Surface sowing a simple and safe technique for pasture establishment in the wet upper montane zone of Ceylon

A. B. P. JAYAWARDANA AND W. D. ANDREW*

Veterinary Research Institute, Peradeniya, Ceylon

(Received August, 1970.)

INTRODUCTION

THE wet upper-montane zone of Ceylon, generally upwards from 4,000′, has a wet tropical to temperate climate and is said to comprise about 50,000 acres. It may be divided into two distinct land classes according to natural vegetation (2) (4) viz :—

(*a*) Montane rain-forest (Jungle) 34,000 ac.

(*b*) Grassland (Patana) 15,000 ac.

The jungle vegetation has been described as follows :—

The characteristic trees of this zone are species of damba (*Syzygium*), kina (*Calophyllum walkeri*), val sapu (*Michelia nilagirica*), and species of *Litsea. The* undergrowth consists of nelu (*Strobilanthes spp*) which flower, fruit and die about every twelve years. Masses of mountain bamboo (*Indocalamus Chimonobambusa*) also occur, and the jungle abounds in epiphytic orchids and mosses (7).

Some authors regard the patana as a subclimax vegetation that has developed from clearing jungle and constant burning over a long period of time, others think of it as a natural phenomenon (5) (6). Three main grassland communities have been recognised in the region and are described (7) thus.

(i) The "mana" community (*Cymbopogon confertiflorus*) dominant.

(ii) The "gavara" community (*Chrysopogon zeylanicus*) dominant.

(iii) The "pini-baru-tana" community (*Themeda tremula*) dominant.

But there are numerous intermediate types of grassland associations that represent various stages of succession.

---

* *FAO Agricultural Officer attached to V. R. I.*

In its natural state, the vegetation of this montane zone retards surface run-off and therefore serves to build up groundwater reserves. Some of the major rivers of the Island have their origin here. Certain areas are being utilised in the following ways, viz :—

(i) Tea cultivation.
(ii) Timber production.
(iii) Vegetable cultivation.
(iv) Livestock and potato farming.

On the steeper slopes cultivation is generally undesirable since it accelerates soil erosion and leaching of plant nutrients. The Land Utilization Committee (4) has recommended as follows :—

" 1. The Horton Plains area (2400 ac.) should not be alienated for any cultivation.
2. There should not be any cultivation permitted on forest land above 6000′ elevation.
3. The wet patana grassland, exclusive of those of the Horton Plains, could be used for potato cultivation and pasture.
4. The production of the Islands' requirements of seed potato material requires an extent of 2000 ac. of land preferably above 6000′. Since potato is to be grown in a " one in four season " rotation with an improved pasture ley, a total demand of 8000 ac. would have to be met ".

Patana soils are rich in humus, varying in thickness from a few inches to a few feet. The Land Utilization Committee is of opinion that it is in these wet patanas, with their heavy, fairly evenly distributed rainfall that most might be expected for pasture development (4) (7). However various attempts, to establish pasture on these soils in the conventional manner, have resulted in costly failures.

Leguminous species sometimes do not even become established or may disappear within a few weeks of sowing. On jungle soil, pasture establishment, after cultivation, may be more reliable than on patana land but is not always as successful as it should be. In both circumstances the costs of seed bed preparation can be very high.

Since it has been shown in other countries that improved pastures can be developed without cultivation, it was decided to investigate the possibilities of doing this in both jungle and patana areas.

MATERIALS AND METHODS

At Ambawela, where the experiments reported in this paper were carried out, the elevation is 6000′ and the climate is temperate. Rainfall, mainly from both north-east and south-west monsoons, during the

past ten years has averaged 98 in. on 205 wet days per annum. In addition there are many misty days on which no rainfall is recorded. Air temperatures range from about 28°F to 82°F (7), the light frosts occurring during January, February and March. Soils are generally very acidic. Typical analyses (3) are as follows :—

	p. H	*Organic Matter* (%)	*Nitrogen* (%)	*Ex.bases* (*m.e/100g*)	*Ex. K* (*m.e/100g*)	*Av. P** (*lb/ac*)
Virgin jungle	4.68	13.9	0.60	7.91	0.46	16.0
Virgin patana	4.83	15.4	0.46	1.28	0.16	10.0

*Truog

Field experiments (unpublished data) indicate that jungle soils are deficient in nitrogen, phosphorus, sulphur, boron and molybdenum, and patana soils in potassium and magnesium, as well.

