Evaluation of banana germplasm for the leaf industry and for suitability to different growing environments in India

S. Uma✉, R. Selvarajan, S. Sathiamoorthy, A. Ramesh Kumar and P. Durai
National Research Centre for Banana, Tiruchirapalli-620 017, Tamil Nadu, India. Email: umabinit@yahoo.co.in.

Summary
Evaluation of banana germplasm for the leaf industry and for suitability to different growing environments in India
Bananas and plantains have been exploited as food crops, for fibre and for shelter since time immemorial. With the concept of organic recycling, use of banana leaves as commercial dining plates is in vogue in traditional India. An attempt was made to screen the germplasm and identify suitable cultivars for commercial leaf production. Preliminary screening led to the identification of eight promising clones, of various genomes, groups and sub-groups, with added traits. Observations were made on the number of leaves, usable leaf area, midrib thickness, stomatal density, shelf life of leaves, sucker proliferation and susceptibility to leaf spot diseases along with their yield potentials. The eight accessions selected were found to be best suited for leaf industry in monoculture, marginal conditions, multi-storeyed cropping systems, backyard conditions, saline–sodic soil situations, high altitude and wind prone areas.

Key words: banana, plantains, *Musa*, germplasm screening, leaf spot diseases, leaf production

Résumé
Évaluation du matériel génétique de bananier dans le cadre de l'exploitation industrielle des feuilles et de la détermination de son adaptabilité à différents environnements en Inde
Les bananiers et les plantains sont exploités depuis des temps immémoriaux comme source de nourriture, de fibres et de matériaux de construction. Dans l'optique d'une utilisation de matériaux organiques recyclables, les assiettes jetables en feuilles de bananier sont en vogue dans l'Inde traditionnelle. Le matériel génétique a été analysé afin d'identifier des cultivars utilisables en vue de l'exploitation commerciale de feuilles de bananier. Une analyse préliminaire a permis d'identifier huit clones prometteurs appartenant à différents génomes, groupes et sous-groupes, en incluant d'autres caractères. Des observations ont été faites sur le nombre de feuilles, la surface foliaire utilisable, l'épaisseur de la nervure centrale, la densité des stomates, la conservabilité des feuilles, la prolifération de rejets, la sensibilité des feuilles aux cercosporioses du bananier, ainsi que leurs rendements potentiels. Les huit accessions choisies se sont avérées les mieux adaptées à l'exploitation industrielle des feuilles produites en monoculture, dans des conditions marginales, en culture à étages multiples, en plantation de case, sur sol salin et sodique ou dans des zones montagneuses et ventées.

Resumen
Evaluación de germoplasma de banano para la industria de la hoja y por su idoneidad para su cultivo en diversos ambientes en la India
Bananos y plátanos han sido explotados desde tiempo inmemorial por sus frutos comestibles, por su fibra y para ofrecer cobijo. Con el principio de reciclado orgánico, el uso de hojas de banano como platos para servir comidas está en boga en la India tradicional. Se trató de seleccionar el germoplasma y de identificar cultivares idóneos para la producción comercial de hojas. La selección preliminar permitió identificar ocho clones de varios genomas, grupos y subgrupos, con características añadidas. Se hicieron observaciones sobre número de hojas, superficie utilizable de la hoja, grosor del nervio central, densidad de estomas, tiempo de conservación de las hojas, proliferación de serpollos y vulnerabilidad a enfermedades de la hoja, junto con sus rendimientos potenciales. Se concluyó que las ocho accesiones seleccionadas eran las más idóneas para la industria de la hoja en monocultivo, condiciones marginales, sistemas de cultivo en varios niveles, huertos secundarios, suelos salinos–sódicos, elevadas altitudes y zonas expuestas al viento.

Introduction
Banana is an important fruit crop in India with great socioeconomic relevance. The plant is called *Kalpataru* (plant of all virtues) owing to the versatile uses of all its plant parts. Apart from its commercial dual utilities as a dessert and culinary crop, other banana-based industries have not gained much attention. The banana leaf industry is one of the banana-based businesses in the southern states of Tamil Nadu, Karnataka, Kerala, Karnataka and Andhra Pradesh. The annual turnover of the leaf industry is estimated to be Rupees 128 million (Singh 1996) approximately equivalent to 1/7th of the annual turnover of the banana industry.

