin in raw material naturally consume less chemical during pulping, bleaching and give more yield, leading to less environmental impact to surrounding environment (GIOUARD and SAMSON, 1998, ELBENSEN, 2001, GOEl *et al.,*1998). In addition to fibre supply to paper industry fibre crops would have added environmental benefits over current food crops (MCLAUGHLIn and WALSH 1998). Perennials providing above ground structures throughout the year may provide refuge for wildlife (GIULIANO and DAVES, 2002). Production and turnover of belowground storage organs will add organic matter and carbon to the soil (ZAN *et al.,* 2001). Perennials have more extensive root systems present throughout the year, so providing increased resistance to soil erosion and a more effective means of trapping nutrients and preventing nitrogen loss to drainage water. Because, the crop is not used for food, the land could also be suitable for spreading sewage sludge and farm effluents that may represent health risks in areas sown with food crops (VISSER and PIGNATELLI 2001). Apart from the above these perennials can also be used for other purposes like generation of renewable energy like fuel alcohol or biogas from its juice in case if we use bagasse for paper making or in other words the entire biomass can also be used for heat and electricity generation because biomass generally has energy value of around 4000 to 4500 kcal/ kg which is slightly less than the conventional fossil fuels like coal (5000 to 6000 kcal/kg). However, for paper making, perennial grasses have its own disadvantage like low bulk and short fibre length, presence of pith in the cortex region, relatively poor pulp quality and high handling and transportation cost.

India being a tropical country has many varieties of perennial grasses, one of them is *Erianthus arundinaceus* a wild relative of commercial sugarcane. *Erianthus arundinaceus* is the most widely distributed species and commonly found in the peninsular India and also in the North East India.

Classification

Kingdom	: *Plantae*
Subkingdom	: *Tracheophyta*
Division	: *Spermatophyta*
Class	: *Liliopside*
Subclass	: *Commenlinidae*
Order	:*Cyperales*
Family	: *Poaceae*
Genus	:*Erianthus*
Species	: *arundinaceus*

Erianthus is an evergreen plant mostly found in the river banks in south India and in the north east India but adoptable to sub optimum moisture conditions. Species of *Erianthus* include small bushy type with narrow leaves without cane formation to those tall plants with broad leaves and long, thick canes resembling sugarcane plants. Propagation is by both seeds and by vegetative in the nature and it is possible to propagate artificially by clumps or setts.

Morphology: Tall perennial, erect, gigantic grass with flowering clums (Except *Erianthus arundinaceus*). The stems are pithy without any juice or sucrose (Except *Erianthus arundinaceus*). Leaves are flat, long narrow with stout midrib. Leaf insertion is finely bearded with hairs often extending up into the coloured (off- white, pale green, purple, brown or combinations of the above).

Anatomy: Stem epidermis contains solidary cork cell and absence of silica cells. Cork cells are always squarish, never pointed closely crowded. Presence of papillae on the lower surface, stomata distributed in the both surfaces randomly. Vascular bundles are of four types viz. primary, secondary, tertiary and quaternary. Sclerenchyma cell are generally well developed around the primary and secondary vascular bundles.

Cytology: *Erianthus* has mostly euploid series with lower chromosome numbers in multiples of 10. based on the chromosome numbers, Erianthus clones can classified in to four groups based on chromosome number i.e. 2n = 20, 30, 40 & 60. These variations indicate the occurrence of polyploidy in the *Erianthus* genus. Total seven species have been recorded in this genus. They are *Erianthus* arundinaceus (India, China, Myanmar, Thailand, Philippines, Malaysia, Indonesia, New Guinea), *Erianthus bengalense,* (India, China, Myanmar) Erianthus *ravennae* (India), *Erianthus elephantinus* (India), *Erianthus procerus* (India), *Erianthus longisetosus* (India) and *Erianthus hookeri* (India).

Study carried out in abroad: The higher yield potential of C_4 perennial grasses, such as, wild sugarcane (*Saccharum sp., Erianthus sp.) Switchgrass (Panicum virgatum), Miscanthus (Miscanthus sinensis) and Canary grass (Phalaris arundinacea)* created significant interest in this plant species as lignocellulose biomass crop for fibre and bio-energy. Switchgrass is one of the tall grass found in the North America, *Miscanthus* in Russia, China, Japan and *Erianthus* in South East Asia, India and other tropical region. All the above said grasses have been tested for paper making and found ideal non-wood fibre source especially the stem part (GIROUARD AND SAMSON 1998, CHINNARAJ *et al.,* 2005). More recently ELBENSEN (2001) gave the overall view regarding biology and cultivation practice of perennial grasses (Table - 1). The yield potential of the switchgrass had been studied in detail across the US in 18 different testing sites. The study indicates that the dry yield of fully established stand of best adopted variety averaged around 16 MT/hector/ year (MC

LAUGHLIN *et al*., 1999). In another study conducted using the energy cane reported dry biomass yield of around 48 MT/hector/ year (MISLEVY *et al*., 1995). The same author has compared the dry yield of various perennial grasses in the clay tailing of phosphate mining (MISLEVY *et al*., 1989) and recorded highest yield in *Erianthus* (139 MT/hector/ year) followed by *Leucaena* (58.5 MT/hector/ year) and Elephant grass (56.5 MT/hector/ year).

Pulping studies have found that the stem component of the grasses gave high fibre and pulp yield followed by the sheath and leaf (GOEL *et al.,* 1998). The study also indicates that the high crop yield and hollocellulose content, low extractives and ash makes switch-grass as an excellent candidate for papermaking. The pulp produced by kraft, soda and soda Aq process had similar strength properties and higher yield when compared to wood pulp.

Table1: Biology & cultivation practice of fibre crops under development in Europe

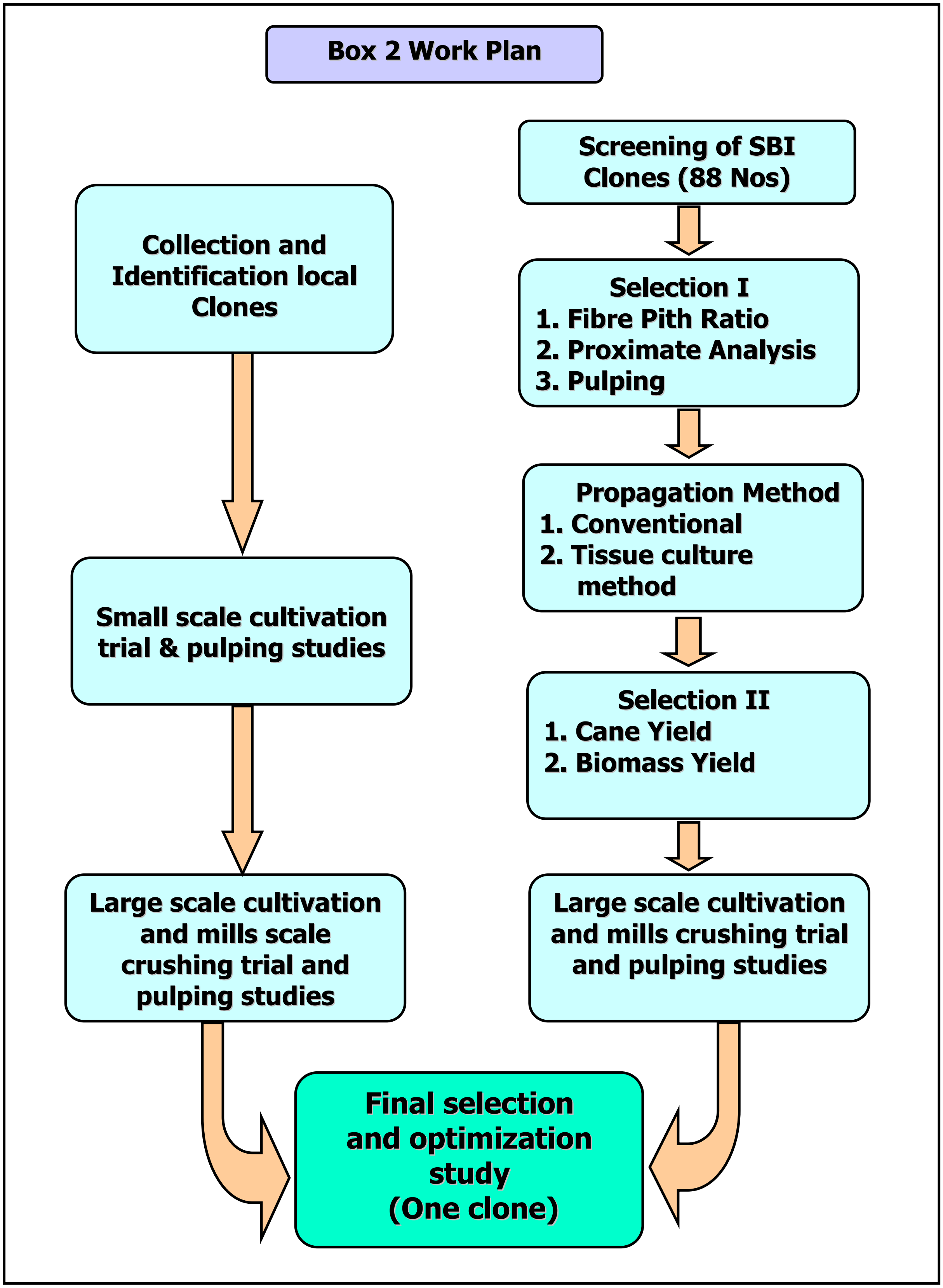
Particulars	*Miscanthus*	*Switchgrass*	Canary grass	Giant reed
Latin Name	*Miscanthus sp.*	*Panicum virgatum*	*Phalaris arundinacea*	*Arundo donax*
Native range	South East Asia, Japan	North America	Europe	Mediterranean & tropical
DM yield/year	30 MT	30 MT	10 MT	> 30 MT
Photosynthesis	C4	C4	C3	C3
Height	Up to 4 m	Up to 2.5 m	Up to 2 m	Up to 5 m
Rotation Time	15 years	15 years	11 years	15 years
Propagation	Vegetative	seed	seed	Vegetative

Study conducted in India: During 1980’s breeding of high fibre varieties was conducted at Sugarcane Breeding Institute (SBI) using Co Canes X IA clones, *S. officinalis* X *S. spontanium, S. rubustum X S. spontanium* and Co Canes X *S. rubustum*. From 1984 nearly 316 clones were developed and among them Fb 86-78 reported the highest fibre content of 28%. The crossing experiments indicates that the fibre content increase with increase in degree of spontanisation. High variation in yield and fibre content in the selected progenies improves the scope of developing a clone with high fibre and high yield per unit area. However, literature survey has revealed that very little work is recorded on such systematic study and our own experience shows that the *Erianthus arundinaceus* has potential to produce high biomass (MISLEVY *et al*., 1989). This increased our interest on this plant.

The pulping study of *Erianthus arundinaceus* clones collected from the Cauvery riverbed indicates that the cane part of the plant can produce acceptable quality of the pulp (Table -2). Nearly 88 clones of *Erianthus arundinaceus* from Sugarcane Breeding Institute were evaluated for paper making based on yield, fibre pith ratio and other parameters. From the 88 clones, 6 clones viz. SES 3, SES 159, IJ 76342, EA Cuttock, Mythan A, and IMP1536 (AMALRAJ *et al.,* 2008). Considering the potential of high biomass productivity of *Erianthus* and raw material shortage, attempts were made to study the technical and commercial viability of *Erianthus arundinaceus* as fibrous raw material for papermaking under the CESS Fund through IPMA in TNPL Research and Development Division along with Sugarcane Breeding Institute. The studies are broadly classified as per the following work plan (Box :2). Results of the study conducted are presented in First Report.

Table 2: Results of wildcane pulping study

S. No	Parameters	Units	Wildcane Whole bagasse	Normal cane whole bagasse
1	Fibre pith ratio		2.14:1	1.3-1.5:1
2	Chemical applied	%	12	12
3	Pulp yield	%	53.0	51.5-52
4	Kappa Number		15.0	17 –18.5
5	Brightness	%	35.5	32-34
Pulp Evaluation @ 300 ml CSF				
6	Breaking length	M	8650	8000 – 8200
7	Tear Factor		54.7	51 – 52
8	Burst Factor		51.0	47 – 48


Box 2 Work Plan
Collection and Identification local Clones
Small scale cultivation trial & pulping studies
Large scale cultivation and mills scale crushing trial and pulping studies
Screening of SBI Clones (88 Nos)
Selection I
1. Fibre Pith Ratio
2. Proximate Analysis
3. Pulping
Propagation Method
1. Conventional
2. Tissue culture method
Selection II
1. Cane Yield
2. Biomass Yield
Large scale cultivation and mills crushing trial and pulping studies
Final selection and optimization study (One clone)

2. OBJECTIVE OF THE PRESENT STUDY

The biomass productivity and cane yield of existing *Erianthus arundinaceus* is comparatively less and needs further improvement to make more attractive to farmers. Therefore, the present project is conceived to improve the biomass productivity and cane yield by using conventional plant breeding techniques usually followed for commercial sugarcane to identify the new clones. Commercial production of tissue culture seedlings for large scale cultivation, nutrient up-take assessment, bio-energy potential from juice through biogas generation, large scale cultivation trial of around 50 acres to assess economic viability of already identified clone in phase 1. Comparison of biomass productivity in poor soil (not suitable for regular cultivation) and good soil (regular cultivation field)

3. RESULTS

A. SCREENING OF AVAILABLE IMPROVED GERMPLASM CLONES FOR FIBER CONTENT

Clones from progeny of 2004 CD (Diverse Cytoplasm) crosses of *S. Spontanium* were analysed for juice and fiber studies (Table -3). The fiber % in the seedling clones ranged from 15.83 to 24.28. Highest fiber of 24.28% was obtained in a seedling from CD116 (GC). The cane characters, such as, stalk dia , Stalk length, No internodes and internode length ranges from minimum 18.6 cm to maximum 24.62 cm, minimum 164 cm to maximum 305 cm, minimum 19 to maximum 31, minimum 10.5 cm to maximum 16 cm, respectively. The cane juice brix% and sucrose% ranges from 13.65 to 21.05 and 7.17 to 17.02 respectively. Table - 4 gives the data collected to evaluate CD (Diverse Cytoplasm) crosses of *S. Spontanium.*

Table 3: Results of evaluation of CD crosses of *S. Spontanium*

	Character	**Min**	**Max**	**Mean**
1	Stalk length (cm)	194	305	244
2	Stalk diameter (mm)	18.6	24.3	20.63
3	Internode length (cm)	10.5	16.0	13.34
4	No of internodes	19	31	21
5	Brix %	13.65	21.05	17.05
6	Sucrose %	7.17	17.02	12.34
7	CCS %	3.34	11.25	7.63
8	Purity	52.51	82.29	69.53
9	Fibre %	15.83	24.28	19.98

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium.*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
1st Row				
CD 9 GC	16.2	12.2	13.93	8
CD 9 GC	13.4	12.2	19.5	55
CD 13 GC	14.2	18.8	18.4	8
CD 13 GC	19.4	18.2	19.2	23
CD 43 x CoLk 8002	18.2	18	19.9	5
CD 43 x CoLk 8002	19	19.2	19.2	23
CD 50 xCoJ 46	21.2	19.2	27.48	11
2nd ROW				
CD 50 xCoJ 46	19	17.4	16.63	50
CD 50 xCoJ 46	13.2	18.4	23.78	1
CD 50 xCoJ 46	15.4	18.4	20.5	4
CD 50 xCoJ 46	16	11.4	22.9	7
BC 52 xCo 86002	13.2	11.8	20.43	11
BC 52 xCo 86002	18.4	17.4	13.83	2
BC 52 xCo 86002	17.2	19.2	17.31	16
BC 52 xCo 86002	21.2	18	19	8
BC 52 xCo 86002	18.4	13.2	21.32	3
BC 52 xCo 86002	17.4	17.2	24.19	6
3 rd ROW				
BC 52 xCo 86002	13.4	13.2	19.36	5
BC 52 xCo 86002	13.4	10.4	12.77	4
BC 52 xCo 86002	15.2	17.2	17.5	7
BC 52 xCo 86002	17.2	17.4	24.15	5
BC 52 xCo 86002	15.4	14.8	22.13	18
BC 52 xCo 86002	17.2	15.4	20.18	16
BC 52 xCo 86002	16.4	14	11.11	8
BC 52 xCo 86002	14.8	12.2	15.12	3
BC 52 xCo 86002	17.4	16.4	24.4	14
BC 52 xCo 86002	18.2	20.2	19.03	10
4th ROW				
BC 52 xCo 86002	16.4	15.2	19.13	2
BC 52 xCo 86002	16.2	17.2	22.63	16
BC 52 xCo 86002	18.2	17	12.43	7
BC 52 xCo 86002	19.4	12.4	22.03	18
BC 52 xCo 86002	15.2	19.8	20.76	7
BC 52 xCo 86002	17.4	14	19.99	4
BC 52 xCo 86002	16.4	16.2	15.39	10
BC 52 xCo 86002	20.2	19.2	26.95	5
5 th ROW				
BC 52 xCo 86002	20.2	20.2	21.22	7
BC 52 xCo 86002	12.4	14.8	19.83	10
BC 52 xCo 86002	10.2	16.2	17.59	11
BC 52 xCo 86002	19.89	19.4	18.2	1
BC 52 xCo 86002	16.2	12.4	22.82	4
BC 52 xCo 86002	14.2	14	16.81	7
BC 52 xCo 86002	17.2	12.80	20.79	3
BC 52 xCo 86002	17.4	17.4	32.53	3
BC 52 xCo 86002	13.4	15	21.51	9
BC 52 xCo 86002	11.2	13.4	17.88	4
BC 52 xCo 86002	15.2	11.2	15.5	25
6th ROW				
BC 52 xCo 86002	17.2	16.2	22.64	5
BC 52 xCo 86002	12.4	9.8	16.31	12
BC 52 xCo 86002	13.4	8.4	22.49	4
BC 52 xCo 86002	16	17.2	17.57	14
BC 52 xCo 86002	15	13.2	21.88	10
BC 52 xCo 86002	9.2	7.8	15.39	8
BC 52 xCo 86002	20.2	19	19.59	6
BC 52 xCo 86002		12.8	15.89	10
BC 52 xCo 86002	15.2	17.2	22.05	10
BC 52 xCo 86002	17.2	16.2	21.9	4
BC 52 xCo 86002	17.4	8.8	17.92	10
7 th ROW				
BC 52 xCo 86002	15.8	13.4	11.89	8
BC 52 xCo 86002	21.2	19	18.18	5
BC 52 xCo 86002	16.4	14.2	16.79	9
BC 52 xCo 86002	16.2	8.4	15.89	15
BC 52 xCo 86002	17.4	15.2	17.54	10
BC 52 xCo 86002	18.2	20	24.72	1
BC 52 xCo 86002	17	18.2	20.34	12
BC 52 xCo 86002	16.4	15.2	18.87	6
BC 52 xCo 86002	13.4	11.4	20.89	6
BC 52 xCo 86002	17.2	14.2	24.91	5
BC 52 xCo 86002	13.4	11	20.22	3
BC 52 xCo 86002	17.4	16	16.41	14
8 th ROW				
BC 52 xCo 86002	13.2	15.2	24.05	21
BC 52 xCo 86002	14.4	11.4	19.28	5
BC 52 xCo 86002	12.8	10.4	19.94	9
BC 52 xCo 86002	11.2	20.2	19.93	6
BC 52 xCo 86002	19.2	17.8	18.87	3
BC 52 xCo 86002	17	16.8	19.53	20
BC 52 xCo 86002	19.2	17	16.7	4
BC 52 xCo 86002	17.4	15.8	20.62	16
BC 52 xCo 86002	19.2	12.2	17.12	5
BC 52 xCo 86002	11.45	14.2	20.62	2
BC 52 xCo 86002	11.2	18.4	17.7	21
9 th ROW				
BC 52 xCo 86002	19.2	18	17.53	9
BC 52 x Co 1148	16.4	14	15.45	8
BC 52 x Co 1148	16.4	14.2	13.14	25
BC 52 x Co 1148	13.2	13.4	16.47	12
BC 52 x Co 1148	12.4	13	20.86	8
BC 52 x Co 1148	19.4	17.2	17.41	12
BC 52 x Co 1148	16.4	18.4	18.17	10
BC 52 x Co 1148	19	22.2	17.64	5
BC 52 x Co 1148	16.4	13.4	19.7	9
BC 52 x Co 1148	13.4	16.2	20.37	3

