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Research and development of sabai grass (*Eulaliopsis binata*) in India

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Abstract
Sabai grass farming, trading and industry provide sustenance to the tribal people of various states of our country. The productivity of sabai grass can be doubled by following the improved package of practices developed for different agroclimatic zones. Identification of fertilizer dose, herbicide and crop geometry had increased the yield and net return of the production system. Successful models of sabai grass based intercropping systems and sabai grass in different agroforestry systems improved ravines, boulder riverbed and eroded lands of Similipal foot hills of Eastern India and Shiwalik foot hills of Northern India. In this paper attempts have been made to summarize and present the achievements made so far in the sabai grass research and also to highlight the constraints faced by this sector and its possible mitigation options.

Keywords: *Eulaliopsis binata*, Forage and fibre crops, Production and cropping system

Introduction

Sabai grass (*Eulaliopsis binata* (Retz.) C.E.Hubb) is a fibre and forage producing tufted perennial grass of poaceae family (Huang *et al*., 2004). It is Bhabar or Babui in Hindi, Jun in Bengali, Bobei or Panasi in Odiya and Balvaja in Sanskrit. This plant has got many commercial uses like preparation of paper pulp, rope and thatching the rural houses. The rope in turn is used for making cots, sofa sets, mats, wall hangings and many house hold and decorative articles (Barik, 1998; Mohapatra *et al*., 2001; Basu *et al*., 2006). Sabai grass is considered to be 'the money plant of tribals' which ensures cash receipt throughout the year. The crop is highly adopted by tribals because (a) it thrives better in hill slopes, degraded marginal and sub-marginal uplands, (b) it is hardy and not grazed by animals except in early stages of growth, (c) it is less infested by diseases and pests, (d) it is resistant to drought, (e) it gives good return with very small investment, (f) it provides year round engagement for cultivation of grass and preparation of ropes. On an average it generates 69 mandays per hectare per year for cultivation and 294 mandays per hectare per year for making rope and other decorative articles. At tender or early stages of growth, the leaves are used for fodder purposes and grazed by livestock.

Sabai grass has been a significant source of fibre for papermaking in India (Dutta *et al*., 2005). Better quality paper pulp has been produced from sabai grass due to thinner (0.4-4.4 mm) and lengthy fibre (0.01-0.016 mm) than bamboo. Fibres are relatively thick walled with narrow lumen and the ends are pointed and never forked (Ilvessalo-pfaffli, 1995). It has more pectose (33.2%) and less lignin (4.4%) than bamboo. But less quantities of pulp is produced from sabai grass. The sabai rope is used for binding bamboo, while feeding in the machine.

Distribution

It is mainly found in the Asian countries like India, China, Pakistan, Nepal, Bhutan, Myanmar, Thailand, Malaysia and Philippines (Sial, 1994; Yong, 1994). The grass is characteristic of bhabar tract – a region named after this grass occurring in the belt on the foot hill region of outer spurs of the Himalayas. Besides Uttarakhand, it grows in plenty in Jungle Mahal of Eastern India, comprising of different districts like Mayurbhanj (Odisha), Midnapur, Purulia (West Bengal), Santhal Praganas (Jharkhand). It also grows to a small extent in Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Maharashtra and Tamil Nadu (Gupta, 1994). The sabai grass area under Mayurbhanj district of Odisha is about 22,758 ha and the production was around 47,500 tons of dry sabai grass during the year 2008-09. Out of 26 blocks in the district, it is cultivated in 19 blocks. About 66% of area and 70% of production come from Baripada, Muruda and Suliapada (Hathy *et al*., 2010). Besides Mayurbhanj it is also found in the forest areas of Dhenkanal, Keonjhar, Nayagarh, Ganjam and Kalahandi districts of Odisha.

Production constraints of sabai grass

Ecological constraints

Erratic precipitation: Sabai grass is a rainfed crop. The rains are often erratic, uncertain and unevenly distributed. In some years, the crop is even affected by water logging due to heavy rainfall and in other years it experiences yield loss due to moisture stress.