The experiment consisted of sowing twelve legumes and one grass in uncultivated strips and observing their establishment and performance in jungle and patana lands.

(*a*) *Jungle*—An area of 0.2 ac. was selected for the surface sowing experiment. It had been " underbrushed " and burnt during early 1968 leaving only the high shade trees and stumps and had subsequently been planted with *Pennisetum clandestinum* (kikuyu grass) in June of that year. Underbrushing involves, the lopping of the understory, piling it in heaps and burning during dry weather. Some of the weaker tall trees subsequently had fallen over, and in places where there were clumps of trees a little thinning out was done. Some places had a fair amount of weeds and these were removed by hand weeding, but otherwise the land was undisturbed. Legume seeds, to be sown, were inoculated with peat inoculum and pelletted with lime or saphosphosphate according to the procedure normally followed. (1)

Twelve strips, each 11′ × 66′, were marked out and subdivided, into sub-strips 16′ × 6″ long for differential treatment with potassic fertilizer. Each strip received ordinary superphosphate at 560 lb. and ground dolomitic limestone at one ton per ac. Two sub-strips on each strip were given, at random, sulphate of potash at 112 lb. per acre, the other two were not treated with potassic fertilizer.

Pelletted legume seeds plus *Festuca arundinacea* seed and fertilizer were mixed just prior to sowing, on October 10th, 1968, and then broadcast, by hand, as shown in table No. 1.

Table No. 1—Species and cultivars sown in both jungle and patana plots

Group	*Strip Number*	*Species*	*Cultivar*	*Seed rate lb. per ac.*
A	1	*Trifolium subterraneum*	Dwalganup	20
A	2	do. do.	Mt. Barker	20
A	3	do. do.	Tallarook	20
A	4	*Trifolium pratense*	Pennscott	20
A	5	*Trifolium repens*	Ladino	10
A	6	do. do.	Huia	10
A	7	*Lotus corniculatus*	San Gabriel	10
B	8	*Phaseolus atropurpureus*	Siratro	20
B	9	*Desmodium uncinatum*	Commercial	20
B	10	*Glycine javanica*	Clarence	20
B	11	do	Cooper	20
B	12	do	Tinaroo	20

Seeds in group "A" were pelletted with calcium carbonate and those in Group "B" with saphosphosphate.

(*b*) *Patana*—An undisturbed area of patana land, which had been grazed intermittently by farm cattle, was fenced off, pegged out, and sown as for the jungle plot. The ground was completely covered with a low-grass sward the most common species being *Arundinella villosa, Chrysopogon montanus, Eulalia phaeothrix, Ischaemum indicum* and *Tripogon bromoides.* A few weeds were present, the most prominent being *Anaphalis subdecurrens, Justicia procumbens* and *Osbeckia cupularis.*

Amounts of rainfall from October, 1968, until September, 1969, are shown in appendix No. 1, and weather conditions from time of sowing until taking establishment counts, in appendix No. 2.

RESULTS

As germination was complete within three weeks of sowing, seedling populations were determined by making quadret counts at the end of October. Results are shown in Table No. 2.

Table No. 2—Establishment counts obtained on October 31 (jungle) and on November 1, 1968 (patana)