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk.Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
10 th ROW						**15th ROW**				
BC 52 x Co 1148	17.2	18.8	19.35	3		BC 52 x Co 1148	17.2	19.2	19.36	13
BC 52 x Co 1148	14.2	16.4	19.96	22		BC 52 x Co 1148	15	18	16.36	16
BC 52 x Co 1148	16.2	16.2	16.49	3		BC 52 x Co 1148	11.2	18.2	18.52	19
BC 52 x Co 1148	16.8	16.2	19.33	8		BC 52 x Co 1148	17.4	10.4	14.29	17
BC 52 x Co 1148	11.4	11.2	15.09	16		BC 52 x Co 1148	12.4	14.2	12.77	16
BC 52 x Co 1148	13.4	16	20.28	1		BC 51 x CoH 15	18	18.4	24.07	6
BC 52 x Co 1148	10.2	14.8	19.72	5		BC 51 x CoH 15	17.2	7.8	19.93	3
BC 52 x Co 1148	16.4	17	22.44	9		BC 51 x CoH 15	13.4	12.2	20.78	3
BC 52 x Co 1148	18.2	13.2	20.37	6		BC 51 x CoH 15	18.2	17.8	13.83	7
BC 52 x Co 1148	17.4	17.2	26.03	10		BC 51 x CoH 15	14	14	11.83	7
11 th ROW						**16 th ROW**				
BC 52 x Co 1148	14.2	13.4	18.63	22		BC 51 x CoH 15	19.4	19	20.7	11
BC 52 x Co 1148	15.4	13.8	16.84	14		BC 51 x CoH 15	16	15.4	17.78	14
BC 52 x Co 1148	14.4	11.2	14.47	5		BC 51 x CoH 15	17.2	17.6	18.38	6
BC 52 x Co 1148	18.2	18.4	21.08	5		BC 51 x CoH 15	18.2	19.4	14.4	7
BC 52 x Co 1148	13.4	12.2	15.52	5		BC 51 x CoH 15	17.4	18.2	20.24	15
BC 52 x Co 1148	21.2	18	22.34	3		BC 51 x CoH 15	17.2	18.4	24.99	8
BC 52 x Co 1148	17.4	13.4	22.2	6		BC 51 x CoH 15	16.2	12.4	16.13	14
BC 52 x Co 1148	15.4	10.8	17	7		BC 51 x CoH 15	13.4	11.2	18.64	4
BC 52 x Co 1148	16.2	11.8	28.49	6		BC 51 x CoH 15	14.2	16.4	17.83	6
12 th ROW						BC 51 x CoH 15	11.2	10.2	19.07	13
BC 52 x Co 1148	17.4	16.4	20.75	25		**17 th ROW**				
BC 52 x Co 1148	22.4	21.2	22.35	3		BC 51 x CoH 15	14.2	15.4	17.83	8
BC 52 x Co 1148	15.8	17.2	23.14	8		BC 51 x CoH 15	13.4	14.2	18.56	7
BC 52 x Co 1148	16.4	15.4	18.14	9		BC 51 x CoH 15	15.4	14.4	17.57	3
BC 52 x Co 1148	17.4	15.4	17.82	5		BC 51 x CoH 15	19.2	19.8	20.04	2
BC 52 x Co 1148	18.2	19.4	17.63	3		BC 51 x CoH 15	14.2	16.2	20.05	5
BC 52 x Co 1148	18.4	17.4	19.9	8		BC 51 x CoH 15	23.2	22.2	20.19	10
BC 52 x Co 1148	14.2	14.4	23.4	4		BC 51 x CoH 15	21.4	21.4	20.58	5
BC 52 x Co 1148	15.4	16.2	20.93	9		BC 51 x CoH 15	16.2	19.2	16.75	12
BC 52 x Co 1148	12.2	11.2	17.46	10		BC 51 x CoH 15	14.4	16.4	12.69	3
BC 52 x Co 1148	14.2	17.8	22.11	4		BC 51 x CoH 15	15.2	14.2	16.88	6
BC 52 x Co 1148	20.4	17.4	18.15	6		BC 51 x CoH 15	16.4	18.2	18.43	9
13 th ROW						BC 51 x CoH 15	18.2	18.2	25.13	10
BC 52 x Co 1148	12.4	12.2	17.19	15		**18 th ROW**				
BC 52 x Co 1148	12.4	12.2	26.63	7		BC 51 x CoH 15	18.2	16.4	19.81	6
BC 52 x Co 1148	12.8	17.4	15.24	3		BC 51 x CoH 15	17.4	16.4	16.4	5
BC 52 x Co 1148	15.4	11.4	21.43	8		BC 51 x CoH 15	16.4	18.2	18.15	8
BC 52 x Co 1148	19.4	19.4	22.28	12		BC 51 x CoH 15	20.2	20.4	18.44	7
BC 52 x Co 1148	15.4	9.8	19.15	5		BC 51 x CoH 15	17.2	18.4	20.17	12
BC 52 x Co 1148	16.4	11.8	17.7	27		BC 51 x CoH 15	15.4	17.2	19.13	2
14 th ROW						BC 51 x CoH 15	13.2	19.4	17.85	4
BC 52 x Co 1148	15.2	15.2	18.34	17		BC 51 x CoH 15	18.4	17.2	23.38	8
BC 52 x Co 1148	12.4	12.4	17.04	4		BC 51 x CoH 15	14.2	14.4	16.14	17
BC 52 x Co 1148	15.4	15.6	15.45	9		CD 6 x Co 1148	17.4	17.2	18.81	3
BC 52 x Co 1148	14.2	12.2	14.36	11		CD 6 x Co 1148	17.2	16.8	15.88	11
BC 52 x Co 1148	18.4	17.4	13.33	10						
BC 52 x Co 1148	12.2	12.4	17.74	16						
BC 52 x Co 1148	14.4	10.2	11.68	2						
BC 52 x Co 1148	17.2	14.2	22.75	16						
BC 52 x Co 1148	11.2	12.2	16.66	10						
BC 52 x Co 1148	16	15.2	15.16	15						

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
19 th ROW				
CD 6 x Co 1148	19.8	20.2	17.09	4
CD 6 x Co 1148	21.2	21.2	17.26	13
CD 6 x Co 1148	17.4	21	22.62	6
CD 6 x Co 1148	14.2	17.4	13.51	1
CD 6 x Co 1148	16.8	14.4	18.73	3
CD 6 x Co 1148	18.2	17.4	16.79	9
CD 6 x Co 1148	18.4	17.2	18.59	5
CD 6 x Co 1148	18.2	17.4	19.03	7
CD 6 x Co 1148	14.2	16.4	19.27	5
CD 6 x Co 1148	20.2	19.8	16.14	3
CD 6 x Co 1148	19	19.4	21.42	11
20 th ROW				
CD 6 x Co 1148	18.4	17.4	22.03	6
CD 6 x Co 1148	16.2	19.8	23.08	4
CD 6 x Co 1148	19.4	19.4	19.23	8
CD 6 x Co 1148	18.2	20.2	18.61	8
CD 6 x Co 1148	20	20	16.06	2
CD 6 x Co 1148	23.2	22.8	23.33	6
CD 6 x Co 1148	18.4	21.2	16.9	5
CD 6 x Co 1148	19.2	19.2	15.9	4
CD 6 x Co 1148	17.2	17.2	22.67	7
CD 6 x Co 1148	17.4	17.4	18.25	9
21 th ROW				
CD 6 x Co 1148	19.2	19.4	18.78	16
CD 6 x Co 1148	18.4	17.4	16.79	7
CD 6 x Co 1148	17.2	17.2	15.67	3
CD 6 x Co 1148	17.4	17.4	15.95	4
CD 6 x Co 1148	20	19.6	17.4	12
CD 6 x Co 1148	13	15.2	16.5	16
CD 6 x Co 1148	19.2	20.2	27.73	8
CD 6 x Co 1148	16.4	17.8	21.17	3
CD 6 x Co 1148	18	19.4	21.53	16
CD 6 x Co 1148	19.4	19.8	20.56	11
22th ROW				
CD 6 x Co 1148	18.8	19.8	24.62	15
CD 6 x Co 1148	15.4	19.2	17.13	10
CD 6 x Co 1148	17.2	19.4	19	7
CD 6 x Co 1148	21	21.8	14.13	7
CD 6 x Co 1148	20.4	20.4	17.16	7
CD 6 x Co 1148	17.4	19.8	17.73	7
CD 6 x Co 1148	23	20.2	21.58	3
CD 6 x Co 1148	21	20.2	20.52	7
23 th ROW				
BC 51 x CoS 8436	19.2	19.2	22.83	2
BC 51 x CoS 8436	14.4	13.4	17.75	2
BC 51 x CoS 8436	21.2	19.8	20.13	12
BC 51 x CoS 8436	13.4	15.4	22.36	15
BC 51 x CoS 8436	14.4	15.2	21.42	3
BC 51 x CoS 8436	18	18	22.21	6
BC 51 x CoS 8436	15.4	16.2	23.64	14
BC 51 x CoS 8436	20.2	19.8	25.91	12
BC 51 x CoS 8436	18.4	18.4	24.34	5

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
24 th ROW				
BC 51 x CoS 8436	20.2	19.2	21.27	8
BC 51 x CoS 8436	12.4	13.2	18.13	4
BC 51 x CoS 8436	18.4	19.2	18.93	13
BC 51 x CoS 8436	13.2	14.2	17.27	9
BC 51 x CoS 8436	15.4	16.2	18.47	4
BC 51 x CoS 8436	16.2	17.2	21.78	7
BC 51 x CoS 8436	16.8	15.8	21.59	3
BC 51 x CoS 8436	20	19.4	25.86	5
BC 51 x CoS 8436	17.2	17.2	17.9	3
BC 51 x CoS 8436	17.4	18.2	23.74	4
25 th ROW				
BC 51 x CoS 8436	18.2	20.2	21.98	7
BC 51 x CoS 8436	20	18.2	20.12	9
BC 51 x CoS 8436	12.2	13.4	21.27	5
BC 51 x CoS 8436	19.4	19.8	24.81	10
BC 51 x CoS 8436	15.2	16.4	16.28	1
BC 51 x CoS 8436	17.4	16.4	17.62	11
BC 51 x CoS 8436	16	17	19.64	11
BC 51 x CoS 8436	17.4	17.2	22.23	13
26 th ROW				
BC 51 x CoS 8436	19.4	18.8	28.54	14
BC 51 x CoS 8436	18.2	18.8	21.45	8
BC 51 x CoS 8436	15.1	15	19.78	13
BC 51 x CoS 8436	17	17	17.79	9
BC 51 x CoS 8436	11.2	10	18.2	1
BC 51 x CoS 8436	15.4	17.2	27.27	6
BC 51 x CoS 8436	15.2	16.4	20.48	18
BC 51 x CoS 8436	16.4	17.2	14.4	3
BC 51 x CoS 8436	21.2	20.2	24.48	7
27 th ROW				
BC 51 x CoS 8436	19.2	20.8	25.73	12
BC 51 x CoS 8436	16.4	15.2	19.65	17
BC 51 x CoS 8436	15.2	16	23.39	11
BC 51 x CoS 8436	19.4	18.8	26.25	5
BC 51 x CoS 8436	17.8	19.8	25.2	6
CD 11 x CoC 8001	19.2	19.8	27.52	12
CD 11 x CoC 8001	21	21.2	19.94	5
28 th ROW				
CD 11 x CoC 8001	17.2	18	22.49	3
CD 11 x CoC 8001	16.8	15.4	16.44	10
CD 11 x CoC 8001	21.2	20.2	22.26	4
CD 11 x CoC 8001	17.2	21.2	36.29	12
CD 11 x CoC 8001	19.2	22.2	20.9	3
CD 11 x CoC 8001	20.2	20.2	23.2	2

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
29 th ROW				
CD 11 x CoC 8001	21.2	22	23.53	7
CD 11 x CoC 8001	19.4	20.2	22.56	10
CD 11 x CoC 8001	18.4	20.4	21.85	4
CD 11 x CoC 8001	19.4	19.8	17.44	3
CD 11 x CoC 8001	18.4	19.4	14.76	2
CD 11 x CoC 8001	21.2	19.2	17.13	2
CD 11 x CoC 8001	19.8	19.2	23.37	13
CD 11 x CoC 8001	20.2	18.8	17.19	1
CD 11 x CoC 8001	18.8	21.2	24.22	2
CD 11 x CoC 8001	19.8	18.8	21.29	10
CD 11 x CoC 8001	19.2	19.4	22.78	5
30 th ROW				
CD 11 x CoC 8001	17.2	19.2	20.54	20
CD 11 x CoC 8001	16.4	20.8	21.14	10
CD 11 x CoC 8001	18.2	20.2	25.91	15
CD 11 x CoC 8001	17.2	17	17.22	3
CD 11 x CoC 8001	18.2	20.4	24.55	11
CD 11 x CoC 8001	20.2	19.8	23.61	5
CD 11 x CoC 8001	17.4	17.4	23.68	7
CD 11 x CoC 8001	19.2	17.8	15.69	4
CD 11 x CoC 8001	18.8	20.2	23.06	3
CD 11 x CoC 8001	20.2	19.8	27.29	7
CD 11 x CoC 8001	17.8	19.2	23.13	11
31 th ROW				
CD 11 x CoC 8001	11.2	13.2	22.27	5
CD 11 x CoC 8001	15.4	16.2	15.54	2
CD 11 x CoC 8001	15.2	15.2	16.65	13
CD 11 x CoC 8001	15.2	15.4	20.17	8
CD 11 x CoC 8001	19.2	18.4	22.94	6
CD 11 x CoC 8001	19.4	19.2	15.45	2
CD 11 x CoC 8001	21.2	20.2	19.39	6
CD 11 x CoC 8001	21	22.2	21.35	5
CD 11 x CoC 8001	18.4	19.8	22.78	18
32 th ROW				
CD 11 x CoC 8001	21	21.2	22.11	2
CD 11 x CoC 8001	22.2	22.4	25.75	11
CD 11 x CoC 8001	20	18.8	23.37	3
CD 11 x CoC 8001	18.2	19.8	24.75	8
CD 11 x CoC 8001	17.2	17.2	24.97	6
CD 11 x CoC 8001	18.8	20.2	17.49	7
CD 11 x CoC 8001	18.2	19.8	20.29	4
CD 11 x CoC 8001	19.4	18.4	18.11	4
CD 11 x CoC 8001	17	20.2	23.18	18
CD 11 x CoC 8001	19.2	20.8	24.69	2
CD 11 x CoC 8001	17.2	17.2	19.26	7
33 th ROW				
CD 11 x CoC 8001	20.2	21.2	16.21	12
CD 11 x CoC 8001	17.4	18.4	23.86	5
CD 11 x CoC 8001	15.2	15.2	15.28	9
CD 11 x CoC 8001	18.8	21.2	25.46	2
CD 11 x CoC 8001	17.2	19.4	23.84	8
CD 11 x CoC 8001	16.4	20.4	21.01	15
CD 11 x CoC 8001	15.2	20.2	21.39	3
CD 11 x CoC 8001	19.2	21.2	23.27	4
CD 11 x CoC 8001	19.4	21.2	19.39	5
CD 11 x CoC 8001	23.8	22	21.47	3
34 th ROW				
CD 11 x CoC 8001	13.2	20.2	27.97	7
CD 11 x CoC 8001	19.2	19.2	22.02	1
CD 11 x CoC 8001	14	20.2	20.81	14
CD 11 x CoC 8001	17.2	16.2	20.18	5
CD 11 x CoC 8001	20.8	22.2	20.18	5
CD 11 x CoC 8001	18	21.2	19.39	5
CD 11 x CoC 8001	17	21.2	22.09	4
CD 11 x CoC 8001	21.2	21.2	16.56	1
CD 11 x CoC 8001	21.8	22.2	22.99	10
35 th ROW				
CD 11 x CoC 8001	18.8	18.8	20.22	4
CD 11 x CoC 8001	17.6	18.2	17.98	3
CD 11 x CoC 8001	16	16	15.62	4
CD 11 x CoC 8001	21.2	20	18.29	4
CD 11 x CoC 8001	15.6	18.8	23.68	3
CD 11 x CoC 8001	21.2	19.4	20.22	16
CD 11 x CoC 8001	17.4	18.2	20.4	1
CD 11 x CoC 8001	19.8	20.2	19.46	3
36 th ROW				
CD 366 GC	15.2	15.2	21.16	14
CD 366 GC	14.2	15	18.86	13
CD 366 GC	12.4	11.2	17.84	7
CD 366 GC	14.4	15.4	20.54	4
CD 366 GC	19.2	19.2	20.13	13
CD 366 GC	15.4	16.2	19.19	10
CD 366 GC	10.2	11	11.18	4
CD 366 GC	17.4	19.8	23.06	10
CD 70 GC	13.2	14.4	12.92	13
CD 70 GC	13.2	12.2	12.16	19
37 th ROW				
CD 70 GC	13.8	14.2	14.8	8
CD 70 GC	14.2	15.4	15.77	30
CD 70 GC	13.4	12.2	11.16	26
CD 70 GC	18.2	19	12.61	18
CD 70 GC	5.4	5.4	10.01	2
CD 70 GC	17.2	17.4	16.98	7
CD 70 GC	14.2	15.2	16.21	3
CD 70 GC	14.2	14	17.52	6
CD 70 GC	16	16	13.17	6
CD 70 GC	17.2	17.2	17.43	4