Use of banana leaves as biodegradable dining plates has both cultural and ecological significance. Compared with other banana-based industries, such as the fibre industry, this has become a source of livelihood for several marginal farming communities. This industry has proved advantageous due to: (a) sustainable demand for leaf throughout the year; (b) a year-round sustained source of income for the farming families; (c) the ability to balance the price fluctuation faced by the farmer in the fruit industry, to a greater extent; and (d) its applicability to different banana production systems including garden land cultivation, wet land cultivation and high-land gardens.

At present banana cultivation is increasingly threatened by different fungal and viral diseases. But different leaf spot diseases caused by different fungal pathogens are of highest concern in the leaf industry. Of late, in cv. Poovan, the leaf spot caused by *Mycospharella* has become very serious. *Drechslera* leaf spot, which affects only the young leaves, is a major concern during January to April (Selvarajan et al. 2000, 2001). In spite of its importance, research towards the banana-leaf industry has been limited. In the present study efforts have been made to screen and evaluate banana germplasm for leaf harvesting purposes.

Banana leaf Industry
Traditionally banana-leaf harvesting has been a commercial venture of most banana growers. In the southern states of India, serving food on banana leaves is considered very religious and auspicious in traditional households. It has been a practice to have 2–3 clumps of banana plants as a source of leaf for dining purpose along with dessert and cooking bananas in the backyard. But this has grown into an industry over the past decade with standardized practices and organized marketing channels.

The leaf industry is not cultivar specific but varieties of local preference both for bunch and leaf purposes are used, they are mostly Poovan (AAB- Mysore), Monthan (ABB- Monthan), Peyan (ABB- Unique), Sakkai (ABB- Bluggoe) and Karpuravalli (ABB- Pisang Awak).

The plant crop is generally left for bunch production while first and second ratoons are used for leaf production. The newly emerging unfurled leaf is identified, which is ready for opening in 2–4 days. A ring made of thread derived from dried banana leaf sheath is inserted at the leaf tip to prevent it from furling, which otherwise leads to reduction in leaf quality.

Leaves are left for full emergence and harvested carefully with a sharp knife at the base. A well-managed plant produces good size leaves of 2.0–2.5 m in length and 0.6–0.8 m width. Leaves are bundled in batches of 50s arranged alternatively with an outer layer of dried leaf sheath to prevent moisture loss and bruises. The bundles later enter into various marketing channels.

Material and methods
At present NRCB, which is the largest banana gene bank in Asia, maintains about 1030 banana accessions under field conditions. The varieties include both indigenous and exotic collections. The collections include diploids (2x), triploids (3x) and tetraploids (4x) that belong to different genomic groups and offer multiple uses as dessert, culinary and resistant breeding stock for different biotic and abiotic factors, aesthetic value etc.

Preliminary screening was conducted on 85 accessions based on general traits such as yield, sucker productivity and phyllochron. Details of the accessions included in the preliminary screening are provided in Table 1. Screening also included