Strip	Species	Cultivar	Germinable* seeds sown (sq/lk)	ESTABLISHMENT: Seedlings sq/lk jungle	Seedlings sq/lk patana	Percentage of seeds sown jungle	Percentage of seeds sown patana
1.	*T. subtemaneum*	Dwalganup	12·1	12·1	6·2	100·0	51·2
2.	do.	Mt. Barker	8·1	ND	4·2	ND	51·8
3.	do.	Tallarook	12·3	ND	5·3	ND	43·0
4.	*T. pratense*	Pennscott	41·0	20·1	12·6	49·0	30·7
5.	*T. repens*	Ladino	72·0	27·3	13·4	37·9	18·6
6.	do.	Huia	50·0	ND	10·8	ND	21·7
7.	*L. corniculatus*	San Gabriel	18·	4·7	4·0	25·0	21·7
8.	*P. atropurpureus*	Siratro	3.0	1·6	0·7	53·0	23·8
9.	*D. uncinatum*	Commercial	16·9	5·0	4·2	29·5	24·8
10.	*Glycine javanica*	Clarence	3·8	0·1	0·4	2·1	10·5
11.	do.	Cooper	4·2	0·7	0·6	16·6	14·2
12.	do.	Tinaroo	6·7	2·7	0·8	40·2	11·9
	Festuca arundinacea	Tall	45·4	10·2	ND	22	ND

* Based on germination and purity test of original sample. Seeding establishment in the jungle was considerably better than on the patana plot. N.D. = not determined.

Healthy nodules developed near the crown of *Trifolium* plants, at an early stage of growth, but took longer to develop on species in other genera. The apparent vigour of the various species was judged, on February 2nd, 1969, by giving a value of ten to the best one and a value to each of the others, in descending order.

The result is shown in table No. 3.

Table No. 3—Evaluation of various species, on a 0-10 scale on February 2, 1969

Strip	Species	Cultivar	Jungle plot (+K)	Jungle plot (−K)	Patana plot (+K)	Patana plot (−K)
1.	*T. subterraneum*	Dwalganup	10	8	5	1
2.	do.	Mt. Barker	10	10	7	2
3.	do.	Tallarook	8	4	7	2
4.	*T. pratense*	Pennscott	7	7	9	5
5.	*T. repens*	Ladino	7	7	10	4
6.	do.	Huia	5	5	6	2
7.	*Lotus corniculatus*	San Gabriel	*	*	*	*
8.	*P. atropurpureus*	Siratro	1	1	*	*
9.	*D. uncinatum*	Commercial	8	5	*	*
10.	*Glycine javanica*	Clarence	1	1	*	*
11.	do.	Cooper	1	1	*	*
12.	do.	Tinaroo	3	1	*	*

*Population insufficient for evaluation.

In the jungle area, from February onwards, all the *Trifoliums* developed well and although *Desmodium* was a little slow in starting, after the cold months were over made tremendous growth. The *Glycines* were slow at first but steadily improved subsequently. *Phaseolus* produced a little herbage but *Lotus* never got beyond the seedling stage. Tall fescue and kikuyu developed very well and with the strong legume growth produced a good mixed pasture.

On the patana plot the development of the legumes was similar but generally less vigorous than in the jungle and during February *Desmodium Phaseolus* and *Glycine* were completely cut back by the frost because of the absence of protective tree cover. During the first twelve months a proper assessment of the development of the fescue in the patana sward was not possible because the plants were too tiny.

About one month after sowing the jungle plot, a small response to potassium was evident on strips sown with *D. uncinatum,* Tallarook subterranean clover and Tinaroo glycine but subsequently this effect disappeared.

On July 10th, 1969, as a strong response to potassium was still evident, on the patana plot, the unsown headland and the best of the sown plots were sampled for yield and composition. Results obtained are shown in table No. 4.

Table No. 4—Yield, legume and crude protein content of selected plots within patana experimental area

Treatment	*Sulphate of Potash*	*Yield* (*dm/ac*) (*lb.*)	*Yield* (*d n/ac/day*) (*lb*)	*Botanical Composition* (%) (*Legun.e*)	*Crude Protein* (%) (*dm*)
Unsown patna (control)	—	1,430	5·3	0	8·5
Mt. Barker sub.	+	3,321	12·3	70	12·0
do	–	2,238	8·2	50	10·5
Pennscott red	+	3,976	14·7	30	12·3
do	—	2,188	8·1	15	9·9
Ladino white	+	3,748	13·8	25	13.7
do	—	1,966	7·2	10	10·2
Huia white	+	4,285	15·8	50	15·5
do	—	2,041	7·5	30	11·4

+indicates treatment with sulphate of potash.

