TRENDS IN PASTURE AND FORAGE PRODUCTION IN BRUNEI DARUSSALAM

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ABSTRACT

The report summarizes the main features of the climate, topography and soils of Brunei Darussalam, including a description of the present pasture resources, both native and improved, within the State.

The system of intensive pasture-production currently applied in the main Government livestock center is described, together with observations on selected pasture species, establishment, output and general management practices, including a discussion on the improved legume species so far identified for the up-grading of marginal and extensive grazing areas.

Agronomic research work on a range of species, including *Pennisetum purpureum, Panicum maximum, Tripsacum laxum, Digitaria decumbens, Brachiaria mutica, Brachiaria decumbens* and other species selected for local use is summarized with brief notes and plans for further investigations.

Introduction

Negara Brunei Darussalam covers a total area of 5,756 square kilometers and is situated on the north west of the island of Borneo. It lies between latitudes 40' and 55'N and longitudes 114°4' and 115°23'E.

The State with its population of 192,832 (Census 1981) comprises Brunei/Muara, Tutong and Belait districts on the western part and Temburong district on the east, which is isolated from the western section by the Limbang valley of Sarawak.

The climate is equatorial with high rainfall ranging from 2,500mm to 5,000mm a year, humidity in the region of 82% year-round and temperatures averaging 28°C, with a diurnal range of 8-12°C, but little annual variation.

Primary vegetation in the State can be classed as tropical rain-forest, with mangrove and nipah palms (*Nipa fructicus*) in the coastal plain. Dipterocarp forest is dominant in the hilly and alluvial areas, with extensive developments of swamp forest in the Belait and Tutong basins.

The general topography is one of hilly-lowland, mainly below 90m, with pronounced ridges. Along the coast and following the main rivers, there are extensive tidal and swampy areas with alluvial valleys extending inland.

Soils are widely divergent, following the complex distribution of sandstones, shales and mudstone and are typically strongly acidic and of low fertility.

Residual soils are strongly weathered and bleached red and yellow tropical soils, whilst soils on the younger terraces are generally red yellow podzolic. The better agricultural soils are found in the narrow riverine alluvium along the main rivers.

Acid sulfate soils occur extensively in marine alluvium in the coastal plain.

It is estimated that out of a total land area of 520,000 hectares some 130,000 hectares could be suitable for agriculture, provided it is backed by appropriate research (Huntings, 1969); though for reasons of restricted physical access, only a proportion of this area can be

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considered for agriculture at the present time.

The less accessible areas of the State, however have recently been the subject of a intensive and wide-ranging study by U. L. G. Consultants Ltd. in association with the Department of Agriculture and sponsored by Brunei Shell Petroleum (Brunei Agriculture and Forestry Development Study, 1982).

The development of agriculture generally in the State is strongly influenced by opportunities for more remunerative and secure employment elsewhere in the economy and, although this is counter-balanced to some extent by the excellent markets for fruit and vegetables in particular, the percentage of the working population involved in agriculture, forestry and fishing has declined form 33% in 1960 to 5% in 1981 (Population Census, 1960 and 1981).Government is nevertheless committed to a policy of phased development of agriculture, with the long-term aim of self-sufficiency, including also the training and resettlement of new farmers, in which pasture and forage production must play an important role.

Trends in pasture production

1 Native grassland

Native grassland, developing in areas cleared of forest for cultivation, tends to be dominated by Batong-Batong (*Ischaemum* spp.) or in less fertile situations, by Lalang (*Imperata cylindrica*) and will rapidly return to "Belukar" and forest-cover if left ungrazed.

Typically, in the coastal plain and in certain inland areas, such land is grazed by cooperatively-managed or semi-feral buffaloes, and small herds of local Kedah-Kelantan and crossbred cattle, resulting in other grass species becoming established.