SINo	Name	Genome	Sub group	SINo	Name	Genome	Sub group
1	Hatidat	AA	Unique	45	Kaali	AAB	Pome
2	Kadali	AA	Unique	46	Ney Vazhai	AAB	Pome
3	Matti	AA	Unique	47	Kallar Ladan	AAB	Pome
4	Namarai	AA	Unique	48	Thiruvananthapuram	AAB	Unique
5	Pisang Lilin	AA	Unique	49	Myndoli	AAB	Plantain
6	Sanna Chenkadal	AA	Unique	50	Pachakadali	AAB	Unique
7	Anai Komban	AA	Unique	51	Aktoman	AB	Unique
8	Vadakkan Kadali	AA	unique	52	Nallabontha	AB	Neypoovan
9	Sikuzani	AA	Unique	53	Elakkibale	AB	Neypoovan
10	Tongat	AA	Unique	54	Njalipoovan	AB	Neypoovan
11	Gros Michel	AAA	Cavendish	55	Nendra Kunnan	AB	Kunnan
12	Honda	AAA	Thella Chakkarakeli (TC)	56	Adukkan	AB	Kunnan
13	Agniswar	AAA	Red	57	Monthan	ABB	Monthan
14	Borjahaji	AAA	Robusta	58	Kachkel	ABB	Monthan
15	Jahaji	AAA	Cavendish	59	Jatikal	ABB	Monthan
16	Amrit Sagar	AAA	Unique	60	Kashkel	ABB	Monthan
17	Manjahaji	AAA	Cavendish	61	Kachkel	ABB	Monthan
18	Kere	AAA	Unique	62	Goukar	ABB	Monthan
19	Pachakappa	AAA	Red Green	63	Pidi Monthan	ABB	Monthan
20	Bharat Moni	AAA	TC	64	Lamby	ABB	Monthan
21	FHIA-17	AAAA	Cavendish	65	Karpuravalli	ABB	PAwak
22	Malbhog	AAB	Silk	66	Karpura Chakkarakeli	ABB	PAwak
23	Dudhsagar	AAB	Silk	67	Agni Malbhog	ABB	PAwak
24	Saapkal	AAB	Silk	68	Saakpal	ABB	PAwak
25	Digjowa	AAB	Silk	69	Kanthali	ABB	PAwak
26	Rasthali	AAB	Silk	70	Ennabenian	ABB	PAwak
27	Suvandal	AAB	Silk	71	Peyan	ABB	Peyan
28	Amrithapani	AAB	Silk	72	Kait Long	ABB	Peyan
29	Mutheli	AAB	Silk	73	Madavazhai	ABB	Peyan
30	Lalvelchi	AAB	Mysore	74	Nukkala Bontha	ABB	Peyan
31	Chandan	AAB	Mysore	75	Cuba	ABB	Bontha
32	Dasaman	AAB	Mysore	76	Singalaji	ABB	Bontha
33	Borchampa	AAB	Mysore	77	Chakkia	ABB	Bluggoe
34	Jatikal	AAB	Mysore	78	Bungan	ABB	Bluggoe
35	Chenichampa	AAB	Mysore	79	Kanchi	ABB	Bluggoe
36	Garomoina	AAB	Mysore	80	Kanchikela	ABB	Bluggoe
37	Palayankodan	AAB	Mysore	81	Cherapadathi	ABB	Bluggoe
38	Karpurachakkarakeli	AAB	Mysore	82	Bagner	ABB	Bluggoe
39	Ladan	AAB	Pome	83	Bhimkol	BB	Unique
40	Sirumalai	AAB	Pome	82	Borkal Baista	BB	Unique
41	Pachanadan	AAB	Pome	83	Manohar	BB	Unique
42	Krishnavazhai	AAB	Pome	84	Manguthamang	BB	Unique
43	Vannan	AAB	Pome	85	Attikol	BB	Unique
44	Chinali	AAB	Pome				

new exotic introductions from the International Transit Centre (ITC), Belgium under INIBAP (International Network for the Improvement of Banana and Plantains), France. This included global hybrids and cultivars such as FHIA-01, FHIA-03, Saba and Bluggoe, which were found to be performing well as dessert and dual-purpose varieties. But while selecting for leaf-harvest purposes, a survey conducted among end users, indicated that FHIA-01 and FHIA-03 were least preferred in the market, owing to their thick and brittle leaves due to their tetraploidy status (4x). In general all commercial cultivars of the leaf industry are triploid (3x). Of these, Bluggoe produced better quality leaves but its performance in the field with one plant crop and two ratoons was not satisfactory. This is due to the fact that most of commercial banana orchards of the leaf industry have recorded a high build-up of innoculum of *Fusarium oxysporum* spp. *Cubense* race 4. Hence out of four promising exotic introductions, only Saba was used, which exhibited field tolerance to *Fusarium* wilt along with local cultivars and NRCB selections (Anon. 1999).

Based on the results of preliminary screening, eight promising accessions were selected and evaluated further for their suitability to the leaf industry under randomised block design with three replications each. The selected accessions for evaluation for the leaf industry are listed in Table 2.

Table 2. Details of accessions tested for the leaf industry

Sl. No	Accession name	Genomic group	Source of collection
1	Elavazhai	BB	Tamilnadu
2	Kunnan	AB	Kerala
3	Poovan	AAB	Tamilnadu
4	Saba	ABB	Philippines
5	Borkal Baista	ABB	N-E India
6	NRCB Selection-1	ABB	Tamilnadu
7	Peyan	ABB	Tamilnadu
8	Kechulepa	ABB	Assam

The trial was carried out at the farm premises of NRCB, Trichy, India. The test site is located 90 m asl with the maximum temperature ranging from 36 to 40°C and minimum temperature ranging from 18 to 24°C. The production was undertaken in the prevailing wet-land conditions with soil pH ranging from 7.8 to 8.2.