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
38 th ROW						**43th ROW**				
CD 70 GC	15.2	16.4	16.7	19		BC 51 GC	14.8	19.2	18.84	14
CD 43 GC	15.2	15.2	15.29	40		BC 51 GC	17.4	16.2	19.73	4
CD 43 GC	10.2	10.2	12.66	5		BC 51 GC	16.8	18	14.85	8
CD 43 GC	18.2	19.2	10.33	7		BC 51 GC	16.2	17.72	15.73	10
CD 43 GC	12	12	15.79	12		BC 51 GC	14	14	17.48	3
CD 43 GC	15.2	14.4	16.05	19		BC 51 GC	13.2	12.4	20.38	9
39 th ROW						BC 51 GC	14.4	14.4	18.8	25
CD 116 GC	13.2	13.4	20.76	20		BC 51 GC	12.2	12	15.94	7
CD 116 GC	14.2	14	17.08	4		BC 51 GC	19.4	18.8	16.54	9
CD 116 GC	15.2	16.4	13.33	10		BC 51 GC	16	16	25.74	10
CD 116 GC	18.8	19.2	20.81	1		**44th ROW**				
CD 116 GC	13.8	13.8	11.59	23		BC 51 GC	16	16	26.69	20
CD 116 GC	14	14.4	12.82	1		BC 51 GC	15.2	16.2	22.41	8
CD 116 GC	13.2	14.2	13.68	6		BC 51 GC	19.2	19.2	17.44	13
CD 116 GC	18.8	18	20.13	6		BC 51 GC	19.4	18.2	21.94	2
CD 116 GC	18.8	18.8	19.65	10		BC 51 GC	15.2	16.2	19.69	1
CD 116 GC	19	19	15.46	2		BC 51 GC	18.4	19	17.75	12
CD 116 GC	18	18	18.79	9		BC 51 GC	14	19	20.03	7
40 th ROW						BC 51 GC	15.2	15.2	20.68	3
CD 116 GC	13.4	13.4	10.6	28		BC 51 GC	16	17	19.73	3
CD 116 GC	19.2	19.2	1.093	6		BC 51 GC	17.2	20.2	18.66	5
CD 116 GC	15	16.4	14.06	9		BC 51 GC	18.2	18.2	15.46	7
CD 116 GC	18.8	18.8	20.84	5		BC 51 GC	10.8	11.2	16.19	8
CD 116 GC	19.2	19.4	21.09	4		BC 51 GC	17.2	17.2	21.74	9
CD 116 GC	17	18	17.48	7		**45th ROW**				
CD 116 GC	15	15.4	14.86	23		BC 51 GC	13.2	17	24.99	8
41 th ROW						BC 51 GC	10.2	10.2	15.25	16
BC 51 GC	11.2	11.2	21.01	25		BC 51 GC	13	13.2	16.56	3
BC 51 GC	15.8	16.4	17.78	9		BC 51 GC	14	18.2	21.81	7
BC 51 GC	16.4	17.4	19.4	9		BC 51 GC	17.4	17.2	17.97	4
BC 51 GC	19.2	19.2	16.21	11		BC 51 GC	11.4	10.2	12.99	20
BC 51 GC	11.4	11.2	18.19	30		BC 51 GC	18.4	18.4	14.89	2
BC 51 GC	15	15	20.81	5		BC 51 GC	15.2	19	18.12	8
BC 51 GC	14.4	14.4	19.02	10		BC 51 GC	18.4	18.2	17.3	5
BC 51 GC	14	14	18.32	15		BC 51 GC	17.2	20.2	20.46	10
BC 51 GC	17	17	26.89	1		BC 51 GC	19.4	19.4	11.79	10
BC 51 GC	21	19.8	24.91	3		BC 51 GC	17.8	19.2	22.26	7
BC 51 GC	16	18.2	24.62	7		**46 th ROW**				
42 th ROW						BC 51 GC	17.2	17.2	19.66	22
BC 51 GC	17.2	18	11.02	13		BC 51 GC	18.4	21.2	18.72	9
BC 51 GC	16.4	17.4	16.56	10		BC 51 GC	22.2	21.4	23.32	2
BC 51 GC	16.8	18	14.85	8		BC 51 GC	18.2	10.2	24.85	8
BC 51 GC	11.4	12.2	17.87	5		BC 51 GC	12.4	12.4	12.9	23
BC 51 GC	13.8	13.4	16.3	2		BC 51 GC	13.2	13.2	18.08	8
BC 51 GC	19	19.8	22.14	4		BC 51 GC	16.4	16.4	20.54	26
BC 51 GC	18	18	21.21	4		BC 51 GC	20	21.2	22.57	13
BC 51 GC	17.4	18.2	21.33	10		BC 51 GC	15.4	15.4	15.36	9
BC 51 GC	14	14	11.49	7		BC 51 GC	15.2	15	16.76	20

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
47th ROW						**2 PLOT**				
BC 51 GC	15.4	16.2	21.84	5		**1st ROW**				
BC 51 GC	17.2	19.2	21.41	6		BC 51 xCo 86002	19.4	20.2	16.44	16
BC 51 GC	21.2	21.2	18.06	5		BC 51 xCo 86002	16.2	17.2	23.78	2
BC 51 GC	15.4	17.4	19.89	3		BC 51 xCo 86002	11.2	12.2	21.21	3
BC 51 GC	19	19.2	24.94	5		BC 51 xCo 86002	18.8	19.8	24.79	11
BC 51 GC	17.8	19.4	19.87	4		BC 51 xCo 86002	15.2	16.4	19.94	2
BC 51 GC	15.4	15.4	14.74	7		BC 51 xCo 86002	18	18	14.98	3
BC 51 GC	16.2	16.2	18.44	6		BC 51 xCo 86002	16.8	18	21.56	18
BC 51 GC	20	20.2	22.6	6		BC 51 xCo 86002	20.2	20.2	21.92	2
BC 51 GC	20	19.8	19.84	6		BC 51 xCo 86002	15	15	24.52	7
BC 51 GC	19	20.8	19.23	5		BC 51 xCo 86002	13.2	13.2	21.42	1
BC 51 GC	13.2	13.2	22.79	6		**2 nd ROW**				
48 th ROW						BC 51 xCo 86002	21	21.4	27.16	8
BC 51 GC	19	19.2	24.35	6		BC 51 xCo 86002	17	17	26.63	2
BC 51 GC	17.2	18.8	19.96	4		BC 51 xCo 86002	15.2	15.2	22.05	5
BC 51 GC	16.8	16.8	25.25	6		BC 51 xCo 86002	10.4	10.4	14.75	9
BC 51 GC	15.4	19.2	21.11	13		BC 51 xCo 86002	12	13	23.73	4
BC 51 GC	20	18.8	17.75	5		BC 51 xCo 86002	10	10	18.56	5
BC 51 GC	18.4	20.2	19.1	10		BC 51 xCo 86002	11	12	20.84	2
BC 51 GC	17.2	17.2	19.82	15		BC 51 xCo 86002	15.2	17.2	25.96	3
BC 51 GC	17	17	19.58	13		BC 51 xCo 86002	20	21.2	22.91	16
BC 51 GC	17	17	19.78	2		BC 51 xCo 86002	19	20.4	21.5	4
BC 51 GC	14.2	14.2	19.29	11		**3 rd ROW**				
49th ROW						BC 51 xCo 86002	16	21	27.24	6
BC 51 GC	17.2	17.4	24.35	18		BC 51 xCo 86002	15.2	17	21.22	6
BC 51 GC	19	20.4	18.48	7		BC 51 xCo 86002	15.4	17	22.62	5
BC 51 GC	16.2	19	19.34	8		BC 51 xCo 86002	22.2	21.4	28.04	6
BC 51 GC	19.2	19.4	19.78	5		BC 51 xCo 86002	14.4	14.4	21.02	10
BC 51 GC	16	19.2	23.17	9		BC 51 xCo 86002	17	19.8	26.02	10
BC 51 GC	14.4	15.4	18.38	2		BC 51 xCo 86002	14	17	20.49	2
BC 51 GC	11.2	13.2	16.06	19		BC 51 xCo 86002	18	20.2	21.43	5
BC 51 GC	17.2	17.2	16.19	6		BC 51 xCo 86002	12	15	21.6	5
BC 51 GC	15.4	14.4	16.61	2		**4 th ROW**				
BC 51 xCo 86002	22.4	21.2	22.5	12		BC 51 xCo 86002	20	20.4	22.53	6
BC 51 xCo 86002	12.4	13.4	19.28	2		BC 51 xCo 86002	19	19.4	23.68	4
50 th ROW						BC 51 xCo 86002	21	19.2	14.02	17
BC 51 xCo 86002	22	21.2	22.42	6		BC 51 xCo 86002	12.2	15	24.81	5
BC 51 xCo 86002	21.2	19.8	17.81	7		BC 51 xCo 86002	11	15	27.24	2
BC 51 xCo 86002	13.2	13.2	15.26	9		BC 51 xCo 86002	13.2	13.2	17.61	7
BC 51 xCo 86002	16.4	19.2	25.04	16		BC 51 xCo 86002	15.4	17.2	17.52	2
BC 51 xCo 86002	14.4	15.4	17.31	14		BC 51 xCo 86002	18.8	19.2	23.53	8
BC 51 xCo 86002	15.4	16.2	16.2	6		**5th ROW**				
BC 51 xCo 86002	15.4	17.2	17.5	5		BC 51 xCo 86002	14.4	14.4	23.01	12
BC 51 xCo 86002	13.2	18.2	22.54	4		BC 51 xCo 86002	17.2	17.2	23.95	2
BC 51 xCo 86002	17.4	17.4	19.58	12		BC 51 xCo 86002	20	19.2	28.76	4
BC 51 xCo 86002	19.2	21.2	26.37	13		BC 51 xCo 86002	21.2	19.2	19.75	7
BC 51 xCo 86002	17.2	17.2	16.98	3		BC 51 xCo 86002	19	19.2	26.97	12
BC 51 xCo 86002	23	23.2	24.78	12		BC 51 xCo 86002	12	13.4	20.99	4
						BC 51 xCo 86002	16.2	19.2	22.64	9
						BC 51 xCo 86002	15.8	17.4	21.53	3
						BC 51 xCo 86002	16.2	16.2	18.86	5
						BC 51 xCo 86002	20	20.2	26.25	10

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
6th ROW						**11 th ROW**				
BC 51 xCo 86002	15.4	17.4	28.45	5		CD 11 x CoC 8001	15.4	21.2	20.68	2
BC 51 xCo 86002	21.8	21.4	22.03	9		CD 11 x CoC 8001	19.2	22.2	27.66	20
BC 51 xCo 86002	18.4	19.2	27.48	3		CD 11 x CoC 8001	15.2	19.2	27.57	4
BC 51 xCo 86002	19.4	19.8	21.84	3		CD 11 x CoC 8001	17.2	22	25.08	5
BC 51 xCo 86002	15.2	15.2	16.99	4		CD 11 x CoC 8001	19	20.2	19.95	3
BC 51 xCo 86002	15	15	19.27	3		CD 11 x CoC 8001	21	19.8	21.05	1
BC 51 xCo 86002	15	15	15.17	10		CD 11 x CoC 8001	18.2	16	21.51	3
BC 36 GC	10.2	13.2	20.29	16		CD 11 x CoC 8001	14.2	18	20.23	20
BC 36 GC	13	13	14.18	4		CD 11 x CoC 8001	17.8	18.2	14.59	3
7th ROW						**12 th ROW**				
BC 36 GC	13.2	13.2	15.56	7		CD 11 x CoC 8001	17	21.2	26.61	5
BC 36 GC	11.4	11.4	14.44	12		CD 11 x CoC 8001	15.4	19.8	26.25	6
BC 36 GC	7.2	7.2	16.18	2		CD 11 x CoC 8001	16	19.4	22.61	5
BC 36 GC	19.2	19.2	15.35	3		CD 11 x CoC 8001	15.2	16	15.21	1
BC 36 GC	10.2	10.2	14.01	26		CD 11 x CoC 8001	18.4	21.2	21.8	15
BC 36 GC	8.4	8.4	16.48	4		CD 11 x CoC 8001	19	19.8	19.78	2
BC 36 GC	12.2	12.2	13.76	6		CD 11 x CoC 8001	19.4	19.4	19.47	4
BC 36 GC	11.2	11.2	10.41	25		CD 11 x CoC 8001	19.4	20.2	22.22	17
BC 36 GC	8.4	8.4	22.05	7		**13 th ROW**				
8th ROW						CD 11 x CoC 8001	17.2	19.2	21.59	8
BC 36 GC	8.4	8.4	12.21	3		CD 11 x CoC 8001	19.4	20	23.36	5
BC 36 GC	15.4	15.4	16.7	15		CD 11 x CoC 8001	17.2	21	26.06	3
BC 36 GC	12.2	12.2	13	4		CD 11 x CoC 8001	18.4	19.4	22.9	5
BC 36 GC	10.4	10.4	9.48	14		CD 11 x CoC 8001	20.2	19	20.09	4
BC 36 GC	19.2	19.2	15.35	4		CD 11 x CoC 8001	20.4	21.2	15.87	4
BC 36 GC	12.4	12.4	14.82	7		CD 11 x CoC 8001	19	20.2	18.94	7
BC 36 GC	10.2	10.2	16.83	6		CD 11 x CoC 8001	20	21	22.9	3
BC 36 GC	16.8	16.8	15.63	16		CD 11 x CoC 8001	14.4	15.2	20.61	3
BC 36 GC	13.4	14.4	20.56	10		CD 11 x CoC 8001	19.2	19.8	28.7	8
9th ROW						CD 11 x CoC 8001	19.2	19.2	19.72	17
BC 36 GC	14.4	16	19.76	12		**14 th ROW**				
BC 36 GC	12.4	12.4	16.89	2		CD 11 x CoC 8001	17.4	19.2	20.03	10
BC 36 GC	10.8	10.8	19.49	8		CD 11 x CoC 8001	16.4	19.4	24.34	5
BC 36 GC	15.4	15.4	28.91	2		CD 11 x CoC 8001	18	19.2	26.61	9
BC 36 GC	9.2	9.2	14.43	5		CD 11 x CoC 8001	16	19	23.04	9
BC 36 GC	12.4	14.4	21.22	4		CD 11 x CoC 8001	20.4	20.4	22.79	5
BC 36 GC	12	12	16.75	9		CD 11 x CoC 8001	18.2	19.2	23.18	5
CD 11 x CoC 8001	18	21.2	21.12	3		CD 11 x CoC 8001	21.2	19.8	21.82	7
10 th ROW						CD 11 x CoC 8001	20.2	21.2	25.78	1
CD 11 x CoC 8001	17.4	20	18.51	5		**15 th ROW**				
CD 11 x CoC 8001	20.8	22	19.73	4		CD 11 x CoC 8001	19	21.2	20.35	12
CD 11 x CoC 8001	18.8	19.8	24	5		CD 11 x CoC 8001	19.2	21.2	25.35	12
CD 11 x CoC 8001	17.4	20.2	25.68	5		CD 11 x CoC 8001	18.4	19	22.26	2
CD 11 x CoC 8001	19	20.2	19.86	3		CD 11 x CoC 8001	23.2	21.2	16.95	8
CD 11 x CoC 8001	19.2	19.2	23.87	8		CD 11 x CoC 8001	19.2	21.2	18.05	3
CD 11 x CoC 8001	16	18	21.28	3		CD 11 x CoC 8001	18.2	19.2	22.06	2
CD 11 x CoC 8001	19.2	20	20.16	20		CD 11 x CoC 8001	20.8	19	19.67	4
						CD 11 x CoC 8001	21	18.8	19.57	5
						CD 11 x CoC 8001	17.4	19	28.76	7
						CD 11 x CoC 8001	17.2	19	20.16	2
						CD 11 x CoC 8001	16.8	18.8	25.75	3

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
16 th ROW				
CD 11 x CoC 8001	21.2	19.4	21.28	3
CD 11 x CoC 8001	18.4	19.4	24.37	5
CD 11 x CoC 8001	23.2	21	20.67	5
CD 11 x CoC 8001	21.2	21.8	25.01	3
CD 11 x CoC 8001	17.8	20	16.25	4
CD 11 x CoC 8001	19.2	18.2	22.82	14
CD 11 x CoC 8001	21.2	18.4	21.36	2
CD 11 x CoC 8001	14.8	15.2	19.26	7
CD 11 x CoC 8001	20.8	19.2	23.13	12
17 th ROW				
CD 11 x CoC 8001	18.8	19.4	23.86	3
CD 11 x CoC 8001	18.4	19.4	27.14	6
CD 11 x CoC 8001	19	19.4	19.33	13
CD 11 x CoC 8001	17.4	19.2	24.09	6
CD 11 x CoC 8001	20.2	19	23.9	2
CD 11 x CoC 8001	20.8	21.2	22.6	15
CD 11 x CoC 8001	19.2	21.2	25.8	4
CD 11 x CoC 8001	19.2	19.8	27.05	3
CD 11 x CoC 8001	21.2	21.2	19.97	3
CD 11 x CoC 8001	17.8	18.8	16.23	2
CD 11 x CoC 8001	20.2	19	26.92	2
CD 11 x CoC 8001	20.8	20	24.25	9
18 th ROW				
CD 11 x CoC 8001	20	19.2	20.59	3
CD 11 x CoC 8001	18.4	20	22.44	10
CD 11 x CoC 8001	20	21.2	26.08	4
CD 11 x CoC 8001	18.4	19.4	29	5
CD 11 x CoC 8001	19.4	19	26.12	9
CD 11 x CoC 8001	17.2	20.4	26.02	6
CD 11 x CoC 8001	21.2	20.4	21.52	3
CD 11 x CoC 8001	19.4	19.8	13.82	18
CD 11 x CoC 8001	17.8	19	23.91	6
CD 11 x CoC 8001	20	19.2	16.4	2
CD 11 x CoC 8001	20.2	19	23.29	8
19 th ROW				
CD 11 x CoC 8001	21	21.4	18.53	3
CD 11 x CoC 8001	22	21.2	20.51	4
CD 11 x CoC 8001	19.4	19	25.2	3
CD 11 x CoC 8001	19	20	19.11	3
CD 11 x CoC 8001	21	23.2	20.26	4
CD 11 x CoC 8001	18.8	21	18.57	4
CD 11 x CoC 8001	19.2	19	18.66	9
CD 11 x CoC 8001	19	19.8	18.79	2
CD 11 x CoC 8001	18.2	19.8	26.04	20

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
20 th ROW				
CD 11 x CoC 8001	16.4	19	24.09	13
CD 11 x CoC 8001	19.2	21	20.9	5
CD 11 x CoC 8001	21.2	21.2	24.42	3
CD 11 x CoC 8001	16.4	19.4	28.27	4
CD 11 x CoC 8001	20.2	20	24.79	4
CD 11 x CoC 8001	21.4	19.4	25.03	6
CD 11 x CoC 8001	20.4	20.2	21.68	8
CD 11 x CoC 8001	17.4	19	25.38	6
CD 11 x CoC 8001	19.2	21	18.25	1
CD 11 x CoC 8001	19.4	21.2	24.65	3
CD 11 x CoC 8001	17.2	19.4	20.69	2
21 th ROW				
CD 12 x CoC 8001	18.2	19	22	9
CD 12 x CoC 8001	20.2	22.2	22.84	4
CD 12 x CoC 8001	17.2	15.2	22.57	7
CD 12 x CoC 8001	21.8	20.2	16.73	1
CD 12 x CoC 8001	20.2	19.2	20.48	5
CD 12 x CoC 8001	20.4	19	23.28	4
CD 12 x CoC 8001	20.2	19.2	27.21	4
CD 12 x CoC 8001	21	18	18.79	7
CD 12 x CoC 8001	22	22.4	20.01	19
22 th ROW				
CD 12 x CoC 8001	20.2	20	20.31	13
CD 12 x CoC 8001	20	20.4	21.92	3
CD 12 x CoC 8001	19	19.2	19.75	5
CD 12 x CoC 8001	18.4	18.4	22.31	5
CD 12 x CoC 8001	16.8	18.8	24.96	10
CD 12 x CoC 8001	16.2	20.4	20.31	3
CD 12 x CoC 8001	18.4	20.4	18.84	21
23 th ROW				
CD 12 x CoC 8001	18.2	21.2	17.32	2
CD 12 x CoC 8001	21.2	21.2	21.14	13
CD 12 x CoC 8001	15.2	22.2	24.32	7
CD 12 x CoC 8001	19.4	21.2	20.49	8
CD 12 x CoC 8001	17.2	19	19.28	16
CD 12 x CoC 8001	12.4	17.2	23.12	1
CD 12 x CoC 8001	17	17	17.4	5
CD 12 x CoC 8001	19.2	19.2	24.93	9
CD 12 x CoC 8001	19.8	17	20.47	9
24 th ROW				
CD 12 x CoC 8001	18	20.2	20.58	13
CD 12 x CoC 8001	15.2	17.2	14.62	6
CD 12 x CoC 8001	19.2	16	14.55	7
CD 12 x CoC 8001	19	19	17.89	3
CD 12 x CoC 8001	16	17.8	26.84	17