According to the Report on the Buffalo Census and Survey in Brunei 1980/81, the area of natural grassland in the State was estimated at 6,547 hectares. Some results are shown in Table 1:

Table 1 Land area under buffalo

	Brunei/Muara	Tutong	District Belait	Temburong	Total
District area (ha)	57,000	116,500	272,700	130,000	576,000
Buffalo area (ha)	4.027	2,153	114	253	6,547
% Land area under buffalo rearing	7.06	1.85	0.04	0.19	1.14
Buffalo population (head)	3,838	1,848	109	382	6,157
Hectare/buffalo	1.10	1.16	1.05	0.66	1.06
Number of owners	458	391	17	11	877
Buffalo area/owner	8.8	5.5	6.7	23.0	7.5

Native pasture under the grazed conditions described in the report consisted mainly of Carpet (*Axonopus compressus*), 'Batong-Batong' (*Ischaemum* spp.), Love grass (*Chrysopogon aciculatus*), 'Puroon' (*Fimbristylis* spp.), Sedge (*Rhycospora corymbosa*), 'Benta' (*Leersia hexandra*), 'Uma' (*Cytococcum oxphyllum*) and 'Kumpai' (*Hymenachne acutigluma*). Other vegetation present in smaller proportion, included *Paspalum comersonii*, ferns and herbs. (Legumes commonly found in such situations, in areas of better drainage/fertility commonly include *Desmodium* spp. and *Mimosa pudica*).

The study showed average native pasture production in the swamp to be 18.7 metric ton per ha per year, with mean crude proteins of nearly 6% and dry-matter contents of the

various species ranging from 33.4 to 46.0%. (T. Lee Kok Cho, 1983).

In such extensively-grazed pasture situations an attempt is now being made to introduce Para grass (*Brachiaria mutica*) and initial observations appear promising. Suitable legumes for the wetter and generally acid conditions are also being sought.

2 Improved pastures

Improved pastures have been introduced on government stations and joint-projects and, to a limited extent, on private units, as shown in Table 2.

Table 2 Areas planted to improved grass species under intensive management

Government stations	120ha
Farmer resettlement schemes	120ha
McFarm cattle breeding project	160ha
Sinaut agricultural training center	10ha
Small holder farmer units	50ha
Total	460ha

To date, response from farmers/part-time farmers to government schemes to encourage improved pasture production has been disappointingly low and it is clear that the extent and direction of future development of improved pastures and forages for beef or dairy production, must be largely determined by economic factors and cost/price relationships.

Management and utilization of local pastures

1 Intensive grass-dominant pastures

Where improved species and pasture management have been introduced in Brunei a system of rotational paddock-grazing has been generally recommended, due to the need for the intensive use of relatively limited areas of land suitable and available for cattle production and in view of the small, average, size of holdings within the State.

The results discussed in this section of the report refer to practical experience gained in the operation of the Government Cattle Units at Luahan and Jerudong, as part of an overall Beef Breeding and Development Program and are presented as observational and not statistically valid results.

1) Pasture grass species

The most successful species identified so far for rotational grazing under local conditions include:

(1) Pangola grass (*Digitaria decumbens*), including the leafy and productive MARDI cultivar
(2) Signal grass (*Brachiaria decumbens*)
(3) Para grass (*Brachiaria mutica*)

The main criteria for their selection being:

(1) Good response to fertilizer in initial agronomic trials
(2) Ease of establishment and persistence under grazing
(3) Resistance to disease and seasonal waterlogging or drought conditions
(4) Aggressive competition with local weed species
(5) Apparent palatability and productivity, in terms of liveweight gains per hectare.

Other grass species, which grow well, but which have not yet been used on any scale

include *Setaria* spp; *Paspalum* spp; principally Bahia; Guinea grass (*Panicum maximum*) and molasses grass (*Melinis minutiflora*).

It is recognized that these grasses are likely to have a place in more extensive legume-based systems, as specialist grasses for erosion control or as pioneer species. More field trials are planned for these and other introductions.

2) Methods of establishment

Experience has shown on the typical "hill or swamp" situations, which exist over much of Brunei Darussalam, that seeding has generally been much less successful than vegetative establishment, due to a number of factors which include reduced germination capacity as a result of high humidity in storage, very variable weather conditions, making the preparation of ideal seedbeds difficult. Small unit areas also tend to make systems such as sod-seeding less than economic even if feasible technically.

Conversely, the hot humid conditions favor vegetative planting and even though labor-intensive the resulting improved "take" and rapid smothering of weeds justifies this system in many cases.

Nevertheless, better seed storage which is now available, increased mechanization, including appropriate hand-planters and the availability of Para grass seed (though currently expensive), will no doubt lead to the increased use of seed-sown grass in the future.