Suitability of accessions for the study

The primary criterion for selection of an accession for the leaf industry is that it should produce a greater number of quality leaves in a given span of time and a bunch with marketable quality. Though the leaves are harvested at the unfurled stage (before complete opening), its freeness from leaf spot diseases is a desirable quality. Usually younger leaves are preferred than mature and older that are liable to tear either in transit or in use. The accession should possess stability in yield traits, since the crop is maintained as one plant crop with two ratoons. A profuse suckering habit is another good trait to yield a greater number of plants per clump. The leaves need to be soft and flexible rather than brittle.

Based on these traits the following eight accessions were selected and evaluated. Apart from the above selection criteria, they possessed certain unique traits as discussed below.

Elavazhai *(BB)*

Is a wild diploid variety grown in the Western Ghats. Although it bears a bunch with seeded fruits it is highly suitable for marginal lands, exhibiting a high degree of resistance to leaf spot diseases, and is conventionally used as a shade crop in areca plantations. Being diploid it has erect leaf orientation and accommodates a greater number of plants per unit area.

Kunnan *(AB)*

Is a popular variety of Kerala and Tamil Nadu and is a suitable variety for mixed cropping systems as it tolerates shady conditions. It has a shorter life cycle, is semi tall in stature, with profuse suckering (producing thick and succulent water suckers) and is tolerant to nematodes and leaf spot diseases. It bears a good bunch of 14–16 kg with parthenocarpic edible fruits with a delicious taste.

Poovan *(AAB)*

This is the second largest cultivar of commerce in banana industry. It is a hardy cultivar with good bunches and a unique sweet–acid blend, suitable for ratooning, has selective tolerance to leaf spot diseases and is resistant to *Fusarium* wilt. This survives even under marginal conditions unlike other commercial Cavendish clones.

Saba *(ABB)*

An exotic variety originating from the Philippines, suitable for marginal lands, has dual utility, high yielding, substitute for Chakkia group (ABB), requires less care, exhibits tolerance to leaf spot diseases and field tolerance to *Fusarium* wilt. This cultivar expresses a strong stability for yield over generations and hence needs fewer replanting sequences over time.

NRCB Selection-1 (ABB)

A single plant selection of NRCB, a high yielder with 40-45 kg bunches and good marketability. Expresses good phyllochron over others of the Pisang Awak subgroup, suited for a 1+3 cropping system (1 plant crop+3 ratoons). Expresses good yield stability and tolerance to leaf spot diseases (Anon. 1995).

Borkal Baista *(ABB)*

A collection from the north-eastern states, collected during NRCB exploration programmes (Uma et al. 2001). This is a culinary type, a high yielder even under marginal conditions, suited for backyards, exhibits high tolerance to leaf spot diseases, has a better phyllochron and needs minimum care.

Peyan (ABB)

Suitable for backyards and mixed cropping systems, it is a choice variety, suitable for the fresh leaf market and is highly prized for its medicinal values. It is slightly longer in duration compared with other backyard varieties. It exhibits field tolerance to *Fusarium* wilt and a high degree of tolerance to leaf spot diseases,

Kechulepa (ABB)

Suitable for the fresh leaf market, produces a robust bunch with good quality and dual-purpose fruits with high TSS (30–31°B). It is a choice variety of north-eastern India, has tolerance to leaf spot diseases and field tolerance to *Fusarium* wilt.

Observations recorded

Observations were made on the following parameters.

Total number of leaves

The total number of leaves produced by the banana plant in its entire ontogeny, from the emergence of the first commercially acceptable leaf to the flag leaf emerging before the onset of inflorescence, was counted.

Leaf area

The leaf length (*L*) from the base of the leaf lamina to the apex was measured. The leaf breadth (*B*) was measured at the broadest part of the leaf. The leaf area (m^2) was calculated using the following formula:

$$\text{Leaf area} = L \times B \times 0.8 \qquad \text{(Murray 1960)}$$

Midrib thickness

The midrib thickness at the juncture of midrib and leaf petiole was measured and expressed in centimetres.

Stomatal density

Stomatal studies were made from the upper surface of the lamina about one-third of the length from the apex. The sample leaves were cut into 1 cm^2 portions and boiled for 2 min in water and then transferred to 70% ethanol for 24 h. They were then washed with water and boiled in 70% lactic acid for 5 min to soften the tissues. The treated sample was kept on a clean glass slide with the upper surface of the leaf in contact with the glass. With a sharp blade the tissues were gently scraped and the intervening fibres were removed with a pointed needle. The material was gently washed and maintained in glycerine, sealed with a cover slip and examined under microscope.