At various times, during the experiment, observations were made on the development and regeneration behaviour of the sown species. Information obtained is summarised in table 5.

TABLE 5.—Dates on which (a) seedlings emerged (b) root nodules first observed (c) first flower appeared (d) viable seed developed and annuals subsequently regenerated from seed. All seed originally sown in October, 1968

Treatment		*Establishment*				*Regeneration*
Species	*Cultivar*	(*a*) *Emergence*	(*b*) *Nodules*	(*c*) *Flowering*	(*d*) *Seeding*	*Emergence*
T. subterraneum	Dwalganup	Oct. 24th, 1968	Oct. 30th, 1968	Jan. 11th, 1969	Feb. 12th, 1969	May 11th, 1969
do.	Mr. Barker	do.	do.	Feb. 25th, 1969	Apr. 11th, 1969	Jun. 23rd, 1969
do.	Tallarook	do.	do..	Apr. 19th, 1969	May 20th, 1969	July 23rd, 1969
T. pratense	Pennscott	do.	do.	May 20th, 1969	—	Perennial
T. repens	Ladino	do.	do.	—	—	do.
do.	Huia	do.	do.	Apr. 11th, 1969	—	do.
L. corniculatus	San Gabriel	Oct. 31st, 1968	—	—	—	do.
P. atropurpureus	Siratro	do.	Nov. 22nd, 1968	—	—	do.
D. uncinatum	Commercial	Oct. 24th, 1968	do.	July 23rd, 1969	—	do.
G. javanica	Clarence	do.	do.	—	—	do.
do.	Cooper	do.	do.	—	—	do.
do.	Tinaroo	do.	do.	Apr. 11th, 1969	—	do.

The Dwalganup and Mt. Barker cultivars of subterranean clover flowered prefusely, Tallarook quite well, but flowering on all other cultivars was very spare, until the end of September 1969.

DISCUSSION

After underbrushing jungle there is normally some woody regeneration and a volunteer growth of various weeds. The former does not present any real problem, as it is easily destroyed, but the longer the interval between burning and sowing the more serious the competition from weed growth becomes. If a substantial amount of weed growth has developed before sowing, it is necessary to reduce this by controlled grazing at regular intervals.

Since the pasture seed is dropped on the surface of the ground and has very little protection from drying out, sowing is best undertaken during the rainy season. In this experiment it was done in October which is the beginning of the north-east monsoon period. However because of shady conditions and less competition, conditions for germination in the jungle are generally better than on the patana, so that, time of sowing in the former is less critical than in the latter environment. As will be seen from the weather records, rainy days during the north-east monsoon period were normal during October but below average during November and December. As temperatures were steadily falling after sowing, the cold sensitive genera such as *Phaseolus, Glycine and Desmodium* made slower growth than the *Trifoliums*. Although growth was not seriously retarded in the jungle, because of the protection against frost by the tree canopy, on the open patana, legumes other than the *Trifoliums,* were completely burnt off during February of 1969. It is more than likely that nodulation and thus competition of the species intolerent of lower temperatures was poorer than if they had been sown during the south-west monsoon period when air temperatures are higher.

On the other hand, soil temperatures under undisturbed patana and in the shady environment of the underbrushed jungle are more favourable for the development of pasture seedlings than on bare cultivated soil. This could well explain successful establishment from surface sowing but failure when seed is sown on a well prepared seed bed in the conventional manner.

For each of the three cultivars of *T. subterraneum,* day length was sufficient to induce flowering, which occurred in the expected sequence viz. first Dwalganup then Mt. Barker and last Tallarook.

A strong regeneration from seed occurred with Dwalganup during May, and in June and July in the Mt. Barker and Tallarook cultivars respectively. This is during the period of the south-west monsoon. Thus all three cultivars of subterranean clover went through their life cycles in a normal manner, and, provided they are given proper management should remain as permanent elements in the pasture. Mt. Barker appears to be more suited to the wet upper-montane environment than either of the other two cultivars of subterraneum clover.