Cultivation in marginal and degraded lands: Sabai grass finds a place in hill slopes, marginal and submarginal lands that are highly eroded and erosion prone and therefore, poor in inherent fertility. This crop is pushed into degraded lands as grain crops preoccupy the fertile lands.

Management constraints

Lack of improved varieties: Varietal improvement in this crop has not yet been done except evaluation of some locally available germplasms. Inadequate knowledge of physiological growth behavior and varied agro-ecological situations in which sabai grass is grown and lack of any effort to identify specific plant type ideal for various agroforestry by the plant breeders.

Improper agronomic management: Agronomic practices play a vital role in boosting up crop yields. Sabai grass is grown without fertilizer application and other agronomic cares. Normally the crop suffers from following agronomic draw backs

- *Poor management conditions*: Sabai grass is grown in neglected conditions as provisions for removal of perennial weeds, nutrient management, tilth etc. are not made properly. The crop is grown on marginal lands under energy starvation situations. Though sabai grass responds to application of fertilizers, farmers hardly apply any fertilizer due to poor socio-economic condition.

- *Unscientific method of planting and harvesting*: The crop is planted at a wider spacing (4×3 ft). The vegetative part of sabai grass is economical to the farmers. Due to wider spacing plant density becomes less and that causes reduction in yield. Similarly delayed or early harvesting before physiological maturity affects the quality, length and strength of leaves. The crop is generally cut close to the ground level. Such cuttings reduce the carbohydrate level of the plant, therefore it affects regeneration of new shoots and clump becomes gappy at central portion.

- *Weed menace*: Though sabai grass smothers the ground, yet it suffers from severe weed competition in early growth stages owing to very slow and poor growth behavior in the initial years of growth.

- *Crop damage due to attack of insect*: Termites are abundantly found in lateritic acid soils. They damage the root systems of the crop which adversely affects tiller production and whole plants gradually.
- *Baldness of clump*: After 4th year of harvest, the central portion of clump becomes bald. The exact reason of such baldness has not yet been known. This might be due to aging of plant, nutrient deficiency, cutting the grass close to the ground level or disease and pest attack.
- *Collection of planting materials from over aged plantation*: The planting materials (slips) are usually collected from the fields of 11 to 12 year old. The tillering ability of such plants and yields potentiality of those fields is comparatively low. Moreover, most of such plants are affected by diseases and pests.

Significant research achievements

Climate: Sabai grass grows well in sub humid hot and dry climate with rainfall ranging from 750 to 1500 mm. It is hardy to both drought, frost and is a light demander. It grows with mean annual temperature range of 24 to 27^{0}C. It can also tolerate a minimum temperature of 2.2 to 6.6^{0}C and maximum temperature up to 45^{0}C. When temperature falls below 2^{0}C, the leaves became yellow (Wang *et al*., 2004). Winter survival was significantly improved by application of potassium fertilizer. Total N, P and K content of leaves increased significantly by application of potassium fertilizer, which could promote growth, thereby improving low temperature resistant ability for *Eulaliopsis binata*. It is commonly grown under rainfed or drought areas, but rains during growing period result in good growth of the crop, however, there should be no rain at the time of harvest, because it causes discolouration of the leaf and reduces its quality. Indeed, the crop is strong light demander, but sensitive to water logging.

Soil: Sabai grass thrives best in well drained acidic red, sandy-loam soils. It adopts itself readily to the sandy (*bhur*) soils of Utter Pradesh and *dange* soils of West Bengal. It prefers a pH of 5.5 to 6.5. The extremely acid soils can be reclaimed by addition of lime @ 2 tons/ha (Mohapatra *et al*., 2006)

Varieties**:** All the *Eulaliopsis binata* resources currently used for cultivation are wild germplasm and there are huge differences among these wild resources in yield potentials under different ecological habitats (Yao *et al.,* 2004; Liu *et al*., 2006). It is urgently required to characterize these wild germplasm resources for breeding new varieties with higher yield potential and

better fibre quality (Zou and Yu, 2011). Cultivators prefer cultivar with large plant height (more than 150 cm) more tillers/clump and less dying of tillers from middle portion of the clump after 4th year of plantation. Traders prefer the sabai grass with yellowish green colour leaf, hardness of rope and better keeping qualities. Some cultivars of sabai grass have been selected from the local germplasm, among them '*Chitrada local'* gave 33% more yield than local cultivar (20 q/ha) (Barik, 1998).