The number of stomata present in the upper lamina of the leaf was counted and expressed in numbers per mm^2.

50% shelf-life of leaves

The topmost unfurled leaves (Brun's stage) were identified and a biological ring made of banana pseudostem thread was applied to prevent the leaf from opening. At full maturity, the leaves were harvested and bundled with dried pseudostem sheath, to prevent moisture loss, and were taken for study. Every day, bundles were opened and the quality of leaf for market suitability and utility was assessed. The number of days taken for 50% of leaves to be determined unsuitable for use was noted.

Sucker proliferation

The total number of side suckers produced by the plant during its life was counted without desuckering of the mother clump.

Yield parameters

Yield and yield contributing parameters such as bunch weight (kg), number of hands, number of fingers per hand and total number of fingers were recorded.

Evaluation of accessions for reaction to leaf spot diseases

To assess the Sigatoka disease incidence two parameters, disease severity and youngest leaf spotted (YLS), were recorded.

Disease severity

The Sigatoka disease severity was recorded as per the International *Musa* Testing Programme guidelines, which is based on a severity scoring system described by Stover and Dickson (1970) and later modified by Gauhl et al. (1993):

0=no symptoms
1=fewer than 1 % of lamina with symptoms
2=1–5% of lamina with symptoms
3=6–15% of lamina with symptoms
4=16–33% of lamina with symptoms
5=34–50% of lamina with symptoms
6=51–100% of lamina with symptoms

The infection index was calculated for each plant in each replication as per the following formula:

$$\text{Infection Index} = \frac{\Sigma nb \times 100}{(N-1)T}$$

where N=number of grades used in the scale (7); n=number of leaves in each grade; b=grade; T=total number of leaves scored.

Youngest leaf spotted (YLS) (Vakili 1968)

This method consists of recording the youngest leaf with necrotic spot, counting from the top unfurled leaf.

The recorded observations were subjected to statistical analysis following the procedure given by Snedecor and Cochron (1968).

Results and discussion

The statistical analysis of collected data revealed significant differences for all the traits except for leaf area (Table 3).

Table 3. Evaluation of selected accessions of banana for leaf industry (plant and yield parameters)

Accession	Total no. of leaves	Leaf area (m^2)	Midrib thickness (cm)	Stomatal density (mm^{-2})	50% shelf-life (days)	No. of side suckers produced	Bunch weight (kg)	No. of hands	No.of fingers per hand	Total fingers	Disease severity (%)	Youngest leaf spotted (YLS)
Elavazhai	51.000^{e}	1.200^{e}	2.533	32.883^{b}	13.333^{d}	18.000^{d}	16.667^{d}	10.667^{b}	14.333^{a}	156.000^{b}	00.00^{a}	12.97^{c}
Kunnan	39.000^{a}	0.991^{a}	1.562	35.553^{c}	12.333^{d}	15.333^{c}	8.667^{a}	7.333^{a}	13.667^{a}	96.667^{a}	46.40^{f}	7.83^{a}
Poovan	38.333^{a}	1.159^{d}	2.720	28.440^{b}	8.667^{b}	10.333^{a}	11.000^{b}	13.000^{c}	16.333^{b}	207.000^{c}	31.74^{d}	10.13^{b}
Saba	40.000^{b}	1.420^{f}	2.218	20.440^{a}	7.667^{a}	9.000^{a}	23.667^{g}	11.667^{c}	14.333^{a}	160.000^{b}	35.30^{e}	9.08^{a}
Borkal Baista	41.000^{b}	1.042^{b}	2.623	33.777^{b}	11.667^{c}	11.333^{b}	12.333^{c}	9.333^{b}	12.667^{a}	114.000^{a}	28.84^{c}	14.33^{c}
NRCB Selection-1	41.333^{b}	1.072^{b}	2.350	23.107^{a}	8.000^{a}	12.666^{b}	21.333^{f}	15.666^{d}	18.000^{b}	249.000^{d}	24.07^{b}	17.65^{d}
Peyan	37.333^{a}	1.153^{d}	2.363	25.773^{a}	8.666^{b}	11.000^{b}	8.000^{a}	6.666^{a}	16.666^{b}	107.666^{a}	35.00^{e}	8.11^{a}
Kechulepa	42.000^{c}	1.101^{c}	4.348	25.773^{a}	8.333^{a}	11.666^{b}	19.666^{e}	10.333^{b}	14.333^{a}	142.666^{b}	30.55^{d}	10.85^{b}
SE (M)	1.0294	0.0897	0.0229	3.2537	0.4131	0.8997	1.1633	0.9019	0.8614	13.3965	1.6232	0.4732
CD5%	2.2081	N.S	0.0491*	6.9791*	0.8861	1.9300*	2.4952*	1.9347*	1.8478*	28.7356*	3.1832	1.7271*
CD1%	3.0646	N.S	0.0681	9.6861	1.2298	2.6786	3.4630	2.6851	2.5645	39.8815	4.9103	2.0212