Vegetative establishment is carried out either by hand-planting at 30-60 cm intervals on prepared seedbeds, directly into burned or paraquat-sprayed sward, or in the case of Para grass (*B. mutica*), in wet areas or seasons by simply spreading mature planting material over a ploughed or rotavated area followed by disking or rotavating in on the drier sites.

This latter method has proved to be most successful under a range of soil conditions and, given adequate rainfall and regular fertilization after the roots have formed, can provide a sward suitable for moderate grazing after 8-12 weeks. The ease, relative low cost and success of this technique have resulted in Para grass becoming the most popular single species for general use. Indeed its aggressive habit has enabled it to establish itself as a valuable "weed" in pure stands of almost all other species, where fertilizer is applied.

In general this can be tolerated, or in some cases encouraged, but it can pose problems in forage grasses such as Napier for cutting, by clogging drains and where mixed livestock and vegetable production are carried out. In such situations, Pangola (*D. decumbens,* cv. Mardi) and or Signal (*B. decumbens*) are more containable and these grasses have been preferred on Young Farmers' Projects, where mixed-farming is encouraged.

At Luahan Station, this tendency of Para grass to become a dominant weed of Napier grass, if not strictly controlled, has been introduced as part of a planned, if somewhat flexible, part of the grass establishment/forage crop rotation.

Napier is planted in 120cm rows, at 20cm intervals, inter-row cultivated and cut at 45-50 day intervals, as part of a zero-grazed forage program. After 3-4 years, after Para grass has been planted or has become self-established in the inter-rows, the field is allowed to revert to grazing. This technique appears to have distinct beneficial effects on the subsequent pasture due, it is suggested, to the breaking-up of sub-surface pans and to the deep root system of the Napier grass, coupled with residual effects of the high rates of fertilizer used on this crop. (It should be noted that the Napier is hand-harvested and soil compaction is much less than would be experienced with mechanized systems).

3) Fertilizer application and stocking rates

Levels of fertilizer applied to established swards of *Digitaria* and *Brachiaria* spp. are high, as a result of the need for intensive production, the low nutrient status of the soil and the relatively regular rainfall pattern (2,500mm per annum).

Soils are of the red-yellow podzolic type and are classed as IIIw on the flatter wetter areas and IIIe-Ive on the steeper and more erosion-prone slopes. They are generally acid, pH4.5-4.7 and phosphate-deficient, levels below 3ppm of available phosphate being common.

Table 3 Annual rates of fertilizer applied to pastures, Luahan.

Nutrient	Kg/ha	Lbs/ac
Nitrogen (N)	328	293
Phosphorus (P O)	146	130
Potash (K)	137	122
Magnesium (MgO)	45	40

The fertilizer program followed at Luahan and Jerudong Stations for pasture species, provides nutrient levels, as shown in Table 3.

In addition lime and rock phosphate are applied, according to soil analyses, at rates of up to 2.5 ton and 560 kg per ha, respectively.

Pastures are normally top-dressed after grazing at approximately 33 day intervals, depending on rainfall.

Magnesium is included in the fertilizer program, both as a plant nutrient and as an insurance against hypomagnesemia (Grass Tetany). In addition trace-mineralized salt licks are offered free-choice to all grazing stock.

Recommendations for farmers on supervised units would normally be less than those outlined above and would depend on appraisal of pasture conditions and stocking rate on individual units.

4) Stocking rate, liveweight gains and output

In an average season, stocking-rates on *Brachiaria/Digitaria* pastures are estimated at 3. 0 L J (Livestock units) per ha. However, in very dry or very wet seasons such levels of stock can result in over-grazing. Forage Napier and limited 14% CP concentrate supplementation (up to 1 kg per head) may be offered to maintain the condition of stock during such periods.

Liveweight gains of cattle, under 2 years of age, average 0.4 kg per day and results from steer grazing trials at Sinaut Agricultural Training Centre have shown that overall liveweight gains of approximately 790 kg per ha are obtainable with good management. The steers used for such observations are mainly Droughtmaster of Crossbred stock from the Luahan unit, where to date all pasture areas have been required for the Cattle Breeding Program.

Growth rates of cattle, particularly in the wetter seasons are often lower than visual appraisal of the swards might suggest and it is planned to look further at the chemical composition of grazing grasses, throughout the year, and other possible limiting factors.