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
25 th ROW						**31 th ROW**				
CD 12 x CoC 8001	21.2	22.2	24.96	18		CD 50 GC	14.2	14.2	11.63	45
CD 12 x CoC 8001	18	19.2	17.59	13		CD 50 GC	14	14	17.09	13
CD 12 x CoC 8001	18	17	18.28	8		CD 50 GC	17	17	12.45	14
CD 12 x CoC 8001	20	19.2	19.5	7		CD 50 GC	12.4	14.4	18.34	5
CD 12 x CoC 8001	13.4	13.4	11.59	4		CD 50 GC	15.2	15.2	14.63	27
CD 12 x CoC 8001	19.2	20.2	26.93	10		CD 50 GC	13.4	13.4	13.93	15
CD 12 x CoC 8001	18.2	18.2	20.46	4		CD 50 GC	15.2	15.2	11.82	6
CD 12 x CoC 8001	19	19.2	24.69	9		CD 50 GC	15.4	15.4	14.58	10
26 th ROW						CD 50 GC	16	16	16.55	6
CD 12 x CoC 8001	15.4	16	18.9	12		**32 th ROW**				
CD 12 x CoC 8001	20.2	19	19	2		CD 50 GC	14	14	17.18	19
CD 12 x CoC 8001	19.4	18	16.39	10		CD 50 GC	15	15	13.99	16
CD 12 x CoC 8001	19.2	19.2	19.67	7		CD 50 GC	10.2	10.2	13.88	13
CD 12 x CoC 8001	20.2	21	23.85	12		CD 50 GC	13.4	13.4	12.05	14
CD 12 x CoC 8001	20.2	20.2	18.82	1		CD 50 GC	13	13	11.52	1
CD 12 x CoC 8001	21.2	20.2	24.17	10		CD 50 GC	10.4	10.4	10.89	16
27 th ROW						**33 th ROW**				
CD 12 x CoC 8001	18	18	19	15		CD 50 GC	17.2	17.2	18.89	9
CD 12 x CoC 8001	20	20	23.44	2		CD 50 GC	15.2	15.2	14.37	8
CD 12 x CoC 8001	18.2	19	18.59	10		CD 50 GC	12.4	12.4	14.73	18
CD 12 x CoC 8001	18.4	19.8	18.3	15		CD 50 GC	16.4	16.4	11.04	8
28 th ROW						CD 50 GC	5.2	5.2	16.68	15
CD 12 x CoC 8001	19.8	18	23.47	10		CD 50 GC	18.4	18.4	17.72	3
CD 12 x CoC 8001	21	18	18.97	11		CD 50 xCo 89029	9.2	9.2	16.18	6
CD 12 x CoC 8001	16.4	15	16.97	4		**34 th ROW**				
CD 12 x CoC 8001	20.4	18.2	20.63	9		CD 50 xCo 89029	19.2	21.2	21.32	11
CD 12 x CoC 8001	15.8	16	23.98	12		CD 50 xCo 89029	21.4	21.4	23.85	8
CD 12 x CoC 8001	16.4	18.8	20.77	5		CD 50 xCo 89029	17.4	18.8	32.65	4
CD 12 x CoC 8001	19.8	19	20.8	10		CD 50 xCo 89029	19.2	19.2	20.18	2
CD 12 x CoC 8001	16.4	15.4	19.28	3		CD 50 xCo 89029	14.4	14.4	20.41	4
CD 12 x CoC 8001	21	21	15.66	1		CD 50 xCo 89029	18.4	18.4	18.56	4
29 th ROW						CD 50 xCo 89029	18	18	19.2	5
CD 12 x CoC 8001	17.8	19.2	25.39	7		CD 50 xCo 89029	14.2	17.2	25.62	2
CD 12 x CoC 8001	17	17	20.33	6		CD 50 xCo 89029	17.4	17.4	18.08	3
CD 12 x CoC 8001	17.4	17.4	16.5	5		CD 50 xCo 89029	13.2	13.2	21.64	3
CD 12 x CoC 8001	16.8	16.8	20.44	1		CD 50 xCo 89029	16	18.2	21.87	3
CD 12 x CoC 8001	18	18	17.69	2		CD 50 xCo 89029	17.2	17.8	16.69	7
CD 12 x CoC 8001	19	18	18.21	11		**35 th ROW**				
30 th ROW						CD 50 xCo 89029	18.2	20.2	24.85	13
CD 12 x CoC 8001	18	18	21.7	8		CD 50 xCo 89029	19.2	18	25.09	4
CD 12 x CoC 8001	19.2	19	18.98	10		CD 50 xCo 89029	16.4	18	23.85	11
CD 12 x CoC 8001	19	19	18.06	2		CD 50 xCo 89029	17.2	16.2	24.33	5
CD 50 GC	10.2	10.2	12.21	25		CD 50 xCo 89029	17.2	18.2	22.9	8
CD 50 GC	13.2	13.2	17.23	8		CD 50 xCo 89029	19	15.2	18.56	3
CD 50 GC	18.2	18.2	10.83	25		CD 50 xCo 89029	10.4	10.4	18.35	5
						CD 50 xCo 89029	17.2	17.2	2.91	1
						CD 50 xCo 89029	19	19	19.37	4
						CD 50 xCo 89029	15	15.4	17.11	6
						CD 50 xCo 89029	17.4	17.4	19.22	3
						CD 50 xCo 89029	16.4	16.4	16.73	3

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
36 th ROW						**40 th ROW**				
CD 50 xCo 89029	13.2	20.2	23.32	12		CD 50 xCo 89029	20.2	20.2	25.55	7
CD 50 xCo 89029	20.8	20.4	2.32	4		CD 50 xCo 89029	19	19	14.59	6
CD 50 xCo 89029	21.2	21.2	23.97	5		CD 50 xCo 89029	17.2	17.2	16.4	4
CD 50 xCo 89029	17.2	21	16.3	23		CD 50 xCo 89029	13.4	13.4	21.05	2
CD 50 xCo 89029	21	19.2	28.32	5		CD 50 xCo 89029	20.2	20.2	20.22	10
CD 50 xCo 89029	15.2	15.2	22.53	5		CD 50 xCo 89029	17.2	17.2	24.15	4
CD 50 xCo 89029	17.4	17.4	17.78	3		CD 50 xCo 89029	17	17	27.49	10
CD 50 xCo 89029	18	18	21.39	5		CD 50 xCo 89029	20.2	20.2	18.37	12
CD 50 xCo 89029	18.2	18.2	17.51	6		**41 th ROW**				
CD 50 xCo 89029	16.4	16.4	22.1	6		CD 50 xCo 89029	15.4	15.4	19.74	3
CD 50 xCo 89029	16.8	16.8	21.32	5		CD 50 xCo 89029	17.2	17.2	20.14	3
37 th ROW						CD 50 xCo 89029	15.4	15.4	24.61	3
CD 50 xCo 89029	19.2	18.2	18.89	14		CD 50 xCo 89029	11.2	11.2	16.62	10
CD 50 xCo 89029	18.4	18.4	17.87	16		CD 50 xCo 89029	13.4	11.2	16.62	5
CD 50 xCo 89029	18	18	17.43	4		CD 50 xCo 89029	15.4	15.4	16.31	2
CD 50 xCo 89029	16.8	16.8	19.38	8		CD 50 xCo 89029	15	15	24.33	6
CD 50 xCo 89029	14.4	14.4	19.24	2		CD 50 xCo 89029	15.4	16.2	20.52	4
CD 50 xCo 89029	18.4	18.4	15.56	7		CD 50 xCo 89029	18.8	18	20.51	5
CD 50 xCo 89029	13.8	13.8	18.56	6		**42 th ROW**				
CD 50 xCo 89029	17.2	19.2	21.65	5		CD 50 xCo 89029	19.2	19.2	18.82	10
CD 50 xCo 89029	16.4	16.4	14.5	9		CD 50 xCo 89029	11.4	12.4	14.1	7
CD 50 xCo 89029	18	18	17.95	10		CD 50 xCo 89029	18.2	18.2	20.14	3
CD 50 xCo 89029	21	21	28.16	8		CD 50 xCo 89029	18.8	18.8	23.69	1
38 th ROW						CD 50 xCo 89029	16.4	16.4	13.06	4
CD 50 xCo 89029	19.2	21	20.79	10		CD 50 xCo 89029	18.8	18.8	19.66	8
CD 50 xCo 89029	15.4	17.4	21.48	5		CD 50 xCo 89029	17.2	17.2	23.53	6
CD 50 xCo 89029	18	18	24.13	6		CD 50 xCo 89029	17	17	23.86	4
CD 50 xCo 89029	18.4	18.4	21.8	5		CD 50 xCo 89029	17.2	17.2	22.81	10
CD 50 xCo 89029	18.4	18.4	28.08	4		CD 50 xCo 89029	15	15	14.95	2
CD 50 xCo 89029	19.2	19.2	17.37	2		CD 50 xCo 89029	17.2	17.2	23.85	10
CD 50 xCo 89029	14	14	15.8	10		**43 th ROW**				
CD 50 xCo 89029	17.2	17.2	18.02	10		CD 50 xCo 89029	15.4	19.2	22.89	13
CD 50 xCo 89029	16.2	16.2	20.29	7		CD 50 xCo 89029	16	17	26.97	5
CD 50 xCo 89029	19	19	24.25	10		CD 50 xCo 89029	18.8	17.2	19.72	6
39 th ROW						CD 50 xCo 89029	21	21	18.71	5
CD 50 xCo 89029	17.4	17.4	14.27	5		CD 50 xCo 89029	16	16.4	17.71	5
CD 50 xCo 89029	17.2	17.2	24.34	6		CD 50 xCo 89029	14	14.6	16.42	4
CD 50 xCo 89029	18.4	17.2	17.18	10		CD 50 xCo 89029	15	15.4	17.24	7
CD 50 xCo 89029	17.2	17.2	17.07	4		CD 50 xCo 89029	16	16.2	18.45	6
CD 50 xCo 89029	16.8	16.8	16.6	4		CD 50 xCo 89029	17.2	17.2	19.25	5
CD 50 xCo 89029	18	18	20.86	6		**44 th ROW**				
CD 50 xCo 89029	18.2	18.2	23.84	5		CD 50 xCo 89029	17.2	17	19.22	4
CD 50 xCo 89029	15.4	15.4	21.01	10		CD 50 xCo 89029	15.4	15.2	17.45	5
CD 50 xCo 89029	21	21	25.32	2		CD 50 xCo 89029	19	19.2	16.42	7
						CD 50 xCo 89029	14.2	14.8	17.2	6
						CD 50 xCo 89029	17.4	16.2	20.42	4
						CD 50 xCo 89029	20.4	20	19.81	7
						CD 50 xCo 89029	19.2	19.4	18.67	6
						CD 50 xCo 89029	19.4	19.2	20.45	5
						CD 50 xCo 89029	15.4	15	14.24	10
						CD 50 xCo 89029	16.2	16.6	17.75	9

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
45 th ROW						**49 th ROW**				
CD 50 xCo 89029	19	19.4	19.45	6		CD 50 xCo 89029	21.2	21.2	21.29	7
CD 50 xCo 89029	14.2	14	14.34	12		CD 50 xCo 89029	19	19	20.45	7
CD 50 xCo 89029	18	18.4	18.35	11		CD 50 xCo 89029	18	18.4	19.26	6
CD 50 xCo 89029	17.2	17.4	14.25	7		CD 50 xCo 89029	19.2	19.4	18.47	5
CD 50 xCo 89029	11.4	11.6	15.12	15		CD 50 xCo 89029	16	16.2	19.26	8
CD 50 xCo 89029	16	16.6	17.05	9		CD 50 xCo 89029	17.2	17.4	20.15	7
CD 50 xCo 89029	15.4	14.2	16.25	7		CD 50 xCo 89029	20.4	20.2	20.45	5
CD 50 xCo 89029	16.2	16.2	17.45	8		CD 50 xCo 89029	17	17.4	19.47	7
CD 50 xCo 89029	18	17.4	17.52	7		CD 50 xCo 89029	16	16.4	19.4	8
CD 50 xCo 89029	18	17.2	17.48	6		CD 50 xCo 89029	20.2	20.2	22.45	9
CD 50 xCo 89029	12.4	11.8	12.11	10		CD 50 xCo 89029	20.2	20.2	20.17	7
CD 50 xCo 89029	21.2	19.2	16.42	5		CD 50 xCo 89029	19.8	19.8	19	6
46 th ROW						**50 th ROW**				
CD 50 xCo 89029	14.4	15.2	11.2	11		CD 50 xCo 89029	17.4	19.2	22.36	23
CD 50 xCo 89029	18.2	18	12.56	5		CD 7 GC	19.2	19.2	18.45	12
CD 50 xCo 89029	17.2	17.4	12.42	6		CD 7 GC	16.8	17	19.22	11
CD 50 xCo 89029	17.2	17	20.42	10		CD 7 GC	17.4	17	16.76	11
CD 50 xCo 89029	18.4	18.4	21.41	6		CD 7 GC	18	18.4	19.45	16
CD 50 xCo 89029	19	19	22.12	4		CD 7 GC	19.2	19.4	20.72	14
CD 50 xCo 89029	16	16	18.01	3		CD 7 GC	15.4	15	16.45	8
CD 50 xCo 89029	18	17.4	15.57	2		CD 7 GC	17	17.4	17.04	9
CD 50 xCo 89029	17.2	17	16.88	3		CD 7 GC	16.2	16.2	18.12	7
47 th ROW						CD 7 GC	17	16.8	19.4	8
CD 50 xCo 89029	22	21.2	21.88	12		**3 rd PLOT**				
CD 50 xCo 89029	19.2	19.2	19.45	1		**1 st ROW**				
CD 50 xCo 89029	13	13.2	18.52	11		CD 7 GC	16.8	17.8	19.42	11
CD 50 xCo 89029	14.4	14.6	17.41	12		CD 7 GC	16	17	22.58	7
CD 50 xCo 89029	16	16.4	16.52	7		CD 7 GC	17.2	16	18.18	7
CD 50 xCo 89029	21	21	19.78	5		CD 7 GC	17.8	16.2	21.49	9
CD 50 xCo 89029	18.4	18.6	21.46	6		CD 7 GC	18	18	22.64	16
CD 50 xCo 89029	19.2	19	20.41	5		CD 7 GC	15.2	15.2	20.55	10
CD 50 xCo 89029	19	19	18.79	4		CD 7 GC	18.2	17	17.39	9
48 th ROW						CD 7 GC	18.4	18.2	19.11	11
CD 50 xCo 89029	18	18	19.4	8		CD 7 GC	19.2	18.2	16.69	11
CD 50 xCo 89029	17	16.8	19.28	9		CD 7 GC	17.2	16.2	22.1	10
CD 50 xCo 89029	18.4	19	19.41	7		CD 7 GC	18	18	17.81	9
CD 50 xCo 89029	15.2	14.8	12.12	10		CD 7 GC	16.8	15.2	20.78	9
CD 50 xCo 89029	16	16.2	14.16	9		**2 nd ROW**				
CD 50 xCo 89029	17	17.4	15.14	7		CD 7 GC	19	20.4	24.43	12
CD 50 xCo 89029	14	15.8	16.12	10		CD 7 GC	18.8	17.2	21.42	12
CD 50 xCo 89029	15.2	15	17	9		CD 7 GC	14.6	14.4	23.45	11
CD 50 xCo 89029	18	18.4	16.14	7		CD 7 GC	19	19	24.52	12
CD 50 xCo 89029	17.2	17.4	16.58	7		CD 7 GC	18.2	17.4	16.42	11
CD 50 xCo 89029	15	15.8	17.4	9		CD 7 GC	17	17.2	19.41	11
CD 50 xCo 89029	17	17.4	17.98	6		CD 7 GC	15.8	15	17.68	14
						CD 7 GC	17.2	16.8	16.42	13
						CD 7 GC	18	17.4	19.51	12
						CD 7 GC	17.8	16.8	20.21	12
						CD 7 GC	20.2	21.2	18.78	7