Values with the same superscript letters are on a par with each other.

Total number of leaves

A banana cultivar, which is cultivated exclusively for leaf purposes, should produce a greater number of healthy leaves. The maximum total number of leaves was recorded by the cv. Elavazhai (51 000) and differed significantly from other accessions. The cv. Kechulepa produced a total of 42.000 leaves, which was on par with NRCB Selection-1 (41.333), Borkal Baista (41.000), Saba (40.000) and Kunnan (39.000). The cultivar Peyan registered the least value for this trait (37.333), which was on a a par with Poovan (38.333). For the leaf industry, usually clumps of 6–8 plants are maintained. The leaf output per clump with a phyllochron value of 42.00 in Kechulepa works out to be 294–300 leaves and in Poovan 266–270 leaves. The difference between two extreme cultivars is approximately 21000–22000 leaves per acre. As the leaf procurement rate at the farm gate is approximately Rs 1/-, the income difference is highly variable between varieties. A variety with a high phyllochron can add better income than conventional varieties.

Leaf area

Although there was no significant variation among the different accessions with respect to leaf area, maximum leaf area was registered for the cultivar Saba (1.420 m^2) followed by Elavazhai (1.20 m^2), whereas the minimum leaf area was recorded for the cv. Kunnan (0.991 m^2). A cultivar which produces leaves with the highest leaf area is preferred by the market. The reduction in leaf area generally renders the leaf vulnerable to easy splitting and thus less market preference. The maximum leaf area for Saba and Elaivazhai is attributed to their tolerance to leaf spot diseases. Though there is not much difference with respect to leaf area and income, the leaf quality in terms of size is an important factor in market acceptability.

Midrib thickness

Usually following harvesting, the leaves are bundled and transported to the markets. For easy bundling and handling, leaves with a slender midrib are preferred over those with conspicuous midribs. The presence of a thick midrib adds to another operation of thinning before its use and hence a cultivar with a slender midrib fetches a better price in the leaf industry. The least midrib thickness was recorded by Kunnan (1.562 cm), which was highly significant from other cultivars. Saba registered the second least value for midrib thickness (2.218 cm) while Kechulepa exhibited the thickest midrib (4.348 cm).

Stomatal density

Stomatal density plays a major role in deciding the shelf life of leaves. Higher stomatal density leads to enhanced transpiration, which consecutively paves the way for water loss, ultimately reducing the shelf-life either in transit or during storage.

Stomatal density is inversely proportional to the ploidy level in banana (Sathiamoorthy 1993). The lower the ploidy level the higher the stomatal density. Thus diploids record higher stomatal density over triploids and tetraploids. The cultivars screened and evaluated under this study belonged to diploid and triploid genomes and the results were statistically significant for stomatal density. The cultivars Elaivazhai and Kunnan, belonged to diploid groups whereas Poovan, Saba, NRCB Selection-1, Peyan, Borkal Baista and Kechulepa belonged to triploids. Among the diploids, the cultivar Elaivazhai registered the least stomatal density (32.883) while Kunnan exhibited a density of 35.55 mm^{-2}, the differences were statistically significant. Among the triploids, the cultivar Saba recorded the least stomatal density of 20.44 mm^{-2} followed by NRCB selection-1. The highest was recorded for cv. Borkal Baista (33.77) followed by cv. Poovan (28.44). As a general practice, diploids such as Kunnan and Elaivazhai, are grown in backyards only and are preferred for household consumption. They exhibit high stomatal density and are eventually less suited for long distance transport, while triploids have a longer shelf-life due to their lesser stomatal density and are more suited for long-distance transportation and distant markets.