Although both cultivars of white clover suffered severely during the dry conditions in January and February they recovered well and the evidence from other parts of the Ambawela farm is that this species will persist. Since it propagates by rooting from stolons, seed production by this species is relatively unimportant. At this stage it appears that the Huia cultivar may be the better of the two. On the other hand the inability of red clover to produce any substantial amount of seed coupled with the fact that it does not propagate vegetatively, would indicate that it is unlikely to persist for very long. *L corniculatus* failed in both jungle and patana sowings, possibily because of ineffective nodulation.

The most promising sub-tropical legume sown is silver-leaf desmodium. This has grown very vigorously in the jungle and commenced flowering in July of 1969. For first twelve months after sowing its performance on the patana has been less impressive because it suffered badly from frost injury, but had it been sown during the south-west instead of in the north-east monsoon period, it may have developed much better. *Glycine* and *Phaseolus* have been unimpressive so far although the former is steadily improving in the jungle.

Reference to appendix No. 1 will show that for twelve months, after sowing in October, the conditions were generally much drier than usual, particularly during November. Therefore it may be safely assumed that if satisfactory results were obtained from surface sowing under such conditions, this method can be recommended with confidence.

Soil analyses and various experiments (unpublished data) indicate that jungle soils are less deficient in potassium than those of the patana. In the present experiments the marked response to potassium on the patana (see tables Nos. 3 and 4) and the lesser transient reponse by only some of the sown legumes in the jungle plot generally conforms to what was expected. This may indicate that some of the legumes have a higher requirement for potassium than others or that observations in the jungle were upset by better growth

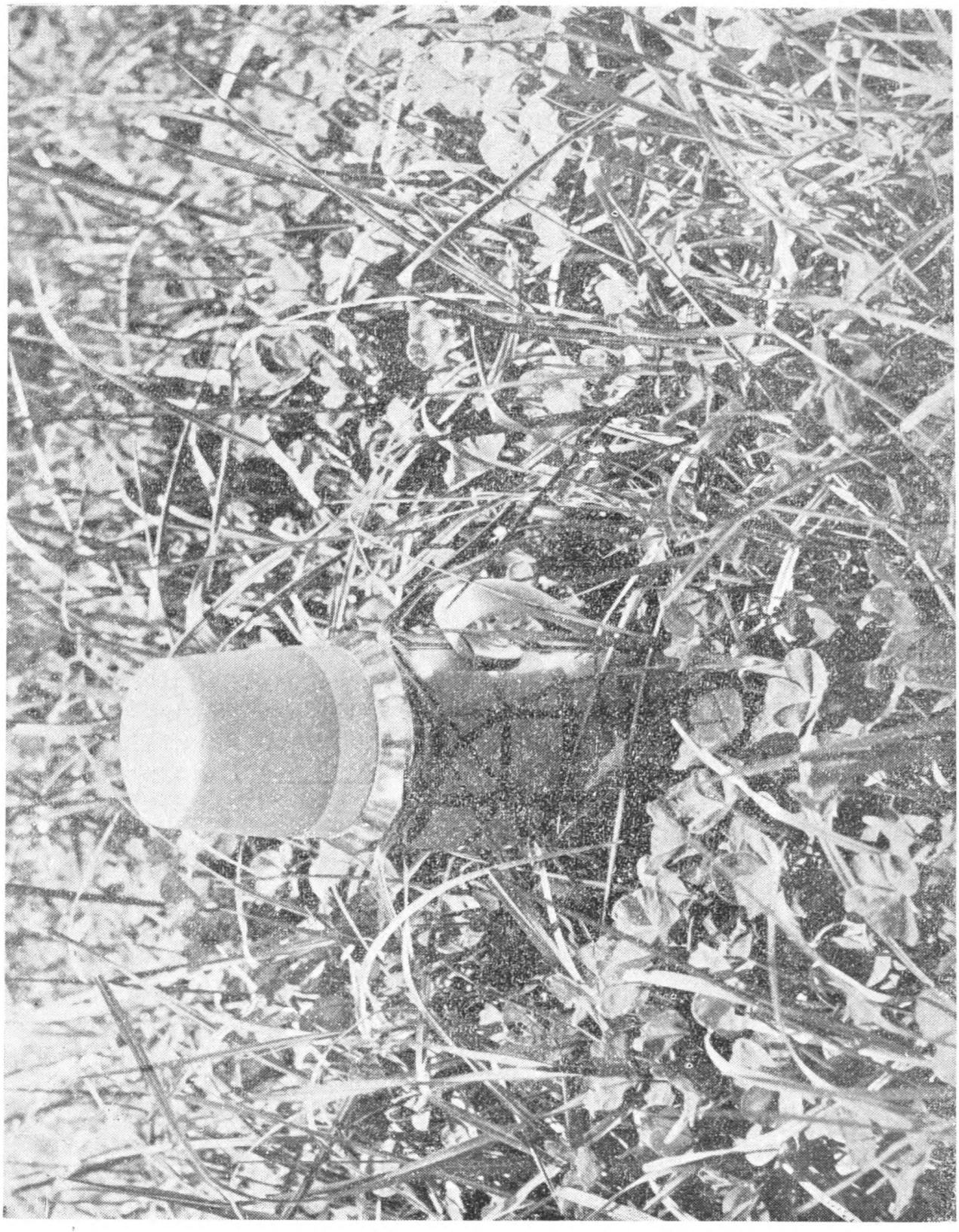
I. TRIFOLIUM SUBTERRANEUM established on patana soil at Ambawela by sufraoe sowing. L. H. S. with potassium, R. H. S. without potassium. Note marked response to potassium. (Photo by J. Keith)