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
3 rd PLOT						**7 th ROW**				
CD 7 GC	15.4	14.4	22.77	20		CD 7 GC	17.2	17	20.79	15
CD 7 GC	15.8	15.8	21.48	22		CD 7 GC	19.2	19	19.58	16
CD 7 GC	15.4	14.8	17.12	17		CD 7 GC	17.8	17.2	20.19	17
CD 7 GC	16.2	15.2	16.81	16		CD 7 GC	17	17.4	20.1	18
CD 7 GC	14	14.4	17.46	10		CD 7 GC	17.2	16.4	19.27	19
CD 7 GC	16.2	16.6	19.23	17		CD 7 GC	17	16.2	19.27	21
CD 7 GC	19	19	20.44	12		CD 7 GC	17.2	16.8	20.17	20
CD 7 GC	15	15.4	17.42	11		CD 7 GC	17.4	16.4	21.27	21
CD 7 GC	14.2	14	19.47	9		CD 7 GC	19	19.2	22.14	11
CD 7 GC	15	15.2	19.49	8		CD 7 GC	17.2	17	22.21	11
CD 7 GC	15.4	15.4	20.41	9		CD 7 GC	21	19	19.27	12
4 th ROW						**8 th ROW**				
CD 7 GC	15.4	15.2	20.61	10		CD 7 GC	17	16	20.38	11
CD 7 GC	18	18	20.72	10		CD 7 GC	16.2	16	20.12	10
CD 7 GC	15.2	15.2	21.11	11		CD 7 GC	16.4	16.2	19.87	9
CD 7 GC	13.2	13.2	19.14	13		CD 7 GC	17.2	16.8	20.21	11
CD 7 GC	16.4	16.2	19.27	14		CD 7 GC	19	18.2	19.58	12
CD 7 GC	15.2	15	19.78	12		CD 7 GC	19.4	18.2	19.47	13
CD 7 GC	18.8	18.8	20.12	11		CD 7 GC	16	16.4	21.42	12
CD 7 GC	16.4	16.2	18.99	10		CD 7 GC	18	18	22.47	11
CD 7 GC	17.2	17	19.71	11		CD 7 GC	14.4	14.2	12.12	10
CD 7 GC	17.4	17	19.77	11		CD 7 GC	15.2	15	12.98	15
CD 7 GC	16.8	16.2	20.11	11		CD 7 GC	16	16.6	17.41	14
5 th ROW						CD 7 GC	15.4	15	18.42	12
CD 7 GC	18	17.4	19.32	14		**9 th ROW**				
CD 7 GC	18.2	16.6	20.12	12		CD 7 GC	18.2	19.2	23.84	17
CD 7 GC	17.4	17.2	19.42	13		CD 7 GC	18.4	18	21.82	18
CD 7 GC	17.2	17	19.67	12		CD 7 GC	19	19	23.12	10
CD 7 GC	16.2	16.4	19.55	19		CD 7 GC	18.8	18.8	22.48	10
CD 7 GC	17.2	17.2	19.67	9		CD 7 GC	17.2	17	22.46	8
CD 7 GC	17.2	17	18.98	10		CD 7 GC	17.8	17.2	21.47	9
CD 7 GC	13.4	13.2	19.97	16		CD 7 GC	18.8	18	20.98	15
CD 7 GC	16.8	16.8	17.42	15		CD 7 GC	17.2	17.4	21.41	15
CD 7 GC	16.4	16.2	17.67	17		CD 7 GC	12.4	12	16.42	7
CD 7 GC	17.2	17	18.42	19		**10 th ROW**				
CD 7 GC	16.4	16.2	19.67	21		CD 7 GC	17.4	19	17.56	11
6 th ROW						CD 7 GC	19	19	20.49	12
CD 7 GC	18	18	23.53	12		CD 7 GC	18	17.2	19.89	12
CD 7 GC	17.8	17.4	21.12	23		CD 7 GC	19.2	19	20.47	9
CD 7 GC	16.2	16	20.48	17		CD 7 GC	21.2	21.2	21.27	10
CD 7 GC	14	12	19.41	16		CD 7 GC	19	19	20.26	7
CD 7 GC	16	16.2	19.67	18		CD 7 GC	20	20	21.57	8
CD 7 GC	16	16	19.52	19		CD 7 GC	19.2	19.4	19.42	8
CD 7 GC	15	14.8	20	21		CD 7 GC	17.2	17	16.47	9
CD 7 GC	14.2	14	21.21	17		CD 7 GC	15.2	15	19.58	11
CD 7 GC	18.4	18.2	20.76	16		CD 7 GC	18	18.2	21.42	12
CD 7 GC	17.2	17	19.42	14						
CD 7 GC	19.4	19.2	18.47	15						
CD 7 GC	16	16.2	19.42	12						

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC		Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Dia (mm)	NMC
11 th ROW						**15 th ROW**				
CD 61 x CoC 8001	19.2	19	20.9	11		CD 61 x CoC 8001	16.4	20.2	22.87	15
CD 61 x CoC 8001	21.2	16	20.95	5		CD 61 x CoC 8001	22.2	21.2	23.13	9
CD 61 x CoC 8001	16.4	15.2	23	8		CD 61 x CoC 8001	19.4	19.2	22.19	10
CD 61 x CoC 8001	17.2	21.4	23	8		CD 61 x CoC 8001	17.4	17	22.76	11
CD 61 x CoC 8001	19	19.2	22.51	3		CD 61 x CoC 8001	19.2	19	21.79	10
CD 61 x CoC 8001	21	21	20.51	4		CD 61 x CoC 8001	17.2	18.2	22.71	12
CD 61 x CoC 8001	19	17.4	21	7		CD 61 x CoC 8001	17.2	17	22.48	7
CD 61 x CoC 8001	19.2	17.2	19.28	6		CD 61 x CoC 8001	23.2	21.2	23.36	6
CD 61 x CoC 8001	15.4	15.2	18.81	4		CD 61 x CoC 8001	19.4	19	20.41	9
CD 61 x CoC 8001	17.2	17.4	19.41	8		CD 61 x CoC 8001	18.2	17.2	22.4	10
12 th ROW						CD 61 x CoC 8001	16.4	17.4	19.46	11
CD 61 x CoC 8001	17.2	16.8	20.16	16		CD 61 x CoC 8001	18.2	18	20.48	10
CD 61 x CoC 8001	15.4	16.2	25.29	7		**16 th ROW**				
CD 61 x CoC 8001	19.4	19	22.47	10		CD 61 x CoC 8001	21	21	20.75	12
CD 61 x CoC 8001	15.2	15.2	21.42	11		CD 61 x CoC 8001	16.8	15.2	21.76	11
CD 61 x CoC 8001	16.4	16.2	19.51	12		CD 61 x CoC 8001	19.4	18.4	20.59	12
CD 61 x CoC 8001	20.2	19.4	21.42	16		CD 61 x CoC 8001	17.4	18.8	19.48	13
CD 61 x CoC 8001	19.4	19	22	15		CD 61 x CoC 8001	17.2	17.2	18.47	12
CD 61 x CoC 8001	18.8	18.8	21.47	14		CD 61 x CoC 8001	18	18	19.48	10
CD 61 x CoC 8001	23	21	18.87	13		CD 61 x CoC 8001	21	21	20.76	10
13 th ROW						CD 61 x CoC 8001	20.2	20.2	21.47	9
CD 61 x CoC 8001	17.2	19.2	21.14	10		CD 61 x CoC 8001	18	17	21.98	7
CD 61 x CoC 8001	17.4	17	22.24	11		CD 61 x CoC 8001	18.2	17.2	22.45	6
CD 61 x CoC 8001	18.4	18.2	19.48	11		CD 61 x CoC 8001	19.4	18.4	18.47	9
CD 61 x CoC 8001	16.2	16.4	18.56	11		**17 th ROW**				
CD 61 x CoC 8001	16.4	16	19.64	11		CD 61 x CoC 8001	17.2	18.4	21.62	7
CD 61 x CoC 8001	20.2	19.8	20.49	12		CD 61 x CoC 8001	18	18	19.67	8
CD 61 x CoC 8001	17.4	17	21.46	10		CD 61 x CoC 8001	19.4	19.2	18.56	8
CD 61 x CoC 8001	18	18.2	20.48	10		CD 61 x CoC 8001	20	20.2	17.47	7
CD 61 x CoC 8001	16.8	16	21.49	11		CD 61 x CoC 8001	17.4	16.4	18.59	6
CD 61 x CoC 8001	22	22.2	20.89	8		CD 61 x CoC 8001	21	20	18.46	9
CD 61 x CoC 8001	17.2	17.4	22.49	9		CD 61 x CoC 8001	19.4	17.4	25.65	7
14 th ROW						CD 61 x CoC 8001	16.2	15.4	21.67	7
CD 61 x CoC 8001	20.2	21.4	24.67	11		CD 61 x CoC 8001	16	16.4	22.47	10
CD 61 x CoC 8001	19.8	19	23.96	12		**18 th ROW**				
CD 61 x CoC 8001	19	19.4	22.94	12		CD 61 x CoC 8001	15.4	16.4	21.63	5
CD 61 x CoC 8001	19.4	19.4	20.87	12		CD 61 x CoC 8001	19	19.2	20.48	7
CD 61 x CoC 8001	19.2	19.2	19.89	10		CD 61 x CoC 8001	18.4	17.4	21.51	8
CD 61 x CoC 8001	20.2	20.2	21.46	11		CD 61 x CoC 8001	14.8	13.2	19.42	7
CD 61 x CoC 8001	16.4	16	20.49	12		CD 61 x CoC 8001	15.4	14.4	19.47	9
CD 61 x CoC 8001	19	19.2	21.46	12		CD 61 x CoC 8001	19.4	18.4	18.46	13
						CD 61 x CoC 8001	18.8	18.2	19.41	15
						CD 61 x CoC 8001	19.2	19	17.61	19

Table – 4: Data on stalk characters of CD crosses of *S. Spontanium*

Clone	H.R Brix (10)	H.R Brix (12)	Stalk.Dia (mm)	NMC
19 th ROW				
CD 61 x CoC 8001	17.4	15.2	20.53	4
CD 61 x CoC 8001	19.2	21.2	19.83	8
CD 61 x CoC 8001	18	17	21.46	8
CD 61 x CoC 8001	17.4	17.4	22.48	7
CD 61 x CoC 8001	16.2	16.2	21.4	5
CD 61 x CoC 8001	18.4	20.2	20.33	9
CD 61 x CoC 8001	16.2	15.4	20.44	10
CD 61 x CoC 8001	15.4	16.2	20.41	12
CD 61 x CoC 8001	18	19.2	19.46	12
CD 61 x CoC 8001	21	21.2	18.46	16
CD 61 x CoC 8001	17	16	19.41	15
20 th ROW				
CD 61 x CoC 8001	19	18	18.29	13
CD 61 x CoC 8001	21	20	16.41	12
CD 61 x CoC 8001	102	11.2	12.42	10
CD 61 x CoC 8001	15.4	14.4	18.46	9
CD 61 x CoC 8001	15.6	15.6	19.41	8
CD 61 x CoC 8001	18	18.2	19.42	7
CD 61 x CoC 8001	18.2	18.2	18.46	8
CD 61 x CoC 8001	17.4	16.2	21.2	9
CD 61 x CoC 8001	19	18.2	21.48	9
CD 61 x CoC 8001	16.4	15	21.01	10
CD 61 x CoC 8001	20	20	22.02	11
21 th ROW				
BC 59 GC	14.4	14.4	8.61	5
BC 59 GC	19.8	18.8	7.42	32
BC 59 GC	18	18	10.11	41
BC 59 GC	17.2	17.4	11.12	28
BC 59 GC	11.4	10.4	16.12	17
BC 59 GC	15.4	14.4	17.12	25
BC 59 GC	11.2	12.2	18.12	31
22 th ROW				
BC 59 GC	11.2	10.2	14.22	30
BC 59 GC	16.4	15.4	19.22	28
BC 59 GC	19.2	19	20.14	27
BC 59 GC	10.4	10.4	17.12	25
BC 59 GC	10.4	10.4	19	28
BC 59 GC	11.2	11.2	12.12	30
BC 59 GC	11.3	11	11.47	31
BC 59 GC	14.4	14.2	12.61	32
BC 59 GC	10.2	10.2	11.41	30
23 th ROW				
BC 59 GC	21.2	21.2	20.05	12
BC 59 GC	13.2	13	12.11	28
BC 59 GC	19.4	19.2	11.24	25
BC 59 GC	10.2	10.2	9.8	25
BC 59 GC	9.2	9	10.4	23
BC 59 GC	20.2	20.2	12.12	30
BC 59 GC	18.8	18.2	17.41	20
BC 59 GC	11.2	11.2	19.42	30
BC 59 GC	18.4	18.2	19.41	15
BC 59 GC	18.2	18	18.81	15
24 th ROW				
BC 59 GC	20.2	20.2	15.22	14
BC 59 GC	19.8	19.2	17.61	10
BC 59 GC	18.8	18.2	19.61	10
BC 59 GC	14.2	14.2	12.21	14
BC 59 GC	14.8	14.2	12	18
BC 59 GC	13.2	13	12.51	31
BC 59 GC	11.4	11.2	12.66	30
BC 59 GC	12.2	12	12.51	30
BC 59 GC	16.8	16.8	14.31	17
25 th ROW				
BC 59 GC	17.8	19.8	18.61	9
BC 59 GC	12.4	12.2	16.71	25
BC 59 GC	16.4	16.2	17.21	20
BC 59 GC	19	19.2	19.61	7
BC 59 GC	17.2	18.4	20.72	10
BC 59 GC	15.2	16.4	12.62	15
BC 59 GC	19.2	19	19.72	12
BC 59 GC	11.4	17.2	10.4	12
BC 59 GC	19.2	19	20.24	7

Among the above seedlings 16 clones were selected based on cane diameter and number of canes and presented in the Table – 5. The fibre and bagasse yield and juice characters were further analysed and presented in the Table -6

Table - 5: Results of selected CD crosses of *S. Spontanium* clones having high productivity

S. No	Clone	H.R Brix (10)	H.R Brix (12)	Stalk. Diameter	NMC
1	CD 9 GC	13.4	12.2	19.5	55
2	BC 52 x Co 1148	17.2	14.2	22.75	16
3	CD 6 x Co 1148	18.8	19.8	24.62	15
4	BC 51 x CoS 8436	13.4	15.4	22.36	15
5	BC 51 x CoS 8436	15.2	16.4	20.48	18
6	BC 51 GC	11.2	11.2	21.01	25
7	BC 51 GC	11.4	11.2	18.19	30
8	BC 51 GC	16	16	26.69	20
9	BC 51 GC	12.4	12.4	12.9	23
10	CD 50 xCo 89029	15	15	24.33	6
11	CD 7 GC	18	18	22.64	16
12	CD 7 GC	15.4	14.4	22.77	20
13	CD 7 GC	15.8	15.8	21.48	22
14	BC 59 GC	10.4	10.4	19	28
15	BC 59 GC	11.2	11.2	19.42	30
16	CD 116 GC	7.2	6.8	14.27	40

Table - 6a: Results of bagasse and juice analysis of selected CD crosses of *S. Spontanium* clones (Clone name as per S.N of Table - 5)

Parameters	**unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Total weight	kg	12	12.5	21.5	16.5	19.5	16.5	12.5	14.5
Juice weight	kg	5.5	7	11.5	8.5	10.5	9	6.5	8
Bagasse weight	kg	6.5	5.5	10	8	9	7.5	6	6.5
Bag. Moisture	%	49.8	53.14	50.62	47.11	52.98	49.33	45.02	48.83
OD bag weight	kg	3.26	2.58	4.94	4.23	4.23	3.80	3.30	3.33
Juice solids	%	13.7	14.6	14.4	13.8	13.6	14.9	12	16
Fibre weight	kg	2.82	2.15	4.21	3.71	3.58	3.25	2.97	2.82
Fibre weight	%	23.48	17.21	19.58	22.49	18.38	19.69	23.80	19.44
Juice analysis									
pH		4.2	4.8	4.3	3.9	4.5	4.5	3.6	3.7
TS	mg L^{-1}	147000	168000	167000	166000	154000	182000	146000	188000
TDS	mg L^{-1}	137000	146000	144000	138000	136000	149000	120000	160000
BOD	mg L^{-1}	135000	135000	122500	115833	115000	140833	109166	147500
COD	mg L^{-1}	187506	212985	188813	190120	191426	213640	167253	246960

Table - 6b: Results of bagasse and juice analysis of selected CD crosses of *S. Spontanium* clones (Clone name as per S.N of Table -5)

Parameters	**unit**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Total weight	kg	17.5	16.5	16	17.5	16	15.5	20.5	18
Juice weight	kg	9.5	8.25	7.5	9.5	8	8.5	12	11
Bagasse weight	kg	8	8.25	8.5	8	8	7	8.5	7
Bag. Moisture	%	48.47	48.1	49.18	50.27	53.87	53.8	47.19	49.75
OD bag weight	kg	4.12	4.28	4.32	3.98	3.69	3.23	4.49	3.52
Juice solids	%	15.6	16.9	14.2	17.6	17.5	16	17.6	17.3
Fibre weight	kg	3.52	3.61	3.73	3.27	2.94	2.64	3.78	2.92
Fibre weight	%	20.10	21.89	23.29	18.69	18.35	17.02	18.45	16.19
Juice analysis									
pH		3.7	3.7	3.8	4.1	3.7	3.7	3.6	3.7
TS	mg L^{-1}	180000	191000	159000	202000	209000	188000	200000	210000
TDS	mg L^{-1}	156000	169000	142000	176000	175000	160000	176000	173000
BOD	mg L^{-1}	144166	139166	125000	147600	146666	140000	135833	141666
COD	mg L^{-1}	219520	237810	181626	230550	229320	214946	225400	224746

B DEVELOPMENT OF IMPROVED CLONES

a. Progeny of 2004 crosses:

In order to produce variability and then, screen and to select clones having high fiber content, flowering clones of E. *arundinaceus* were selfed and open cross pollinated. A total of 2280 seedlings obtained from 2004 GCs of eight clones were planted in polybags in April 2005. Out of these 228 selected seedlings with good vigor were transplanted in field during 2006 for screening the results are as follows.

Table – 7: Data on seedling progeny of 2004 crosses recorded in April 2007 (range in values)

Parameters	**IK76-44 self**	**IK76-78 self**	**IK76-81 self**	**IK76-48 GC**	**IK76-81x Co 8408**	**IMP1547 GC**	**Tongarang self**
Stalk Len. (cm.)	222-373	181-285	250-416	225-330	200-306	223-296	188-366
Stalk Dia. (cm.)	1.49-2.57	1.57-2.12	1.38-2.49	1.65-2.29	1.55-2.19	1.69-2.19	1.57-2.25
No. of internodes	16-36	14-31	15-34	16-28	15-28	20-29	10-30
Intern Len (cm.)	9-18	9-19	12-19	13-18	9-17	11-16	10-16
Stalk wt. (g)	317-1017	233-783	233-983	433-883	217-967	383-767	333-833
Established	23	9	22	15	28	9	15
Selected	9	2	16	8	7	2	5

From above 2004 general cross, high fiber content of 28% and above was recorded in the following clones viz., IK76-81/GC-7 (31.07%), IK76-81/GC-18 (30.98), IK76-81/GC-19 (30.07), Tongarang/GC-8 (30.47), IK76-81/GC-9 (28.6), IK76-81/GC-10 (28.5) , IK76-81/GC-12 (29.6), IK76-81/GC-14 (28.7), IK76-81/GC-16 (28.8), IK76-81/GC-20 (28.3). These ten clones were planted in October 2007 for further studies

b. Progeny of 2005 crosses

During 2005 flowering season, true seeds from three selfs and five GCs were collected and nursery sown on 7.3.06. 230 seedlings derived from 2005 selfs were planted at Agali for screening. Data recorded on selected 16 clones of *Erianthus* seedlings of 2005 selfings/GC at Agali are presented in Table - 8.

Table – 8: Results of 16 selected clones of 2005 crosses

S. No	Clone No	St. leng. (cm.)	St. Diam (cm.)	Intern. Leng (cm.)	No. intern. (cm.)	S. cane wt. (grams)	NMC
1	IK 76-81/6	310	19.1	11.5	22	450	21
2	IK 76-81/13	325	19.1	10.8	24	500	21
3	IK 76-81/49	300	20.45	12.2	26	750	44
4	IK 76-81/65	290	21.89	9	33	600	66
5	IK 76-81/72	290	19.19	11	29	850	17
6	IK 76-81/73	235	16.97	9.6	21	500	74
7	IK 76-81/83	205	18.17	11.7	21	600	28
8	IK 76-88/5	240	26.79	11.2	19	600	46
9	IK 76-88/7	250	18.36	8	26	600	16
10	IK 76-88/15	250	21.87	13	17	950	65
11	IK 76-88/16	240	20.15	12	25	700	60
12	IK 76-88/30	270	21.38	11.5	30	1050	43
13	Mythan B/8	200	12.45	12.8	17	250	95
14	IK 76-78 GC	315	20.86	12.8	31	1000	35
15	IK 76-78/10	260	17.57	13	24	500	41
16	IK 76-78/15	330	18.78	9.8	37	950	42
Mean		269.37	19.56	11.24	25.12	678.12	44.62
SD		40.81	2.99	1.49	5.73	228.01	22.51

c. Progeny of 2006 crosses

Fluff collected from 5 selfs and 5 general crosses of 2006 flowering *Erianthus* clones were sown in nursery in 2007. Following seedlings derived from selfs/GCs of 2006 were planted in polybags in May 07.