Shelf-life of leaves

Among the different accessions, Elavazhai registered the highest shelf-life (13.333 days) followed by Kunnan (12.333 days) and Borkal Baista (11.667 days). Poor shelf life of leaves was noticed in the cultivar Saba (7.667 days) which was on a a par with Poovan (8.667 days), Kechulepa (8.333 days) and NRCB Selection-1 (8.000 days). The better shelf life of leaves in Elaivazhai is ascribed to its resistance to leaf spot diseases and this diploid accession produced thinner leaves, which are least likely to tear during handling and transit. Thicker leaves (usually produced by tetraploids) tend to break easily thus losing shelf-life and thus are less suitable for long distant markets.

Sucker proliferation

The total number of side suckers produced by the plant determines the total yield of leaves per clump. An ideal cultivar for the leaf industry should exhibit a profuse suckering habit. The cultivar Elaivazhai produced the highest number of side suckers (18.000), which was on a par with Kunnan (15.333). NRCB Selection-1 produced 12.666 side suckers which was on a par with all other cultivars except Saba (9.000), which was shy in production of side suckers among the cultivars considered for the study. Usually complete desuckering is not advised where bananas are grown for the leaf industry. A clump of 6–8 healthy plants is maintained per clump for a perennial source of leaves. This study was conducted to determine whether the test accessions meet these minimum requirements for the leaf industry. All the accessions exhibited this trait including Saba.

Yield and yield-contributing parameters

In any orchard meant for the leaf industry, the plant crop is used for bunch production and hence apart from the leaf traits, bunch weight and related parameters such as number of hands, number of fingers per hand and total number of fingers were considered for the study. The highest bunch weight was noticed in Saba (23.333 kg) followed by NRCB Selection-1 (21.33 kg). Cultivar Kechulepa recorded a bunch weight of 19.66 kg while the cultivar Borkal Baista recorded 12.33 kg, which was on a par with Poovan (11.000 kg). Cultivar Kunnan recorded 8.67 kg, which was on a par with Peyan (8.000 kg). Although cv. Elavazhai produced a good bunch of 16.667 kg, it lacks market value because of seediness. The practice of cultivating this cultivar for leaf purposes was observed in the Western Ghats of Karnataka and in most of the backyards of southern states of Tamil Nadu and Kerala where the cultivar was grown as a shade crop in areca gardens (Uma et al. 2000). Lack of edibility of Elaivazhai prevents the farmers adopting it for monoculture, despite its excellent leaf parameters. Among backyard diploids Kunnan proved to be the best alternative for Elaivazhai and other existing cultivars such as Poovan and Peyan, as Kunnan is shade tolerant and found suitable for mixed cropping system. Among the triploids, Saba, the exotic introduction and NRCB Selection-1 prove promising for both the fruit and the leaf industry.

Leaf spot disease

There are three types of leaf spot pathogens recorded in India viz. *Mycosphaerella musicola*, *M. fijiensis* and *Septoria musae*. All of which cause equal damage to the crop (Selvarajan et al. 2001). The incidence of spot, calculated based on the infection index recorded at vegetative stage and also the number of leaves free from leaf spot, was recorded as YLS. Among the different accessions, Elaivazhai recorded 0% disease severity and YLS (13.0) followed by NRCB Selection (24.01%) and YLS (18.0). The highest disease severity was registered by Kunnan (46.4%) with YLS 7.0.

Conclusion

Based on preliminary screening of 85 accessions in a field genebank, eight promising varieties were used as test accessions for evaluating their suitability to the leaf industry. Among all the test accessions evaluated, NRCB selection-1 had more positive points (Table 4) due to its high yield, greater leaf area, high phyllochron rate, medium shelf life and freeness from leaf spot diseases. This was followed by cultivars Borkal Basta and Elaivazhai. Of these Elaivazhai is preferable for backyard cultivation due to its seediness and hardiness. It scores better over others due to immunity to diseases, greater number of usable leaves, profuse suckering and maximum shelf-life owing to its diploidy nature (2x). Borkal Baista, a new introduction from North-eastern India holds promise among banana growers for its dual-purpose fruits, medium size bunch, longer shelf-life of leaves and freeness from leaf spot diseases. Saba marginally trails in total score but has promise due to dual utility of fruits (dessert and cooking), higher yields, bigger leaves and tolerance to leaf spot diseases. These can be effectively substituted for the other existing commercial varieties of the leaf industry.