Seed/rooted slip rate and spacing: The most common method of propagation is by rooted slips. About 20 q of rooted slips or 3 kg of seeds with glumes are required for planting 1 ha of area. Quantities of rooted slips depend upon spacing. The above amount of rooted slips are prescribed for 90 × 60 cm spacing, i.e. 18518 clumps/ha. (Mohapatra *et al*., 2006). A spacing of 50 × 50 cm (Singh, 1978) and 75 × 75 cm (Gupta *et al*., 1995) were reported to give maximum yield of sabai grass in dry boulder lands of North-West India. Choudhury (1992) observed that sabai grass planted at a spacing of 45 × 45 cm under cashew plantation gave highest yield under West Bengal condition. A spacing of 50 × 50 cm for planting of sabai grass under canopy of *Eucalyptus tereticornis* gave the best result in Shiwalik foot hills of Northern India (Grewal *et al*., 1992; Samra *et al*., 1993). The spacing should be 100 × 40 cm (25 000 clumps/ha) for raising the crop in horti-pasture system (Basu *et al*., 2006) in West Bengal. Planting grasses along the contours is extremely effective for erosion control on slopes. In sloppy land near road side, the spacing should be 100 × 10 cm for slope less the 30^0, 50 × 10 cm for 30-45^0 and 30 × 10 cm for slope more than 45^0 (Sattur, 1999).

Time of planting: Sabai grass seeds are sown in nursery beds during March-April, to produce rooted slips for planting in July (Sharma, 2009). Sabai grass slips can be planted in 1st week of July in West Bengal (Mahapatra, 2011). The planting time of sabai grass is 2nd week of July in Odisha (Barik, 1998).

Propagation by rooted slips: Sabai grass slips are collected from old plantation. About 25 tones of rooted slips are available from one hectare of old sabai grass field. In this method, rooted slips are dug out from old plantation. The root system of this plant is massive and very strong. It can not be pulled out by hand. Therefore, clumps are removed by spade. The clumps are separated into individual slips and the aerial part of the grass is trimmed to 20 cm for planting between 10-12 shoots per slip (Barik, 1998).

***Propagation by seed*:** After 1st cutting in the month of September, new tillers and shoots emerge out from the stumps left in the field, which give rise to inflorescence that set seeds. Sabai grass being a short day plant comes to flower during October and seeds mature during November in Odisha. Seeds are collected as soon as they become mature; otherwise these are blown away by wind. One hectare of sabai grass yields about 25-30 kg husked seeds and 25 man-days are required for its collection (Trivedi, 2002). After collecting the seeds these are dried under sun and kept in polythene bags or plastic silo to be used for propagation in the month of April.

Method of raising seedlings: A well drained nursery area of 400 square meters is necessary for raising seedlings of one hectare. The nursery should be made weed free and brought to a fine tilth. Beds should be about 1 m wide and of convenient length, not exceeding 10 m. In between the beds channels of 0.5 m width and 10 cm depth need to be maintained to facilitate drainage and irrigation as and when required. Application of farmyard manure or compost at the rate of 5q per 400 square meter nursery area has been observed as highly beneficial. In addition, a supplementary dose of 400 g N, 200 g P_2O_5 and 200 g K_2O per 400 square meters of nursery areas would suffice nutritional needs of sabai grass seedlings in the nursery. To overcome termite attack, it is desirable to apply Chloropyriphos 5% dust @ 25 kg/ha of nursery area.