5) Fence-grazing

A system of grazing standing Napier grass in the field, from fence "corridors", allowing cattle to graze Napier over the fence before moving to fresh plots for the 45-60 day recovery period, was proposed by Dr. C. N. Williams and examined on a small scale in 1978. Fertilizer N was applied at the rate of 750 kg per ha per year. Potential for stocking rates equivalent to 14.4 head of 270 kg steers per ha was indicated from the initial observations and, whilst the rather wet site was eventually over-run by Para grass, it is likely that further modified trials, on a drier site, will be conducted as a possible alternative to zero-grazing for crossbred dairy cows, which it is planned to introduce on a pilot scale in 1985.

6) Overgrazing and weeds

Overgrazing in either very dry or very wet periods is the principal danger to improved grass pastures, Brunei having, so far, escaped any serious pest or disease problems in pasture.

Fodder Napier, (*P. purpureum*), Guatemala grass (*T. laxum*) Napier grass silage and rice straw have all been used, either fed in the field or to yarded stock, in order to avoid overgrazing situations as far as possible.

Locally, Para grass (*B. mutica*) and the older, creeping type, of Pangola (*D. decumbens*) appear to be hardy in this respect and will tolerate a fair degree of temporary mismanagement, if subsequently rested and fertilized.

Where overgrazing or damage to the sward occurs, the principal weeds gaining access tend to be sedges, Carpet grass (*Axonopus compressus*), Love grass (*Chrysopogon aciculatus*) and *Mimosa pudica* and on hillsides Siam weed (*Eupatoria javanica*). All are difficult to eradicate and prevention in the form of stock-control and adequate fertilizer is recommended.

Mimosa pudica is only eaten to a limited extent by cattle and can cause minor wounds, particularly in bulls, which are open to secondary infestation by screw worm fly (*Chrysomia bezziana*), resulting in considerable economic loss.

Siam weed (*E. javanica*) is principally a problem of older pastures in marginal grazing areas and future plans involve the greater use of climbing legumes, such as *Centrosema pubescens* to control this and other herbaceous regrowth.

Lantana aculeata is also present to a limited degree, often associated with termite mounds, but has not caused problems in practice.

2 Semi-intensive grass-legume pastures

1) Background

Further study is required locally on developing grass-legume mixtures for less intensive pasture situations than described in the previous section, although Signal grass/*Centrosema* spp./*Pueraria* spp. have been grown under coconuts at Sinaut Agricultural Center since 1966 and legumes have been quite extensively used as cover crops.

As stated previously, it is desirable to utilize available flat land as intensively as possible and since such areas may be subject to periodic flooding, the place of legumes is seen initially as being on the hillsides and better drained marginal sites, although there appears to be a case also for the inclusion of legumes as a protein/yield enhancer in Forage Napier (McFarm Evaluation Report, 1984) and there is interest also in reports of legumes such as *Aeschynomene americana* (Miller and Williams, 1981), which could be suitable for poorly drained and acid situations as exist on the flatter swamp margins and newly drained areas in the State.

2) Species

To date the principal introduced legumes identified for general use in pasture programs include:

(1) *Centrosema pubescens*-well adapted and persistent. Not very palatable, but useful for the control of weed growth and regrowth in newly planted areas. Combines well with Signal (*B. decumbens*).

(2) *Stylosanthes* spp.- *S. guianensis,* cv. Cook, has been used relatively extensively and persists well under light to moderate grazing, but it tends to be overgrown by active *Brachiaria* species.

(3) *Pueraria phaseoloides* - strong growing, but tends to be seasonal and is easily killed out by grazing, though it is a useful pioneer and cover crop.

(4) *Calopogonium mucinoides* - grows well, especially in certain pastures and roadside areas, but is unpalatable and can become a weed in semi-intensive swards. An excellent local cover crop.

Other locally indigenous pasture legumes include:

Desmodium spp., which thrive almost everywhere. Desmodium cultivars deserve further screening for this reason.

Legumes are, unlike the grasses, entirely established from seed and when properly inoculated will generally establish well on newly opened forest soil or well-rested belukar.

Seeds are normally surface - seeded or hand-planted and respond to lime and phosphate application. Molybdenum will also be investigated in future legume research programs, as an

aid to establishment of legumes, particularily under acid conditions.