In our earlier studies, varieties suitable to different production systems have been determined—see Table 5 (Anon. 1996, 1997; Uma et al. 2000, 2001; Singh and Uma 2000). This

Table 4. Final score card for the test accessions

Variety/ traits	Total no. of leaves	Leaf area	Midrib thickness	Stomatal density	Shelf-life	No. of side suckers	Yield	Tolerance to leaf spot diseases	Total score	Ranking
NRCB selection-1	++	++	++	++	++	+++	+++	+++	22	I
Elaivazhai	+++	+++	+	+	+++	+++	++	+++	19	II
Borkal Baista	++	++	+++	+	+++	+++	++	+++	19	II
Saba	++	+++	++	+++	+	++	+++	++	18	III
Peyan	+	++	++	++	++	+++	++	+++	17	IV
Kechulepa	++	++	+	++	++	+++	++	+++	17	IV
Poovan	+	++	++	++	+	++	++	++	14	V
Kunnan	+	+	+	+	+++	+++	+	++	13	VI

A single "+" represents one point.

Table 5. Production profiles for banana varieties in this study

Sl. No	Production system (situation)	Accessions suited
1	Marginal conditions	Kechulepa, Elavazhai, Saba
2	Mixed/multi-storied cropping system	Elaivazhai, Kunnan
3	Backyard conditions	Kunnan, Peyan and Elavazhai
4	Monoculture	Poovan, NRCB Selection-1, Saba
5	Saline/alkaline conditions	NRCB Selection-1
6	High altitude with undulating slopes	Elaivazhai
7	Wind prone areas	Saba, NRCB Selection-1

background information was combined with the present study to determine the banana production profiles and the varieties suited for the leaf industry presented here.

References

Gauhl F, Pasberg-Gauhl C, Vuylsteke D, Ortiz R. 1993. Multilocational evaluation of Black Sigatoka resistance in Banana and Plantain. IITA Research Guide 47. IITA, Ibadan, Nigeria.

Murray DB. 1960. The effect of deficiencies of the major nutrients on growth and leaf analysis of banana. Tropical Agriculture TRIN 37:97–106.

NRCB. 1995. Annual Report of NRCB, Tiruchirapalli, India.

NRCB. 1996. Annual Report of NRCB, Tiruchirapalli, India.

NRCB. 1997. Annual Report of NRCB, Tiruchirapalli, India.

NRCB. 1999. Annual Report of NRCB, Tiruchirapalli, India.

Sathiamoorthy S, Balamohan TN. 1993. Improvement of banana. Pp. 313—335 in Chadha KL, Pareek OP, eds. Advances in Horticulture. Vol.1. Fruit Crops Part 1. Malhotra publishing house, New Delhi.

Selvarajan RS, Sathiamoorthy S, Uma S. 2000. Occurrence of new leaf spot diseases in bananas and plantains in India. In Symposium on Emerging trends in Plant Disease Management. Indian Phytopathological Society, Southern zone, 7–8 December 2000, IIHR, Bangalore, India.

Selvarajan R, Uma S, Sathiamoorthy S, Molina AB. 2001. Etiology and Survey of Banana leaf spot diseases in India. Pp. 94—102 in Molina AB, Roa V, eds. Advancing Banana and Plantain R & D in Asia and Pacific, Vol. 10. INIBAP, Montpellier, France.

Singh HP.1996. Growing banana for leaf. Info*Musa* 5:27—28.

Singh HP, Uma S. 2000. Performance assessment of commercial cultivars in production system. In Singh HP, Chadha KL, eds. Banana- Improvement, Production and Utilization. AIPUB, NRCB, Trichy, India.

Stover RH, Dickson JD. 1970. Leaf spot of bananas caused by *Mycosphaerella musicola*—methods of measuring spotting prevalence and severity. Tropical Agriculture TRIN 47:289–302.

Uma S, Shyam B, Selvarajan R, Sathiamoorthy S. 2000. Annual Report of the project on Collection and Characterization of Banana and Plantains of N-E India. INIBAP, Montpellier, France.

Uma S, Shyam B, Selvarajan R, Sathiamoorthy S. 2001. Exploration Programme in North-Eastern India. Pp. 103—110 in Molina AB, Roa V, eds. Advancing Banana and Plantain R & D in Asia and Pacific, Vol. 10. INIBAP, Montpellier, France.

Vakili NG. 1968. Responses of *Musa acuminata* species and edible cultivars to infection by *Mycosphaerella musicola*. Tropical Agriculture TRIN 45:13–32.