Table – 9: Results Crosses made during 2006

Self/GC of Clone	Seedlings In polybags	Seedlings Planted in field
IC76-91	155	84
IK76-92	285	89
IK76-93	135	67
IC76-99	210	192
IK76-91 GC	110	43
Total	895	475

From the above 895 seedlings, 475 were selected and planted in field at ECC on 4th August 07 for evaluation. Data on stalk characters were recorded in 280 seedlings derived from 2006 GCs and selfs.

Table -10: Evaluation of 280 clones – range in variability

Parameters	Minimum	Maximum
Stalk length (cm)	190	354
Stalk diameter (mm)	13.25	23.26
Internodes	10	30
Five cane weight (g)	1100	2900
HR brix %	11.5	18.5
Fiber %	17.31	33.05

Out of 280 seedlings derived from 2006 self/General Cross of flowering *E.arundinaceus* clones planted in August 2007, 203 clones were ratooned in 2008. 50 clones with best growth were selected and data recorded on the following characters:

Table -11: Range in values for stalk characters of 50 clones of 2006 self/GCs.

Parameters	Min.	Max.	Mean
Five cane wt. (g)	1100	3300	1900
Stalk diameter (mm)	13.0	26.0	20.2
Stalk length (cm)	200	345	271
No of internodes	12	30	21
Internode length (cm)	11.0	20.0	15.5
Fiber content %	15.72	33.0	-

From the above, 7 clones were found to have fiber content of 20% or above. Following are the clones that gave fiber above 25%

Table – 12: List of clones having more 25% fibre content

S. No	Clone	Fiber %
1	IK76-91#41	33.01
2	IK76-91GC36	29.50
3	IK76-99#2	25.36
4	IK76-99#41	29.37
5	IK76-99#91	33.05
6	IK76-93#59	26.91
7	IK76-99#21	27.90

d. Progeny of 2007 crosses

Fluff (true seeds) from GCs of 8 clones collected in November 2007 and sown in nursery. Out of 500 seedlings derived from 2007 GCs/selfs of 8 clones, 64 selected seedlings were planted in field in 2008 for evaluation. The 50 surviving clones were evaluated.

Table -13: Stalk characters of 50 selected clones (2007 crosses) – range in variability

Parameters	Minimum	Maximum
Stalk length (cm)	161.7	333.3
Stalk diameter (mm)	12.24	19.31
Internodes	11	34
Single cane weight (g)	166.7	700
Internode length (cm)	9.17	17.33

From the above 50 clones, 20 best clones were selected and tested for fiber content. The fiber content ranged from 22.13% to 30.92 %; the following seven clones gave high % fiber:

Table: 14: List of clones having more than 25% fibre content.

S. No	Clone	Fiber %
1	IK76-99/SF07-20	29.09
2	IK76-99/SF07-30	29.19
3	IK76-91/SF07-15	30.05
4	IK76-91/SF07-14	30.18
5	IK76-91/SF07-33	30.18
6	IK76-99/SF07-46	30.82
7	IK76-91/SF07-34	30.92

From the four years of improvement study through general crosses and selfs, total of 40 clones (Table -15.) having fibre percent of more than 25% was selected as potential clones for captive fibre or bio-energy sources.

Table -15: List of selected clones having more than 25% fibre content

S. No	Clone -2004	S. No	Clone - 2005	S. No	Clone -2006	S. No	Clone -2007
1	IK76-81/GC-7	1	IK 76-81/6	1	IK76-91#41	1	IK76-99/SF07-20
2	IK76-81/GC- 18	2	IK 76-81/13	2	IK76-91GC36	2	IK76-99/SF07-30
3	IK76-81/GC-19	3	IK 76-81/49	3	IK76-99#2	3	IK76-91/SF07-15
4	Tongarang/GC- 8	4	IK 76-81/65	4	IK76-99#41	4	IK76-91/SF07-14
5	IK76-81/GC-9	5	IK 76-81/72	5	IK76-99#91	5	IK76-91/SF07-33
6	IK76-81/GC-10	6	IK 76-81/73	6	IK76-93#59	6	IK76-99/SF07-46
7	IK76-81/GC-12	7	IK 76-81/83	7	IK76-99#21	7	IK76-91/SF07-34
8	IK76-81/GC-14	8	IK 76-88/5				
9	IK76-81/GC-16	9	IK 76-88/7				
10	IK76-81/GC-20	10	IK 76-88/15				
		11	IK 76-88/16				
		12	IK 76-88/30				
		13	Mythan B/8				
		14	IK76-78 GC				
		15	IK 76-78/10				
		16	IK 76-78/15				

e. Screening for red rot and pest resistance

A total of 40 high fiber *Erianthus* 34 clones were tested for red rot reaction by CCT, IK76/91SF07-14 was highly Resistant, 2 (IK76-99#91and IK76-91#41) were resistant, 23 clones were moderately resistant, four – Susceptible, four- Moderately susceptible and one clone - Highly susceptible. It has been generally observed that progeny from selfing gave a higher fiber per cent than those derived from general (open) cross.

f. NPK uptake studies:

The NPK uptake in selected clones of *E. arundinaceus* to produce one tonne of biomass was studied. The range and mean of uptake of Nitrogen, Phosphorus and Potassium are given in the table below:

Table - 16: NPK uptake (kg) to produce one tonne of biomass

Nutrients	Range	Mean
Nitrogen	2.80 – 5.78	2.40
Phosphorus	5.33 – 8.83	7.03
Potassium	0.65 – 1.26	0.89

C: IDENTIFICATION OF NEW CLONES THROUGH EVALUATION OF GERMPLASM:

In addition to the selection made through crosses and selfs, 55 new clones of *E. arundinaceus* brought from Kannur germplasm collection were evaluated for stalk length, stalk thickness, internode length, number of internodes, stalk weight and brix and presented in the Table 17.

Table -17: Evaluation of results of *E. arundinacus* collected from Kannur germplasm

No	Character	Minimum	Maximum	Mean
1	Stalk length (cm)	88.4	346	250.7
2	Stalk thickness (mm)	11.11	23.76	18.82
3	Single stalk weight (g)	120	1080	597
4	Internode length (cm)	8.1	19.9	13.8
5	No of internodes	10	34	23
6	Juice volume (ml/500g)	160	258	209
7	Juice wt. (g/500g)	165	263	215
8	Brix %	5.0	10.0	6.9
9	Fiber content %	15.02	26.15	19.86

D. PULPING STUDIES OF SELECTED CLONES

Out 40 clones selected, through breeding and selection, five clones having very high percentage of fibre, i.e. more than 30% was selected for pulping. The results are presented in the Table - 18. The unbleached pulps were analysed for strength properties, fibre and optical properties and results are presented in the Table – 19,20.

Table – 18: Results of pulping study of high fibre *E. arundinaceus* clones

S.No	Clone	Un screened Pulp yield %	Screened Pulp yield %	Bright. % ISO	Kappa No	WBL pH	Total Solids GPL	TTA @ 200 GPL	RAA @ 200 GPL
1	IK76-99#91	52.40	51.38	33.50	21.8	11.5	200	26.2	4.8
2	IK76-91#41	51.47	50.93	33.6	22.6	11.8	173	30.8	5.2
3	Mythan B/8	53.12	52.95	35.1	16.6	11.7	170	25.0	6.8
4	IK76-81/GC-7	50.40	49.62	33.10	19.0	11.4	204	27.1	3.4
5	IK76-91/SF07-34	53.44	52.86	32.00	23.8	11.7	181	27.1	4.2

Table -19: Results of fibre classification and CSF analysis of high fibre *E. arundinaceus* clones

S.No	Clone	CSF ml	fibre classification %				
			+30	+50	+100	+200	-200
1	IK76-99#91	520	11.6	25.8	31.2	22.7	8.70
2	IK76-91#41	510	7.60	21.9	31.7	27.5	11.3
3	Mythan B/8	490	6.20	19.3	30.9	28.3	15.3
4	IK76-81/GC-7	470	7.30	22.0	34.4	27.8	8.50
5	IK76-91/SF07-34	540	8.90	21.3	34.8	27.5	7.50

Table - 20: Unbleached pulp properties of high fibre *E. arundinaceus* clones

S.No	Clone	Bulk cc/g	Brea-king length m	Tear Factor	Burst Factor	Bright. % ISO	Opa-city %	Sc. coffi. m^2/kg	Yello-wness %
1	IK76-99#91	1.64	7140	68.2	43.7	30.2	97.5	28	36.9
2	IK76-91#41	1.54	6890	65.1	42.9	30.9	96.2	25.7	34.3
3	Mythan B/8	1.47	6150	56.1	40.6	31.6	97.5	26.1	32.9
4	IK76-81/ GC-7	1.68	4430	54.9	34.8	30.5	97.2	29	35.5
5	IK76- 91/SF07-34	1.48	5900	53.3	34.7	29.2	97.0	26.7	35.2

E. DEVELOPMENT OF TISSUE CULTURE PROTOCOL FOR MASS MULTIPLICATION *E. arundinaceus*

As indicated earlier, during our field trials, we found that the survival percentage was very poor for the *E. arundinaceus* clones due to poor rooting. This is because, in general the commercial cane varieties are having 3 to 4 rows of the root primordium, whereas the *Erianthus arundinaceus* has only one row of root primordium leading to poor rooting percentage. Also for large scale cultivation study we require quite large amount of seed cane or seedlings. Use of the conventional setts method where maximum multiplication ratio achievable is 1:10 for this type of grass might take more than five years to get the required seed material to take any cultivation trial. Therefore, we have initiated in vitro propagation of six clones using meristem culture (shoot tip) micro-propagation techniques to produce more seedlings in short time. Protocol for selected clones viz. SES 159, Mythan A, SES 3, IMP 1536, and EA Cuttack were developed in phase 1. Among the above, SES 159 is found to respond well for in vitro multiplication and rooting.

Box – 3: Tissue culture protocol for *E. arundinaceus*

1.	Surface sterilization of the explant by 70% ethanol treatment for one minute and 10% sodium hypochlorite treatment for 20 minutes.
2.	Then shoot tips were excised and inoculated with MS medium supplemented with Riboflavin, BAP and GA_3 for shoot initiation.
3.	Multiple shoots were developed by transferring culture to MS medium with BA.
4.	The well developed shoots were then placed in ½ MS medium with NAA for in vitro rooting.
5.	The in vitro regenerated plants were planted in polybag containing a mixture of sand, silt & compost (1:1:1) and covered with polythene sheet.
6.	After one month, they were exposed to sunlight and hardened plants were planted in field.

The protocol was developed on pilot scale and produced limited number of seedlings during phase one. To take up this to large scale cultivation, efforts were made to scale up the tissue culture production process to a commercial scale.

Plant material: Nodal and apical cuttings of *E. arundinaceus* were collected from well grown mature mother plant maintained in mill. Initially the mother stock plants were cut at one foot from ground level after 6 months of growth to stimulate coppice growth. The actively growing shoot tips were collected and used for further study.

Culture medium

MS- A

Macronutrients	mg/L
Potassium nitrate (KNO_3)	- 1900
Ammonium nitrate (NH_4NO_3)	- 1650
Calcium chloride ($CaCl_2$)	- 440
Magnesium sulphate ($MgSO_4.7H_2O$)	- 370
Potassium dihydrogen phosphate (KH_2PO_4)	- 170

Micronutrients	mg/L
$Na_2EDTA.2H_2O$	- 37.25
Ferrous sulphate ($FeSO_4.7H_2O$)	- 27.85
Boric acid (H_3BO_4)	- 6.2
Manganese sulphate ($MnSO_4.7H_2O$)	- 17
Potassium iodide (KI)	- 0.83
Sodium molybdate ($Na_2MO_4.2H_2O$)	- 0.25
Copper sulphate ($CuSO_4$)	- 0.16
Cobalt chloride ($CoCl_2.H_2O$)	- 0.025

MS- B:

Organics	mg/L
Inositol	- 100
Glycine	- 2
Nicotinic acid	- 0.5
Pyridoxine HCl	- 0.4
Thiamine HCl	- 0.1

Hormones:

BAP : 6 – benzyl amino purine

GA3 : gibberellic acid

Good and actively growing coppice shoots were selected from healthy mother plant and for direct regeneration both apical and nodal buds were used as explants. The scaly shoots were removed and were cut in to explants of about 4 cm long and kept immersed in a jar containing water in order to prevent the explants from getting brown. The explants were surface sterilized by rinsing in tap water for 60 minutes. Then they were washed with detergent and Bavistin for 2 to 3 times and then washed with distilled water for 3 to 5 times and stored in a sterile conical flask with explants immersed in distilled water to prevent he explants from drying out. After thorough washing the explants were taken in to the laminar flow chamber and were treated with 70% alcohol for 2 minutes and then treated with 0.1% of mercuric chloride for 5 minutes and after which they were rinsed with sterile distilled water for 3 times. Later the explants were transferred in to a sterile bottle containing sterile water.

The surface sterilized ends were cut at their either ends using a sterile knife for nodal buds. Whereas, for apical buds their outer layer was removed to remove the remaining contaminants which have escaped surface sterilization and their tips were excised. These prepared explants with their basal region were inserted vertically using a forceps on the initiation media already prepared sterilized test tubes. The test tubes were then plugged with cotton to prevent microbial contamination. The cultures were maintained in culture room at 25ºc and under light with an intensity of 1350 LUX supplied by a cool white fluorescent tube, at the rate of 16:8 hours photo period. After 2 weeks of inoculation the shoots were sub cultured. The following media composition were identified as optimized medium for various stages of commercial scale production

INITIATION

Media	:	Agar free MS media
Sucrose	:	30 g/L
Riboflavin	:	10 mg / Liter
Hormone	:	BAP - 1 mg + GA3 - 0.5 mg / Liter

MULTIPLICATION

Media	:	Agar free MS media
Sucrose	:	20 g/L
Hormone	:	BAP - 0.25 mg / Liter

ROOTING

Media	:	½ MS media

Sucrose	:	20 g/L
Hormone	:	IBA - 1 mg / Liter

HARDENING

Media	:	Coir pith + Sand + Soil (1:1:1 ration)

We are able to get 10% initiation initially and it was subsequently improved to 40% (Plate - 1). The initiated shoots were sub-cultured once in three weeks in a multiplication medium containing BAP - 0.25 mg / Liter (Plate - 2). The multiplication ratio was found to be around 1:10 which is considered to be high. After about 10 -12 subculture, the cultures were transferred to rooting medium containing ½ MS media with 1 mg / Liter IBA (Plate - 3,4). The rooting response was also good and were able to get 100% rooting after about 15 days of incubation in the growth room (Plate - 6). The rooted cultures were separated as individual shoots (Plate - 7) and then transferred to portrays containing Coir pith + Sand + Soil (1:1:1 ration) and kept in poly tunnels for about fifteen days for acclimatization and then transferred to open nursery and kept for one month for hardening (Plate – 8,9,10). About 2, 80,000 seedlings were produced and used for large scale cultivation trail. The cost of production was very attractive and it works out to be around Rs 0.95 which is very less when compared other plants. The main reason for low production cost is due to non use of agar in the medium, high multiplication rate, 100 % rooting and hardening.

F.LARGE SCALE PLANTATION TRAIL

About 50 acres of large scale cultivation trial (Plate - 11,12,13,14,15) was taken using tissue culture seedlings produced by the commercial scale process. The cultivation practice and methods are presented un the BOX - 4. Table indicates list of farmers and area of plantation using both under captive plantation and farm forestry. It is learnt that, *E. arundinaceus* clones can grow in the poor soil. Therefore, out of 50 acres (Table - 21) trails, 6 acres consisting two acres each plot having poor soil conditions were taken for biomass productivity study and compared with regular cultivable land. The results on soil analysis and biomass productivity are presented in the Table - 22.

Box:4 CULTIVATION PRACTICES OF *E. arundinaceus*

Land preparation:

In the sodic soils, the excess salt was removed by applying gypsum @ 6 t ha^{-1} and leaching out. This was followed by sowing of green manure seeds (*Sesbania rostrata*) and incorporation of grown green manure crop at 60^{th} day after planting with rotary uprooter. The land was ploughed with disc plough initially and followed by two times tyne plough to pulverize the soil. Thirty cm wide ridges with the height and interval of 30 cm each was prepared for planting of *E. arundinaceus.*

Planting:

One foot height *E. arundinaceus* clones were planted in the ridges with the spacing of 60 cm. Thus, the spacing for *E. arundinaceus* is 60 cm X 30 cm.

Fertilizer applications:

Application of single super phosphate @ 375 kg ha^{-1} (60 kg of P_2O_5) was given as basal dose i.e. at the time of last ploughing. Nitrogen @ 275 kg ha^{-1} and K2O @ 112.5 kg ha^{-1} were applied in three equal splits on 30, 60 and 90^{th} day after planting. The source of N and K fertilizers were urea and muriate of potash respectively.

Weeding:

Three times weeding and earthing up of soil on 30^{th}, 60^{th} and 90^{th} day after planting was carried out.

Irrigation:

Up to three month of growth period, the *E. arundinaceus* was irrigated at seven days interval. After three months the irrigation interval was 15 days.

Harvest:

Since the *E. arundinaceus* crop was too dense, manual harvesting was ruled out and it was uprooted using heavy machineries.

Table – 21: List of *E. arundinaceus* cultivation sites.