As the size of seed is very small, it should be mixed with sufficient quantity of sand and FYM and evenly distributed over bed. After sowing, it is covered with a thin layer of soil immediately and thereafter the bed is mulched with straw, sabai grass hay or jute bag. Under favourable condition, germination starts from 7th day after sowing and completed within 15th day. Then the mulches are removed, but by then the overhead shed should be established. The shed may be removed at 30 days of sowing, but the beds are watered every alternate day with necessary weeding and hoeing. Germination of dehusked seeds was recorded as 94-98% when compared to husked seeds, which was 35-42%. The stored seeds showed better germination as compared to freshly collected seeds (Trivedi, 2002). Bavistin 50 WP @ 1 g/litre (0.1%) may be sprayed to protect the seedlings from diseases. For better growth, urea and cow dung solution in water (50 g urea + 3 kg cow dung + 10 l water) should be fermented for 7 days. Then it should be applied to the bed with rose cane once in fortnight. Grass seedlings will be ready for transplanting after 6 weeks, when they are attaining 25 cm height. At the time of

uprooting, the seedlings are lifted with minimum root injury. It will help in quick establishment of seedlings in the main field.

***Manures and fertilizers*:** Being perennial crop sabai grass utilizes lot of nutrients from the soil, thereby reduces the productivity and fertility status of the soil (Tripathy, 1998). So it is necessary to replenish the soil with suitable nutrient management practices, which will increase the productivity. Manures and fertilizers are applied to the soil to provide plant nutrition and improve structure of the soil and water holding capacity. Farmyard manure @ 3 t/ha is applied only in the 1st year, in rest of the years the dry leaves left in the field add organic manure to the soil, but fertilizers can be applied to the fileld every year to supply desired nutrition. The fertilizer dose of sabai grass is 40-20-20 kg N-P_2O_5-K_2O/ha. In the first year all P_2O_5 and K_2O and half of the N is applied in the pit before planting. Rest of the N is applied 1 month after planting. From 2nd year onward 2/3rd of the recommended dose (40-20-20 kg N-P_2O_5 –K_2O/ha) is applied in month of July and rest 1/3rd applied after 1st cut, in the month of October (Mohapatra *et al*., 2007). The result of the fertilizer trial at IIT, Kharagpur revealed that a fertilizer dose of 30-20-20 kg N-P_2O_5-K_2O/ha recorded 2300 kg dry grass yield /ha, where as in control plot the yield was 1500 kg/ha (Basu *et al*., 2006). In acid (pH 5.2) lateritic soil, integrated application of chemical fertilizer (30-20-20 kg N-P_2O_5-K_2O /ha), FYM (50% N dose) and lime (2 t/ha) gave 18.7 % higher yield (2139 kg/ha) in wet season and 54.6% higher yield (1280 kg/ha) under residual effect during dry season than control (Basu *et al*., 2006). In acid soil, lime treatment (2 t/ha) recorded 15.4% (1883 kg/ha) and 24.5%(1037 kg/ha) higher yield as compared to no lime application during wet and dry season, respectively (Basu *et al*., 2006). Fly ash, a by-product of thermal power plants is alkaline in nature (Cha *et al*., 1999), can neutralise acidic soils (Rout ray *et al*., 2003). In acid soil, application of chemical fertilizer (30-20-20 kg N-P_2O_5 –K_2O/ha) along with fly ash (10 t/ha) increased the yield of sabai grass by 11.6% than chemical fertilizer (2816 kg/ha) alone. The pH of fly ash is 8.08. This may neutralised the acid soil whose pH is 5.3 and increased the availability of nutrients (Basu *et al*., 2006). Paper sludge, a by-product of paper industry can also be used as liming material. Liming at 0.5 LR in the form of paper sludge (75% $CaCO_3$) to an acid soil (pH 5.0) increased the biomass yield of sabai grass by 12.5 to 23.9% in 1st and 2nd year, respectively over no lime treated plot (Tripathy *et al*., 2006).

***Weed control*:** The major weed species infesting the sabai fields are as follows-

Grasses: *Cyanodon dactylon* (L.) Pers., *Digitaria sanguinalis* (L.) Scop., *Heteropogon contortus* (L.) Roem and Schult., *Echinochloa colona*(L.) Link., *Eragrostis unioloides* (Retz.) Nees, Ex Steud., *Penisetum purpereum* Schum.
Sedges: *Cyperus rotundus* (L.), *Cyperus iria* (L.), *Cyperus compressus* (L.), *Cyperus kyllingia* (L.).
Broad leaved weeds: *Ocimum sativum* (L.), *Sida rhombifolia* (L.) *Boerhavia diffusa* (L.), *Ageratum conyzoides* (L.), *Urena Lobata* (L.), *Hyptis suavelens* (L.), *Tephrosia purpurea* (L.).