Research activities

Over recent years, pasture and forage production has become an important sector in the development of agriculture is this country. This is in line with the government's wish to increase meat production, especially beef and buffalo to a level of self-sufficiency. Works on some selected introduced and improved varieties of grass have been initiated at Luahan and Jerudong Livestock Agriculture Stations. Current activities are primarily focussed on finding suitably adapted grass cultivars, high-yielding, tolerant to waterlogging and humid conditions, palatable and able to withstand adverse conditions. Trials have also been carried out on fertilizer and cutting frequency management in relation to yield, as shown in the appendix. Production and grazing studies were also conducted on Napier grass (*P. purpureum*) using fence-grazing system (Williams and Woodford, 1978).

Grass species that have been tested and found to grow well were as follows:

1) Napier grass forage (*P. purpureum*)

Although this grass has been utilized as forage rather than pasture, some works have suggested that fence-grazing system can be quite a success on certain management levels. (see details under utilization).

In fertilizer trials, annual production at 1,680 kg fertilizer level yielded 300 ton per ha of fresh forage at 50, 60, and 70 day harvest intervals. Annual dry matter production exceeded 60 ton per ha at all the three cutting frequencies. Varietal trials of Napier consisting of nine Napier cultivars viz: Mardi, University, Uganda, Cameroon, Capricorn, Papua New Guinea, Taiwan Green, Taiwan White and 'Local' were also carried out. It was found that Taiwan Green was the most productive among the other cultivars, giving an average of 200 ton per ha at 1,120 kg N and a cutting frequency of 50 days.

The lowest yielding cultivar was Uganda with about 130 ton per ha.

Nevertheless, the potential of the cultivars has not been fully determined and further investigations are still necessary on agronomic, fertilizer, and managerial aspects. In trying to utilize marginal areas fertilizer trial on a sandy soil was also initiated. Rates up to 1,680 kg N per ha were used, with a harvest interval of 60 days. The highest yield achieved was in the region of 84 ton per ha.

In an experiment using different levels of lime, and fertilizer on an acid sulfate soil, yields of about 120 ton per ha were achieved when 4,000 kg lime and 1,680 kg N were applied.

2) Pangola grass (*D. decumbens*)

Basically, the investigation was on fertilizer levels and different cutting frequencies, where 4 levels of N i. e. 56, 280, 560 and 840 kg per ha per year were used, with three different cutting intervals of 21, 28 and 35 days. These levels were later adjusted to 0, 560, 1,120 and 1,680 kg N per ha and 35, 42 and 49 day harvest intervals.

The investigations have shown that a cutting interval of 35 days at 840 kg N per ha per year gave an average production of 180 ton of fresh herbage or 35 ton DM per hectare. It was also observed that the species appeared to tolerate waterlogging better than other grass species growing under the same conditions.

3) Guinea grass (*P. maximum*)

Like in Pangola grass, the trial examined cutting frequencies and different fertilizer levels. Levels of fertilizer were the same as in Pangola grass in the final fertilizer adjustment with harvest intervals of 30, 40 and 50 days. The result showed that there was no significant difference between the cutting frequencies. However, the effect of different levels of fertilizer was highly significant. Yields of 160 ton of DM per ha were produced when given 1,680 kg N per ha at a harvest interval of 30 days.

4) Guatemala grass

This grass has not been widely used because of its inferiority in yield to forage Napier. Nevertheless, this grass has been considered very useful as an insurance feed and it is usually used in marginal areas where it does not require proper management and fertilization.

According to the trials being conducted on this grass where 3 levels of cutting intervals of 50, 60 and 70 days and 4 levels of fertilizer i.e. 0, 560, 1,120 and 1,680 kg N were used, the highest production of 190 ton per ha or 40 ton DM was achieved when given 1,680 kg N at a harvest interval of 70 days.

5) *Cynodon plectostachyus, Paspalum notatum, Setaria anceps, Brachiaria mutica, Brachiaria decumbens*

The above 5 grass species were subject to observational trials on different fertilizer levels using 0, 560, 1,120 and 1,680 kg N per ha. In the case of *C. plectostachyus,* maximum yields of 130 ton per ha or 30 ton DM were achieved when given 1,680 kg N at harvest intervals of 42 days. Bahia grass, nevertheless appeared to yield better than *C. plectosachyus.* Under the same level of fertilizer and cutting intervals, the grass yielded 190 ton fresh herbage or 40 to DM.