Type	year	Name of land owner	Location of plantation	Village	Taluk	District	Area (acre)
Core Captive	2008-09	Thangavel	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.00
Core Captive	2008-09	Karupanan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.40
Core Captive	2008-09	Mathiyalagan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.50
Core Captive	2009-10	Murugasan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.00
Core Captive	2009-10	Amutha	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.50
Core Captive	2009-10	Subbarayan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	2.20
Core Captive	2009-10	Subbarayan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.30
Core Captive	2009-10	Ramalingam	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.81
Core Captive	2009-10	Somasundaram	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.70
Core Captive	2009-10	Nallammal	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.49
Core Captive	2009-10	Muthusamy	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.30
Core Captive	2009-10	Ganapathy	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.06
Core Captive	2009-10	Duraisamy	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.73
Core Captive	2009-10	Perumal	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.40
Core Captive	2009-10	Marrappan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.63
Core Captive	2009-10	Marrappan	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.60
Core Captive	2009-10	Kannammal	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.23
Core Captive	2009-10	Periyasamy	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	0.39
Core Captive	2009-10	Arunachalam	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.47
Core Captive	2009-10	Arunachalam	Moorthipalayam	Punjai Thotakurichi	Karur	Karur	1.63
Core Captive	2009-10	Palanisamy	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.74
Core Captive	2009-10	Marappan	Periyapudhur	Punjai Thotakurichi	Karur	Karur	1.07
Core Captive	2009-10	Subbrayan	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.47
Core Captive	2009-10	Ganesan	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.25
Core Captive	2009-10	Manoharan	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.25
Core Captive	2009-10	Palanisamy	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.36
Core Captive	2009-10	Selembanan	Periyapudhur	Punjai Thotakurichi	Karur	Karur	0.30
Core Captive	2009-10	Subramanian.M.M	Periyapudhur	Punjai Thotakurichi	Karur	Karur	1.12
Core Captive	2009-10	Subramani	Moolimangalam	Punjai Pugalur	Karur	Karur	0.45
Core Captive	2009-10	Subramaniyan	Moolimangalam	Punjai Pugalur	Karur	Karur	1.30
Core Captive	2009-10	Ramasamy	Moolimangalam	Punjai Pugalur	Karur	Karur	3.59
Core Captive	2009-10	Palanisamy	Moolimangalam	Punjai Pugalur	Karur	Karur	0.66
Core Captive	2009-10	ponnusamy	Moolimangalam	Punjai Pugalur	Karur	Karur	0.66
Core Captive	2009-10	Rasappan (Apparu)	Moolimangalam	Punjai Pugalur	Karur	Karur	1.00
Core Captive	2009-10	Chandarasekaran	Moolimangalam	Punjai Pugalur	Karur	Karur	0.41
Core Captive	2007-08	Thirumalai	Pandipalayam	Punjai Pugalur	A.kuruchi	Karur	3.21
Core Captive	2009-10	Rajalingam	Moolimangalam	Punjai Pugalur	Karur	Karur	3.24
Core Captive	2009-10	Palanisamy	Moolimangalam	Punjai Pugalur	Karur	Karur	3.55
Core Captive	2009-10	plantation	CMA	Punjai Pugalur	Karur	Karur	1.5
Farm Forestry	2009-10	Natesan	Azhagapuri	Punjai Pugalur	Karur	Karur	5.50
Farm Forestry	2009-10	Nachiyappa Goundr	Rasathavalasu,	Rasathavalasu	Kangayam	Tirupur	2.00

The Table – 22, clearly indicate that the *E. arundinaceus* is able perform well in the poor soil with EC of more than 8.0 ds/m and gave biomass yield of around 27.5 Mt per acre. The productivity is very high in the good soil and it is able to give green biomass yield of around 95.5 MT per acre.

Table- 22: Comparison of soil characters and yield of *E. arundinaceus* cultivated in both poor and good soil condition.

S.No	Parameters	Unit	Salt Affected Soil (6 acre)				Good Soil	
			Plot I	Plot II	Plot III	Avg.	Karur (5 acre)	Tirupur (2acre)
1	pH		8.52	8.66	8.49	8.56	7.52	6.95
2	EC	ds/m	6.29	4.89	5.98	5.72	2.9	0.45
3	OC	mg/kg	0.52	0.49	0.42	0.48	0.82	0.41
4	N	kg/ha	187	245	203	211.6	256	226
5	P	kg/ha	14.5	17.5	15	15.6	22.5	11.5
6	K	kg/ha	410	435	485	443.3	498.7	324.5
7	Exchangeable Ca	C mol (p+)/kg	10.5	11.2	9.8	10.5	7.4	8.4
8	Exchangeable Mg	C mol (p+)/kg	7.6	8.2	6.9	7.57	5.9	5.6
9	Exchangeable Na	C mol (p+)/kg	7.2	6.9	6.5	6.87	1.6	0.85
10	Exchangeable K	C mol (p+)/kg	2.1	1.9	1.8	1.93	0.95	0.95
11	ESP	%	26.3	24.4	26	25.58	10.09	3.73
12	Yield	MT	165				350	191
13	Avg. Yield/ac	MT	27.5				70	95.5

4: DISCUSSION

Initial screenings of diverse cytoplasm (CD) clones off 2004 from *S. spontanium* were carried out based on plant morphological characteristics viz. plant height, cane length, cane diameter, numbers of internodes, length of internodes, cane weight etc. Form above 16 clones were selected for fibre, bagasse and juice analysis and compared with selected reference clone SES 159. Only, three clones are having fibre percentage more than 23% against the 28.5 of SES 159 (Table - 23). However, quality of the juice in the selected clones are having the high solid content and COD which can be exploited for production bio-energy such as biogas.

Table – 23: Comparison of CD crosses of S. s*pontanium* with reference *E. arundinaceus* clone SES159.

Parameters	**unit**	**CD 9 GC**	**BC 51 GC**	**CD 7 GC**	**SES 159**
Total weight	kg	12	12.5	16	21
Juice weight	kg	5.5	6.5	7.5	6
Bagasse weight	kg	6.5	6	8.5	14
Bag. Moisture	%	49.8	45.02	49.18	55.3
OD bag weight	kg	3.26	3.30	4.32	6.25
Juice solids	%	13.7	12	14.2	4.30
Fibre weight	kg	2.82	2.97	3.73	5.98
Fibre weight	%	23.48	23.80	23.29	28.50
Juice analysis					
pH		4.2	3.6	3.8	5.2
TS	mg L-1	147000	146000	159000	85610
TDS	mg L-1	137000	120000	142000	77100
BOD	mg L-1	135000	109166	125000	78540
COD	mg L-1	187506	167253	181626	104620

The main criteria for development of captive fiber source and bio-energy production (KLASS, 1999, MISLEVY *et al.,* 1989, HEATON *et al.,* 2004, SAMSON *et al.,* 2005) are high biomass productivity in terms of fibre. Therefore, further crosses were made using *E. arundinaceus* which is known for its fibre and biomass productivity (AMALRAJ *et al*., 2008). *E. arundinaceus* were selfed and open cross pollinated to obtain new clones. A total of 2280 seedlings obtained from 2004 GCs of eight clones and 228 were planted for further screening. During 2005 flowering season, true seeds from three selfs and five GCs were collected and nursery sown and 230 seedlings developed. Fluff collected from 5 selfs and 5 general crosses of 2006 flowering *Erianthus* clones were sown in nursery and 895 seedlings were developed out only 474 was chosen for planting. Finally, during 2007 about 500 seedlings derived from GCs/selfs of 8 *E. arundinaceus* clones and 64 were selected and planted in field. To summarize, total 3905 hybrid were developed out that 996 hybrids were planted in the field for evaluation. From the 996 clones, 40 clones having more than 25% are evaluated further like disease resistant and nutrient uptake.

Out the 40 clones, having more than 25%, are evaluated for red rot disease resistance and it was found that IK76/91SF07-14 was highly Resistant and IK76-99#91and IK76-91#41 moderately resistant. Nutrients, such as, Nitrogen, Potassium and Phosphorus are important input to the cultivation any commercial crops. The present study on specific nutrient per tonne of biomass production indicates that *E. arundinaceus* requires around 2.4 kg Nitrogen, 7.03 kg Phosphorus and 0.89 kg Potassium to produce one tonne of biomass (Table - 16).

Pulping studies of clones having more than 30% fibre content were carried and compared with reference clones SES 159 (Table - 18). Pulping studies indicate that clone no IK76-91/SF07-34 gave the highest pulp yield of 53% (With 23.8 Kappa number) followed by Mythanb/8 (53.12%), IK76-99#91 (52.40), IK76-91#41 (51.47) which is more than the SES 159 (51.30). Clone Number IK76-81/GC-7 gave the 50.4% which is slightly less than the reference clone SES 159. All the *E. arundinaceus* clones gave bagasse yield of more than 50% with fiber pith ratio of 2.2:1, which is higher than the conventional sugarcane varieties. (RAJESH AND MOHAN RAO, 1988, CHINNARAJ *et al.,* 2005) where the bagasse yield is around 25-30%. Kappa number was relatively high in all *E. arundinaceus* bagasse pulp against conventional bagasse pulp. One of the possible reason may be the presence of residual sugars present in fresh *E. arundinaceus* bagasse that would have consumed pulping chemicals. Our experience in plant suggests that one of the reason for higher kappa number or chemical consumption is use of fresh bagasse. Other parameters like pulp Brightness, freeness and Black Liquor analysis did not show any significant change and all are almost similar to conventional sugarcane bagasse pulp.

Other parameters like CSF and fibre classification of the selected clones are compared in the Table -19. The reference clone SES 159 has higher +30, +50 and -200 and lower +100 and +200 then the selected clones. However, the useful fibre percentage in the all the selected and reference *E. arundinaceus* is higher than the conventional sugarcane bagasse and switchgrass (GOEL *et al*., 1998). Fibre pith ratio of *Erianthus arundinaceus* clones are in the range of 2.1:1 to 2.8:1 against 1.3: 1 to 1.7:1 of conventional sugarcane varieties. This indicates that *E. arundinaceus* produce high fibre in the unit area with good quality. Higher fibre pith ratio of *E. arundinaceus* open an opportunity to use the whole bagasse as such to produce pulp directly without depithing or mild depithing of 5 to 10% pith removal against the conventional depithing of around 30 to 35 % pith removal practiced for conventional bagasse (CHINNARAJ *et al*., 2005).

The pulp evaluation results in the Table - 20 indicates that tear factor is directly proportional to fibre percentage. For example clone number IK76-99#91 with 33.05% gave a pulp with 68.2 tear factor. In general, strength properties of clone number IK76-99#91 and IK76-91#41 are comparable with reference clone SES 159 and others are less than the reference clone. Comparative analysis of both unrefined pulps of conventional bagasse pulp and *Erianthus arundinaceus* bagasse pulp indicates that strength and optical properties are similar except tear factor, which is higher in all *E. arundinaceus* bagasse pulp against the conventional sugarcane bagasse (RAJESH AND MOHAN RAO, 1998, CHINNARAJ *et al.,* 2005).

Table - 24: Pulping results of selected *E. arundinaceus* clones and reference clone *E. arundinaceus* SES 159.

S.No	Clone	Un screened Pulp yield %	Screened Pulp yield %	Bright. % ISO	Kappa No	WBL pH	Total Solids GPL	TTA @ 200 GPL	RAA @ 200 GPL
1	IK76-99#91	52.40	51.38	33.50	21.8	11.5	200	26.2	4.8
2	IK76-91#41	51.47	50.93	33.6	22.6	11.8	173	30.8	5.2
3	Mythan B/8	53.12	52.95	35.1	16.6	11.7	170	25.0	6.8
4	IK76-81/GC-7	50.40	49.62	33.10	19.0	11.4	204	27.1	3.4
5	IK76-91/SF07-34	53.44	52.86	32.00	23.8	11.7	181	27.1	4.2
6	SES 159	51.30	49.6	35.0	18.3	11.9	183	29.5	4.3

Table - 25: Fibre classification and CSF results of selected *E. arundinaceus* clones and reference clone *E. arundinaceus* SES 159.

S.No	Clone	CSF ml	fibre classification %				
			+30	+50	+100	+200	-200
1	IK76-99#91	520	11.6	25.8	31.2	22.7	8.70
2	IK76-91#41	510	7.60	21.9	31.7	27.5	11.3
3	Mythan B/8	490	6.20	19.3	30.9	28.3	15.3
4	IK76-81/GC-7	470	7.30	22.0	34.4	27.8	8.50
5	IK76-91/SF07-34	540	8.90	21.3	34.8	27.5	7.50
6	SES 159	500	12.8	27.2	29.6	16.2	14.2

Table - 25: Unbleached pulp strength and optical properties of selected *E. arundinaceus* clones and reference clone *E. arundinaceus* SES 159.

S.No	Clone	Bulk cc/g	Brea-king length m	Tear Factor	Burst Factor	Bright. % ISO	Opa-city %	Sc. coffi. m^2/kg	Yello-wness %
1	IK76-99#91	1.64	7140	68.2	43.7	30.2	97.5	28	36.9
2	IK76-91#41	1.54	6890	65.1	42.9	30.9	96.2	25.7	34.3
3	Mythan B/8	1.47	6150	56.1	40.6	31.6	97.5	26.1	32.9
4	IK76-81/ GC-7	1.68	4430	54.9	34.8	30.5	97.2	29	35.5
5	IK76-91/SF07-34	1.48	5900	53.3	34.7	29.2	97.0	26.7	35.2
6	SES 159	1.59	6701	65.5	43.9	33.6	97.5	27.2	32.7

As indicated earlier, during our field trials, we found that the survival percentage was very poor for *E. arundinaceus* clones due to poor rooting. This is because, in general the commercial cane varieties are having 3 to 4 rows of the root primordium, whereas the *E. arundinaceus* has only one row of root primordium leading to poor rooting percentage. Also for large scale or pilot scale cultivation study, we require quite large amount of seed cane or seedlings. Pilot scale protocol for micro-propagation was developed at Sugarcane Breeding Institute (SBI). The SBI method (Box 3) was modified to produce large number of seedlings in a short time to take-up large scale cultivation trail of around 50 acres. About 2, 80,000 seedlings were produced using the modified method. In the modified medium, we have used higher carbon source (Sucrose 3%) during initiation and for rooting NAA was replaced with IBA which gave almost 100% rooting. During the hardening process all the poly bags were replaced with portrays for easy handling and improve the productivity and reduce the labour cost. The multiplication ratio was 1:10 with 0.25mg BAP which is very high and helped to reduce the multiplication cycle time and also the cost of the production.

Erianthus arundinaceus is proved to be one of the highest biomass producing perennial grass when compared to other grasses, such as, *Miscanthus giganteus*, Elephantgras, Sweet Sorghum and *Panicum virgatum* (MISLEVY *et al.,* 1989, PRICE, *et al.*, 2004, SAMSON *et al.,* 2005). Therefore, *E. arundinaceus* clone SES 159 was selected after the detailed evaluation for large sale cultivation trail in marginal soil and also regular good soil simultaneously, along with screening and identification new clones using conventional breeding process, to assess biomass productivity and optimize the cultivation practices. The standard cultivation practice used for this experiments presented in the BOX 4. The cultivation experimental results in poor soil indicates that the *E. arundinaceus* is able perform relatively well in the poor soil where other species, such as, *Eucalyptus* fail to grow. The green biomass yield was around 27.5 MT per acre. On the other hand, the biomass productivity was good in farm forestry field where the soil conditions are good and green yield was found to be 70 MT and 95.5 MT per acre per year. The green biomass had moisture content of around 70% which works out to be 51.8 MT and 67.1 MT per hectare on oven dry basis which is high when compared to earlier study on the *Erianthus*. For example, the recent review on the C_4 annual grasses reported biomass productivity of *Erianthus* ranges from 48.8 to 56.2 tones per hectare on oven dry basis (SAMSON *et al.*, 2005). The variations may be due to the environmental conditions prevailing in the different experimental sites. Also the variation found in the different type *Erianthus* clones as well as species. However, when compared to other perennial grasses, *Erianthus* was proved as highly productive grass because its tolerance to environmental stress, drought, pest and diseases (SUGIMOTO 2000). *Erianthus* is also known for its thick canopy, large numbers of tillers production, extensive dense deep root system. These properties help in improving the biomass productivity by increased light absorption, reduced field drying leading to less irrigation requirements, drought resistance and improved and efficient nutrient uptake from soil (SUGIMOTO, 2000).

The pulp produced from both whole bagasse and depithed bagasse are found to be superior in terms of strength properties to the conventional sugarcane bagasse pulp. Bagasse yield was also found to be high in the *E. arundinaceus* due to higher fibre percentage in the *E. arundinaceus*. In general one ton of sugarcane crushed yield around 250 to 300 kg bagasse whereas *E. arundinaceus* the bagasse yield will be around 500 to 560 kg per ton of *E. arundinaceus* crushed (including leaf). Therefore, for 27.5 tons of *E. arundinaceus* biomass produced in one acre in the poor soil can produce around 7.48 MT of OD bagasse and would generate around 3.84 pulp which is higher than the well grown hardwoods like *Eucalyptus* which can give 60 MT per acre in five years rotation period and produce only 2.48 MT of pulp (Table 26). As indicated earlier, *E. arundinaceus* is one of the highly productive C4 grass and it was confirmed by our cultivation experiments in the regular cultivation soil (MISLEVY *et al.,* 1989). It produced green biomass yield of around 70 MT in one field and 90.5 MT in another field. The average yield works out to be 80.25 MT per year per acre, equal to 59.5 MT on OD basis per hector per year, which can give about 21.8 Mt of OD bagasse and 11.2 MT of pulp per acre per year. This is very high when compared to highly productive hardwood pulp species like *Eucalyptus spp.* where maximum pulp yield per acre in an year would be around 2.48 tones if we get 60 tones wood per acre in five year rotation period. This means that unit area pulp productivity of *E. arundinaceus* is 4.5 times more than the conventional hardwood like Eucalyptus spp. (Table - 26).

Table - 26: Computation of unit area pulp productivity of *E. arundinaceus and Eucalyptus.* .

S. No	Parameters	Units	Poor soil	Good Soil		
				Field 1	Field 2	Avg.
SES 159						
1	Total Green yield	T/acre	27.5	70	90.5	80.25
2	Green yield per year	T/acre	27.5	70	90.5	80.25
3	OD bagasse yield @ 27.2 % fibre	T/acre	7.48	19.04	24.616	21.83
4	Pulp yield @ 51.3%	T/acre	3.84	9.77	12.63	11.20
Eucalyptus						
1	Total Green yield for 5 year rotation	T/acre	60			
2	Green yield per year	T/acre	12			
3	OD wood yield @ 45%	T/acre	5.4			
4	Pulp yield	T/acre	2.48			

In general, high fibre yield would reduce the sugar production in the *E. arundinaceus* resulting in low sugar content in the *E. arundinaceus* juice i.e. Pol % and Brix %. This makes it uneconomical to go for sugar extraction from *E. arundinaceus* juice and reduce economical viability of *E. arundinaceus* cultivation. However, recent developments in the area of renewable energy, due to its environmental advantage against the fossil fuel, makes *E. arundinaceus* as potential bio-energy crop to produce renewable energy, such as, biogas from the juice and even alternate for fuel for co-generation during sugar mill offseason to produce renewable power.

The quantity of reducing sugars and pure sucrose was found to be poor in all clones studied when compared to conventional sugarcane. This is mainly due to higher fiber content in

Erianthus sp. as reported elsewhere (MATSUO *et al.,* 2003). Because, most of the carbon fixed by the plants through photosynthesis are converted into fibre and considered negative character for forage crop due its poor digestibility associated with high fibre content. On the other hand, it will be good for power generation. *E. arundinaceus* juice analysis indicates that it contain reasonable amount of dissolved organic content and it is estimated that the Chemical Oxygen Demand (COD) was around 1,00,000 mg/lit and it is a new raw material resource for producing renewable energy like biogas that can be utilized as in-house energy to save fossil fuel. For 80.25 tones of *E. arundinaceus* annual yield in an acre would approximately generate around 3360 kg COD of juice and for 85% COD reduction with 0.5 m^3 biogas factor, the gas generation potential for the juice generated from one acre of *E. arundinaceus* plantation would be around 1880 m^3 which roughly equivalent 1129 Lit. of furnace oil (CHINNARAJ *et al.,* 2003, CHINNARAJ AND VENKOBA RAO, 2006). Furnace oil is one of the major fossil fuel used in many industrial processes which is non renewable and CO_2 emission from the fossil fuel burning has negative effect on the global climate change and contributes to net raise in CO_2 level in the atmosphere and classified as non renewable carbon in global carbon cycle. Today fossil fuel consumption in the world stands around 6 Gtc/year (Giga tone of carbon) and contributes as largest source CO_2 emission from manmade activities, leading to net increase of 2.1 Gtc/year in atmosphere after neutralizing carbon sequestration potential (3.9 Gtc/ year) of natural resource, such as, forest and ocean ecosystems (REICHER, 1999).