Manual weeding: The weeds can effectively be controlled by hoeing and weeding at 25 days after planting. Repeated ploughing at periodic intervals after 1st year of establishment destroys the germinating seeds of weeds.

Inter cultivation or cultural method: Taking intercrops like cowpea, greengram, blackgram, rice bean etc. in the interspaces of sabai grass can control weeds. This can be taken preferably during initial years of establishment.

Burning the field: Burning followed by intercultivation gave the highest yield (2298 kg/ha) in the 1st year followed by burning and hand weeding at 20 and 40 days after planting (Mohapatra, 2005).

Chemical method: Application of 2,4 D Na salt @0.75 kg ai/ha 20 days after planting was found to be an alternate to manual weeding (Barik, 1998; Mohapatra, 2005).

***Intercropping of sabai grass*:** Wide spacing (90 × 60 cm) and initial slow growth rate of sabai grass provides ample scope for intercropping in association with legumes (Mahapatra *et al*., 2001; Basu *et al*., 2006). Intercrop systems improve yield stability, allowing more consistent yields (Willey, 1979; Horwith, 1985; Fukai and Trenbath, 1993) and efficient use of the resources as well as reductions in costly inputs (Keatings and Carberry, 1993).

Intercrops are the crops taken in the interspaces of a platation, till main crop reaches its bearing stage. Intercrops include short dutation crops like pulses and oil seeds. Studies have shown that blackgram, greengram, groundnut and ricebean can be profitably intercropped in 1:2 row propertion at 30 cm apart in

between two rows of sabai grass grown with 90 cm row spacing (Fig. 1). Intercropping cowpea, greengram or blackgram in the initial years of establishment significantly influenced the growth parameters and increased yield of sabai grass by 70.9, 50.8 and 39.8%, respectively compared with sole grasses. Greengram intercropped with sabai grass gave the highest equivalent yield (36.42 q/ha), net return (Rs.10052/ha) and benefit: cost ratio (2.9), followed by cowpea (35.78 q/ha, Rs. 8925/ha, 2.76) (Barik, 2002). However, the dry grass yield was highest in sole sabai grass in comparison to their intercropping system (Mohapatra *et al*., 2001). Sabai grass produced higher biomass in association with blackgram as compared to sole cropping (Mahapatra, 2011).

Fig 1. Intercropping of sabai grass (sabai grass + green gram)

Harvesting: The grass is harvested when the upper part of leaves turn yellow and become fairly dry (Fig. 2). The clumps are harvested by sickle right from the ground leaving stump of 3 to 5 cm for further regeneration. It is left in the field for two days for sundrying, bundled thereafter and kept for disposal. The colour of dry grass under ideal condition is yellowish green. Harvesting is done twice in a year. Once in the month of October and second in the month of January strarting from 15 months after planting. With proper nutrient management, harvesting can be done from 1st year of planting. The yield of dry grass varies from 30 to 40 q/ha based on locality, rainfall and management.

Fig 2. Harvesting of sabai grass by a tribal women farmer

Sabai grass as forage resource

The leaves of sabai grass are used for forage purpose at tender stages of growth. Bakshi *et al*. (2005) evaluated the sabai grass as livestock feed. The grass samples were collected from forest at 30 days interval for 12 months and tested in the laboratory. The nutritive value of this grass with respect to organic matter, crude protein, neutral detergent fibre and acid detergent lignin were 92.04, 5.71, 78.28 and 8.16%, respectively. The grass is a rich source of Ca (1.12 ppm) and Mg (21.95 ppm), but deficient in P (0.09 ppm) and trace minerals such as Zn (0.25 ppm), Fe (0.058 ppm), Cu (0.072 ppm) and Mn (0.137 ppm). It is, therefore, recommended that animals feeding on *Eulaliopsis binata* must be provided quality mineral mixture to avoid mineral deficiency.