Setaria anceps, B. mutica, and *B. decumbens* yielded 250 ton (30 ton DM), 150 ton (25 ton DM), and 120 ton (20 ton DM) respectively under the same rate of fertilizer and cutting frequency. There is some indication to show that *B. mutica* established very vigorously and appeared to suppress weed growth much more effectively than other species of grass. It was also observed that the grass was able to withstand waterlogging and very wet soils.

Current examinations on Signal, Pangola and Para, are still underway. In the near future some further published data will be made available on the relative performance of these introduced grasses in the local environments.

Constraints

There appear to be few serious technical constraints to grass production in Brunei. Constraints are principally associated with socio-economic factors and the availability of suitable land for commercial pasture or forage-based livestock production.

Future research plans

As a result of increased staffing and changes in organizational structure within the Department of Agriculture, it is expected that increased research will be possible particularly on the livestock and grass utilization side both for cattle (beef and dairy), buffalo and goats.

In the case of buffalo a new breeding and research unit is currently being developed for examination of a wide range of aspects of buffalo production.

The objectives of the research program will continue to be orientated towards "problem-solving" rather than pure research and include:

1) Screening of new cultivars for pasture and forage production, including the examination of leguminous shade crops and browse for cattle and goats.
2) Fertilizer trials on grasses and legumes, including some examination of trace elements as possible limiting factors to production.
3) Grazing and zero-grazing trials to further examine productivity of selected species of proven agronomic worth.
4) Field trials on appropriate systems of grass and legume establishment for small commercial farmers and for the more extensive village "halaman" grazing areas.
5) Further evaluation of fence-grazing for intensive cattle (dairy) production.

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Appendix

List of experiments and observations

1 Napier grass (*Pennisetum purpureum*) variety trial.
2 Foliar application of phosphate fertilizer to Napier grass.
3 Cutting frequency/fertilizer level trial on Pangola grass (*Digitaria decumbens*).
4 Cutting frequency/fertilizer level trial on Guinea grass (*Panicum maximum*).
5 Cutting frequency/fertilizer level trial on Guatemala grass (*Tripsacum laxum* Nash).
6 Observation of *Cynodon plectostachyus* at different fertilizer levels.
7 Observation of Bahia grass (*Paspalum notatum*) at different fertilizer levels.
8 Observation of *Setaria anceps* cv. Kazungula at different fertilizer levels.
9 Observation of Para grass (*Brachiaria decumbens*) at different fertilizer levels.
10 Observation of Signal grass (*Brachiaria decumbens*) at different fertilizer levels.
11 Fertilizer rate trial of Napier grass (*Pennisetum purpureum*) on sandy soil.
12 Lime/fertilizer rates trial on *P. purpureum*.
13 Cutting frequency/cutting height trial on *P. purpureum*.

Discussion

Cocks, P. S. (ICARDA): What is the yield of Napier grass, compared with legumes and what is the response of Napier grass to fertilizer, in particular nitrogen ?

Answer: Field trials have been performed on Napier grass. They indicate that yields of more than 300t/ha (fresh weight basis) can be obtained for a rate of 1,680 kg of fertilizer at

50, 60 and 70 day harvest intervals.

Toutain, B. (GERDAT): In your experiments, have you tested species such as *Setaria anceps* and *Brachiaria humidicola*? In New Caledonia, we have obtained good results with these species and some *Paspalum* species.

Answer: No, we have not studied these species extensively.

Maeno, N. (Japan): What is it the scientific name of MARDI grass?

Answer: Chen, C. P. (Malaysia): It is *Digitaria setivalva* (USDA 299/892). It is a creeping and leafy species whose carrying capacity amounts to 6 local animals/ha/year maximum. It can be used for rotational grazing but cannot withstand heavy grazing. Actually the carrying capacity ranges from 3 to 5 animals/ha/year upon the application of nitrogen fertilizer at the rate of 200kg/ha/year.

This variety was assessed under cutting and grazing conditions by MARDI in Malaysia for some time. It was found to be very promising and was released to the farmers.