on ash-beds remaining after underbrushing and burning. Therefore until more definite evidence is available potassic fertilizer at not less than one cwt. per ac. is recommenced, only for patana sowing. Both superphosphate and dolimitic lime are needed in both situations since soils are deficient in phosphorus, sulphur and calcium. Ordinary superphosphate, which contains sulphur, should be used, and slaked dolomite in preference to ground dolomitic limestone, as the former provides both calcium and magnesium in a readily available form.

The satisfactory nodulation of most of the sown legumes indicates that the technique of inoculation and pelletting with finely powdered calcium carbonate in the case of the *Trifoliums* and with rock phosphate for the others was satisfactory. In the jungle the good establishment of tall fescue and the ability of this grass to persist and compete with the kikuyu indicates that the former species can be included in jungle sowings to provide additional herbage, during the cold January-February-March period, when the growth rate of the kikuyu is at a minimum. Fescue flowers and sets seed readily in this environment. As yet it is too early to say whether it can be satisfactorily established on patana from surface sowing.

Since establishment, from all sowings, was good and generally quite comparable with what might be expected from a successful sowing on a prepared seed bed and as with both methods the type and quantity of fertilizer needed would be similar, the essential difference between costs of establishment from surface and conventional sowing would be the difference between cost of underbrushing and of clearing and cultivation on jungle land, and between no cultivation and cultivation on patana. Estimates for these operations are Rs. 54 for underbrushing Rs. 250 for clearing jungle, and Rs. 300 for cultivating and preparing a seed bed. Thus the saving from surface sowing offsets the cost of the seed except for two species even at the rates used which are probably much higher than necessary to establish a satisfactory stand of sown species.

In its natural state, ten acres of patana may just provide a maintenance ration for one cow (see table No. 4) whereas jungle provides very little graze at all. This experiment shows that both the quantity and the quality of patana herbage can be considerably improved by surface sowing and that in the jungle a mixed pasture of high quality can be established by using this method instead of the conventional one of clearing and cultivation. For large areas aerial seeding would seem to be the logical method to use. The technique of surface sowing if followed correctly, provides a way of establishing pasture in the wet-montane zone with little or no risk



2. Mixed pasture of TRIFOLIUM SUBTERRANEUM, FESTUCA ARUNDINACEA, & PENNISETUM CLANDESTINUM developed on jungle land at Ambawela by surface sowing seed of the first two species and planting kikuyu grass.
(Photo by J. Keith)

from soil erosion and disturbance of the balance of nature but with the added advantages that the soils are being enriched by the fertilizer and animal excreta and much needed animal production is being obtained.