For forage purpose the sabai grass is planted at narrow spacing (30 ×30 cm) in the month of July-August. The fertilizer recommendation is 30 kg N + 20 kg P_2O_5/ha. The yield of the grass varies from 20-75 t/ha according to locality, rainfall and management. Newly established pasture goes well for 7 years and afterwards it should be reestablished (Trivedi, 2002).

Different forage legumes can be intercropped with sabai grass for feeding balanced diets (mixture of cereal and legume) to livestock. Intercropping of sabai grass and stylos (1:2) recorded the highest sabai grass equivalent yield (5.98 t/ha), net return (Rs. 7626/ha) and benefit: cost ratio (2.78) in rainfed condition at Similipal foot hills of Odisha (Mohapatra *et al*., 2001; Fig. 3) and can be fed as mixed fodder to make it more palatable and nutritious to livestock.

Fig 3. Intercropping of sabai grass (sabai grass + stylos)

Sabai grass in hortipasture systems

Basu *et al* (2006) successfully utilized the marginal and submarginal lands by raising different horticultural trees in conjunction with sabai grass. The yields from such horipasture systems varied from 2272 to 3549 kg/ha (Table 1), being found maximum in mango and sabai grass hortipasture system (Fig. 4).

Table 1. Dry grass yield of sabai grass under horticultural trees

Horticultural plants	Yield (kg/ha)
Drumstick (*Moringa olefera*)	2272
Pomegranate(*Punica granatum*)	2905
Sapota (*Pouteria sapota*)	2969
Guava (*Psidium guajava*)	3480
Ber (*Zizyphus jujube*)	3290
Mango (*Mangifera indica*)	3549
Cashewnut (*Anacardium occidentale*)	3528

Source: Basu *et al.* (2006); Choudhury (1992)

Fig 4. Hortipasture system (mango + sabai grass)

Sabai grass in silvipastoral systems

Sabai grass flourish well in ravines and eroded lands. Grewal (1993) reported that eucalyptus and sabai grass based silvipastoral system resulted in minimum soil loss of 0.07 t/ha while maximum soil loss of 5.65 t/ha was observed in cultivation fallow in Shiwaliks. A study was conducted at Shiwalik, which showed that after 5th years of plantation the *Eucalyptus tereticornis* attained a height of 11 meter and sabai grass yield was 4 tons /ha/year. Again the dense cover of sabai grass in the lower canopy and eucalyptus in the upper canopy dully supported by interplot bunds allowed negligible runoff and soil loss in the high rainfall years. This proved that almost all the rainwater was conserved and used by the plants. It was possible to get an average annual net return of about Rs 4000/ha from the sabai grass in addition to the returns from eucalyptus tree. The mean net returns form rainfed agriculture in an adjoining area was only Rs. 700/ha/year. Through this tree and grass based management system, it was possible to achieve the twin objectives of soil conservation and sustainable production (Anonymous, 1994). Agnihotri and Grewal (1993) reported that totlal biomass production of sabai grass as well as eucalyptus plant could be increased by adopting certain silvipastoral systems. In this system, eucalyptus grown in augerholes of size 6 cm × 120 cm filled with 1 kg FYM together with sabai grass proved to be the most economical and gave highest net present value (Rs. 35228 over 8 years) and B:C ratio (2.04). Samra (1995) studied intercropping of *Acacia nilotica* with sabai grass and reported that the growth of *A. nilotica* was affected by sabai grass. An average reduction of 43% was recorded in girth at breast height (GBH) as compared to no grass treatment. The maximum reduction in plant height was recorded by natural grass and sabai grass. The main advantage of genus *Acacia* is that its fast biological N fixation ability to establish on N deficient and drought prone soils and suitable for agroforestry systems and thus can be used in rehabilitation of dry lands (Bargali and Bargali, 2009). Vishwanathan and Joshie (1980) successfullly utilized the bouldery riverbeds in Dehradun by raising *Dalbergia sissoo*, *Acacia catechu* and *Eucalyptus* hybrid trees in conjuction with *Chrysopogon fulvus* and *Eulaliopsis binata* grasses (Table 2).