In the post Kyoto Protocol era reduction of Greenhouse gas emission gets major priority in many countries and in many industrial process due to the predicted adverse effects of climate change like global warming and sea level rise because of increasing greenhouse gas level in atmosphere. As a greenhouse gas, CO_2 contributes to global warming and sea level rise (Climate Change Information Kit, 2001). It is learned that one barrel of furnace oil (160 litters) use result in 487 kg of CO_2 emission to atmosphere (Energyprobe.org.). Saving 1129 liters of furnace oil from one acre *E. arundinaceus* plantation would reduce 3.39 tones of CO_2 emission to atmosphere.

5. CONCLUSION

1. Utilization of fibrus raw material for other purpose, such as, fuel in bioenergy generation system, due to increase in oil price and pressure to reduce the greenhouse gas emission under Kyoto protocol coupled with national legislation, such as, renewable energy certificates and renewable energy purchase obligation and increasing demand for paper and paper product especially in developing economy like India, leads to increase in fibrous raw material cost and demand. The concept of growing perennial C_4 grass such as *E. arundinaceus* as captive fibre source is alternate to meet the fibre demand and to produce bioenergy.

2. *E. arundinaceus* has been identified as excellent biomass producing species in tropical belt and known for its high fibre content. Traditionally *E. arundinaceus* has been used in breeding to genetically improved sugarcane especially for productivity and environmental stress improvement. In this present study the unique grass has been identified as alternate source of fibre to conventional sugarcane bagasse for paper industry..

3. A total of 2280 seedlings obtained from 2004 GCs of eight clones and 228 were planted for screening. During 2005 flowering season, true seeds from three selfs and five GCs were collected and nursery sown and 230 seedlings developed. Fluff collected from 5 selfs and 5 general crosses of 2006 flowering *Erianthus* clones were sown in nursery and 895 seedlings were developed out only 474 was chosen for planting. Final during 2007 about 500 seedlings derived from GCs/selfs of 8 *E. arundinaceus* clones and 64 were selected and planted in field. To summarize, total 3905 hybrid were developed out that 996 hybrids were planted in the field for evaluation. From the 996 clones, 40 clones having more than 25% were evaluated further for disease resistant and nutrient uptake.

4. Pulping studies of clones having more than 30% fibre content were carried and compared with reference clones SES 159. Pulping studies indicate that clone no IK76-91/SF07-34 gave the highest yield of 53% (With 23.8 Kappa number) followed by Mythanb/8 (53.12%), IK76-99#91 (52.40), IK76-91#41 (51.47) which is more than

the SES 159 (51.30). Clone Number IK76-81/GC-7 gave the 50.4% which is slightly less than the reference clone SES 159. All the *E. arundinaceus* clones gave bagasse yield of more than 50% with fiber pith ratio of 2.2:1, which is higher than the conventional sugarcane varieties.

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5. Out 40 clones selected, through breeding and selection, five clones having very high % of fibre, i.e. more than 30% was selected further study, such as, microporopagation and cultivation trial to assess viability.

6. Clone number IK76-99#91 with 33.05% gave a pulp with 68.2 tear factor. In general, strength properties of clone number IK76-99#91 and IK76-91#41 are comparable to reference clone SES 159 and others are less than the reference clone.

7. *E. arundinaceus* clone SES 159 produced 27.5 tones of green biomass in one acre in the poor soil which can give around 7.48 MT of OD bagasse and would generate around 3.84 pulp which is higher than the well grown hardwoods like *Eucalyptus* which can give 60 MT per acre in five years rotation period and produce only 2.48 MT of pulp. In the good soil. *E. arundinaceus* produced green biomass yield of around 70 MT in one field and 90.5 MT in another field. The average yield works out to be 80.25 MT per year per acre which can give about 21.8 Mt of OD bagasse and 11.2 MT of pulp per acre per year. This is very high when compared to highly productive hardwood pulp species like *Eucalyptus* where maximum unit area pulp yield per acre in a year would is only 2.48 tonnes.

8. For 80.25 tones of annual green yield per acre per year, *E. arundinaceus* would approximately generate around 3360 kg COD from the juice and generate around 1880 m^3 biogas which approximately equivalent 1129 Lit. of furnace oil. This would avoid 3.39 tones of fossil fule CO_2 emission to atmosphere.

9. Our field experience indicates that harvesting and transportation is the major bottleneck converting this unique grass into captive fibre source for paper industry. Because of high fibre content and robust growth create many practical problems in the field. This needs further study especially development of suitable technology for

harvesting and production of hybrids with high biomass productivity and optimized cultivation practice.

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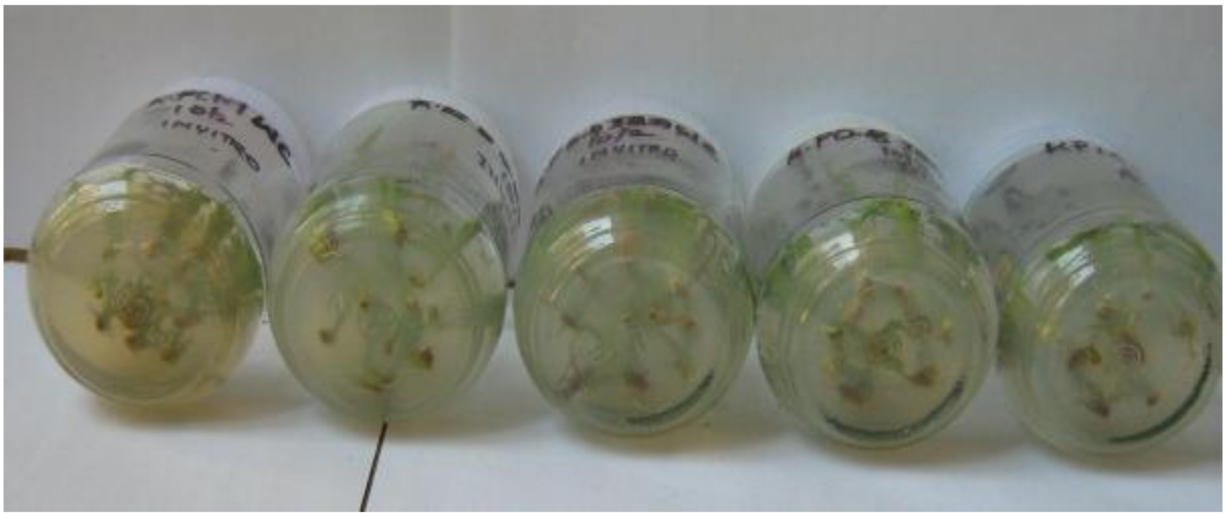
PLATE -1 : *E. arundinaceous Micropropagation – Initiation*

PLATE - 2 : *E. arundinaceous Micropropagation – Multiplication*

PLATE - 3 : *E. arundinaceous Micropropagation – Rooting*

PLATE - 4 : *E. arundinaceous Micropropagation – Rooting*



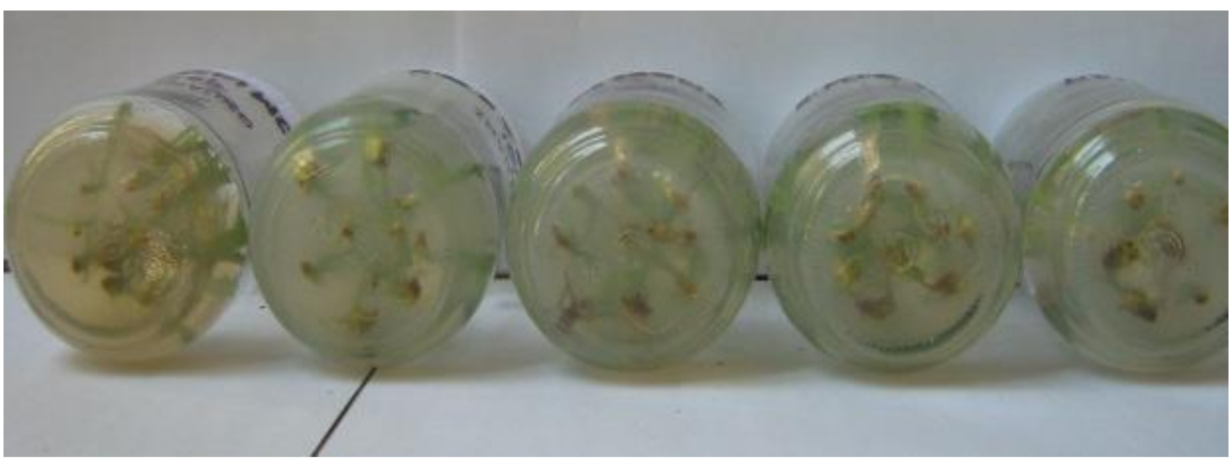


PLATE - 5 : *E. arundinaceous Micropropagation Process*

PLATE - 6 : Plant Growth Room

PLATE - 7 : ***E. arundinaceous Micropropagation – Rooted Micro-cutting Seedlings***

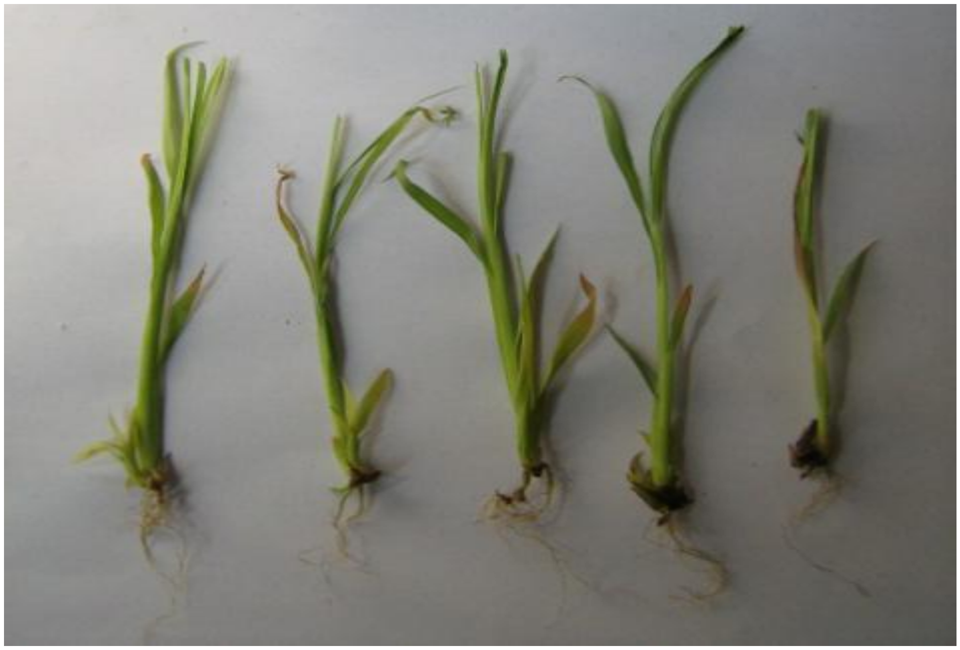
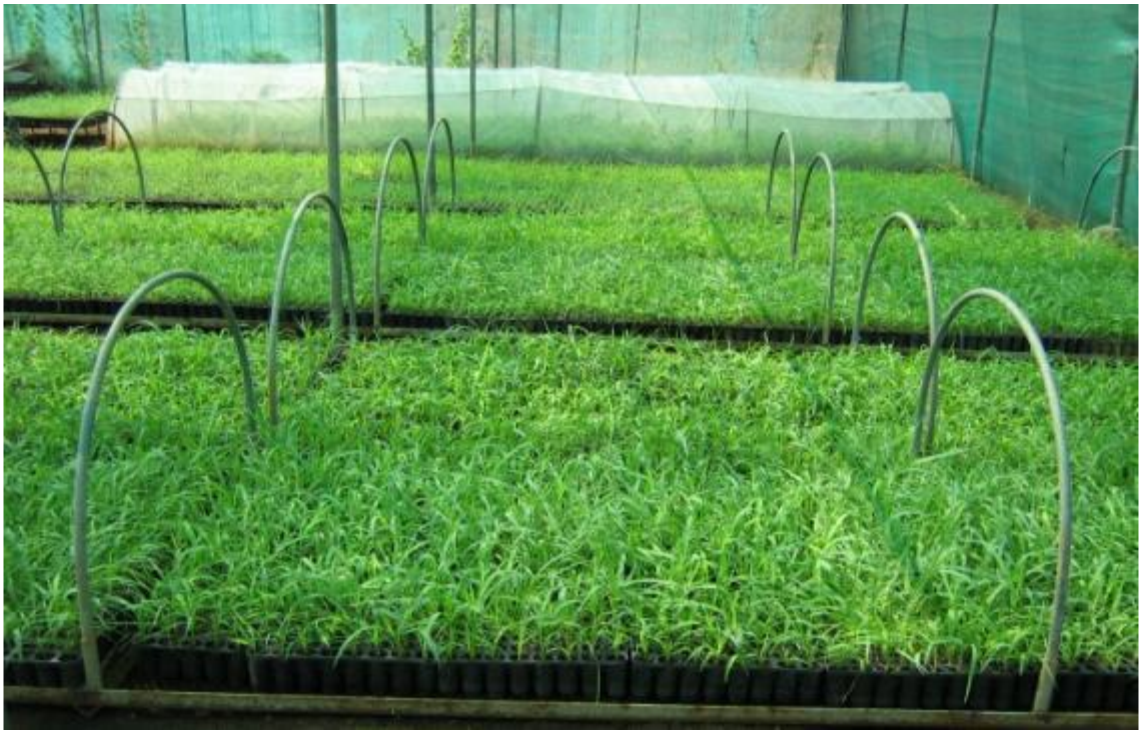


PLATE - 8 : *E. arundinaceous Micro propagation – Seedlings*

PLATE - 9 : *E. arundinaceous Micro propagation – Seedlings in Shade House*



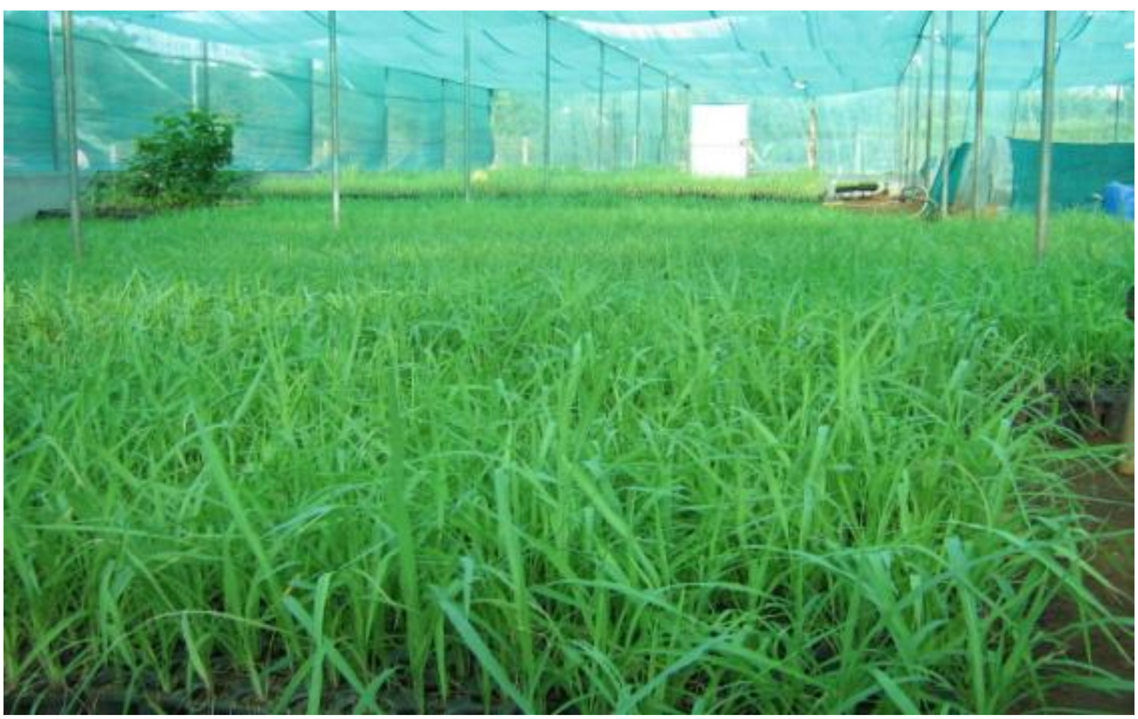


PLATE - 10 : *E. arundinaceous Micro propagation – Seedlings in Open Nursery*

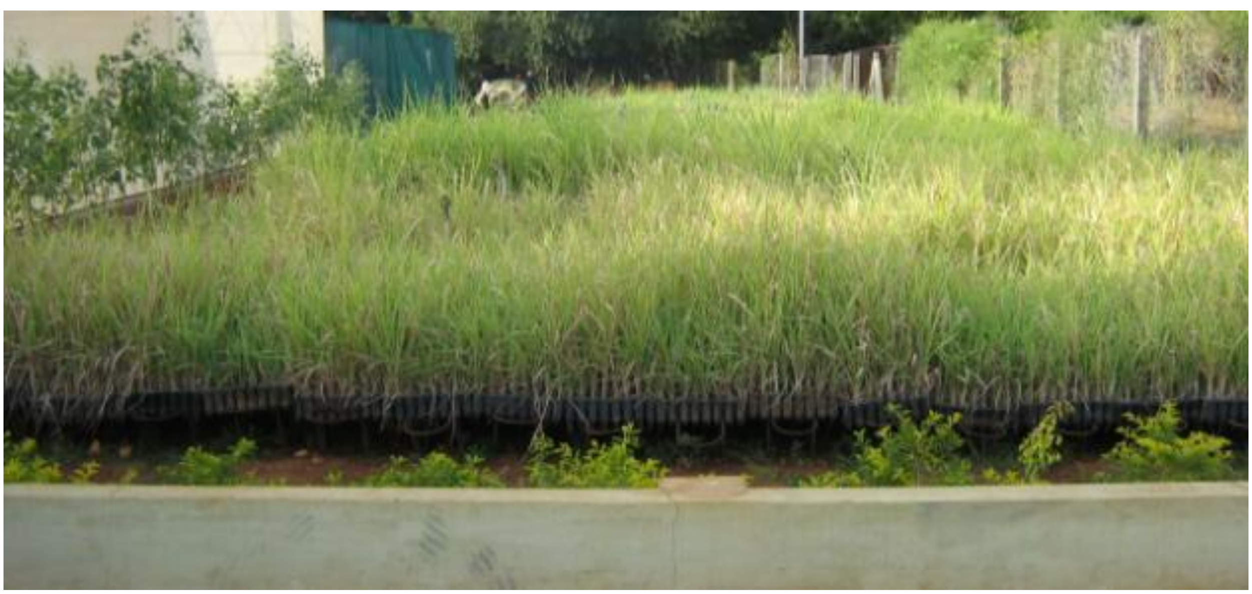


PLATE - 11 : *E. arundinaceous Cultivation – Planting*

PLATE - 12 : *E. arundinaceous Cultivation – Planting*

PLATE - 13 : *E. arundinaceous Cultivation – 2 Month Plantation*

PLATE - 14 : *E. arundinaceous Cultivation – 10 Month Plantation*

PLATE - 15 : *E. arundinaceous Cultivation – 12 Month Plantation*