Sabai grass for soil conservation

It is miraculous plant for conserving soil and rainwater for its extensive surface spreading fibrous root system with high soil binding capacity. It was reported that with 709 mm rainfall, the soil loss was 357.5 kg/ha under sabai grass, 384.8 kg/ha under natural grass and 1415.3 kg/ha without grass cover (Anonymous, 1994). In 11% slopes at Dehradun, sabai grass reduced the runoff and soil loss by 67.1 and 98.4%, respectively (Grewal, 1993). In 2% slope at Similipal foot hills of Odisha, sabai grass reduced the runoff and soil loss by 24.5 and 29.5%, respectively (Mohapatra *et al.*, 2006; Table 3).

Future areas of research and policy issues

- The area under sabai grass is very less (22758 ha only in Odisha). There is an ample scope for increasing the area under this crop by planting sabai grass in ravines and eroded lands (3.67 million ha in India) as vegetative barriers to check soil erosion. The mines areas can be rehabilitated by planting sabai grass under different silvipastoral systems.

Table 2. Yield from silvipastoral system on bouldery river bed

Treatment	Yield
Dalbergia sissoo (9.15 × 9.15 m)+ *Chrysopogon fulvus*	64 t woods/ha + 5.5 t grass/ha/year (avg. of 17 years)
Acacia catachu (4.55 × 4.55 m)+ *Eulaliopsis binata*	71 t woods/ha + 5.3 t grass /ha/year (avg. of 15 years)
Eucalyptus hybrid (2 × 2 m) + *Eulaliopsis binata*	179 t woods/ha + 5.6 t grass/ha/year (avg. of 8 years)

Source: Vishwanathan and Joshie (1980); Samra *et al.* (1993)

Table 3. Runoff and soil loss by *Eulaliopsis binata*

Land slope	Conservation measure	Run off (%)	Soil loss (t/ha)	% reduction		Yield (kg/ha)
				Run off	Soil loss	
At Dehradun						
11%	Cultivated fallow	16.2	18.45	-	-	-
	Eulaliopsis binata	5.2	0.29	67.1	98.43	1129
At Similipal foot hills of Odisha						
2%	Cultivated fallow	27.9	10	-	-	-
	Eulaliopsis binata	21.2	7.05	24.5	29.5	2058

Source: Grewal (1993); Mohapatra *et al*. (2006)

- Site specific nutrient management, cropping system based nutrient recommendation, and role of inorganic/ organic fertilizers on productivity and quality of leaf fibre should be studied to overcome wide negative nutrient balance.
- Studies on use of Leaf Colour Chart (LCC) may also be made as an indicator for N fertilization.
- Since the crop is grown in marginal land and by poor farmers, so research on biofertilizer application may be done to reduce expenditure on fertilizer.
- Cropping systems research should focus on agronomic and economic suitability, pattern of nutrient depletion and pest/disease dynamics, allelopathic influences, multiple options for inclusion of sabai grass in different agroforestry system based on sound scientific data and market perception.
- Studies on weed control in different sabai grass based agroforesty systems and exploitation of allelopathic effects of sabai grass in weed dynamics are needed.
- Use of tools such as Geographic Information System (GIS) to delineate most suitable sabai grass variety found in different forest areas of India.
- Mechanical interventions in field operations and fibre extraction are essential as it will reduce the cost of cultivation and improve fibre quality.
- Studying production potentials of sabai grass in different categories of animals through long term feeding trials and development of varieties exclusively suitable for forage purposes.
- The growing demand of newsprint cannot be met from bamboo alone due to its severe negative impact on environment. Sabai grass is rich in cellulose, have similar strength of bamboo and can be utilized as raw material for paper industries. The large biomass production capacity of sabai grass varieties can be successfully utilized for paper pulp.

Sabai rope industry is facing a stiff competition from its cheaper synthetic counterparts. However, the consumers now-a-days are more concerned about environmental pollution which is a boon for natural fibres. To reap the benefit, the entire production system of natural fibres must be more efficient and cost effective. Besides, significant improvement needs to be made at quality front as it is the prerequisite for product diversification and value addition. The government has to intervene and assure minimum support prices for sabai grass as that of other fibre crops like jute and cotton. Timely and adequate supply of credit to meet the initial plantation costs, assured supply of quality planting material suitable for varied services can further contribute to the expansion of this forage and fibre grass.

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