Since virgin jungle soil does not readily erode, there is little or no risk of losing soil during the period between burning and pasture establishment.

There is no evidence to show that the replacement of the understorey of the jungle vegetation by pasture significantly reduces the intake of the rain water or flow of subsoil water to the rivers.

Overseas experience is that the better the establishment of the pasture the less the run-off of rainfall. Hence there is everything to be gained and nothing to be lost by improving the pasture sward on the patana land.

SUMMARY

This experiment demonstrates the possibility of establishing improved pastures on undisturbed patana and in underbrushed jungle in the wet-montane zone provided the various operations are timed to coincide with suitable climatic conditions and the necessary plant nutrients are used. Various aspects of the surface sowing technique are discussed.

Trifolium subterraneum, T. repens, T. pratense and *Desmodium uncinatum* were the most promising of the species used. This technique could be used to make an important contribution to solving the problem of providing cheap and effective forage for animals in the wet-montane zone of Ceylon.

ACKNOWLEDGMENTS

We wish to thank the Farm Manager and his staff at the Ambawela Cattle Farm, who are engaged in the pasture development programme and particularly the General Manager of Animal Husbandry Farms Mr. L. E. A. Fonseka and Assistant General Manager of the Ambawela-Bopatalawa Livestock Project, Mr. V. Arumugam.

REFERENCE

1. ANDREW, W. D. (1967) Lime pelletting legume seed. *Anim Prod & Hlth Bull, Ceylon* 1 (2) : 49.

2. ANDREWS, J. R. T. (1961) A forest inventory of Ceylon, *Hunting Survey Report,* Govt. Press, Ceylon.

3. KATHIRGAMATHAIYA, S & CAESAR, K. (1964). Fertilizer response studies on potato. *Trop. Agriculturist* CXX (2) : 87-124.

4. Land Utilization Committee (1967) Report, Government Press, Ceylon Published June 1968.

5. PEARSON, H. H. W. (1899) The botany of the Ceylon Patanas, *J. Linn-Soc.* Bot. 34 : 300-365.

6. ROSAYRO DE R. A. (1945) The montane grassland (Patanas) of Ceylon An ecological study with reference to afforestation *Trop. Agriculturist* 101 : 206-213.

7. SENARATNA S. D. J. E. (1956) The grasses of Ceylon, Department of Agriculture, Ceylon.

Appendix No. 1

*Ambawela **rainfall**, and offsets from average, for the twelve months following sowing on October 10, 1968*

Month	*Year*	*Amount (in)*	*Offset (in.)*	*Rainy days (No.)*	*Offset (No.)*
October	1968	14·14	+ 2·80	21	+ 1
November	1968	5·33	— 6·40	10	—11
December	1968	12·41	+ 3·04	13	— 4
January	1969	7·07	— 0·17	8	— 6
February	1969	2·04	— 3·10	5	— 5
March	1969	1·09	— 4·40	4	— 6
April	1969	12·86	+ 3·77	16	— 1
May	1969	10·87	+ 2·55	16	— 2
June	1969	8·25	— 0·01	20	— 2
July	1969	6·31	— 1·21	17	— 4
August	1969	6·06	— 0·57	16	— 3
September	1969	12·66	+ 5·09	13	— 5

Appendix No. 2

Daily weather conditions at Ambawela from sowing seed on October 10th, 1968, until seedlings were counted at the end of the month

Occtober 11th — Bright till noon, thereafter rain
Otober 12th — Bright till noon, thereafter rain.
October 13th — Bright till noon, thereafter rain.
October 14th — Alternately sunny and bright till noon, then rain.
October 15th — Bright till noon, then rain.
October 16th — Bright till noon, then rain.
October 17th — Bright till noon, then rain.
October 18th — Very bright all day.
October 19th — Very bright all day.
October 20th — Bright till noon, thereafter rain.
October 21st — Bright till noon, thereafter rain.
October 22nd — Bright till noon, thereafter rain.
October 23rd — Overcast day but no rain.
October 24th — Bright for whole day.
October 25th — Bright for whole day
October 26th — Bright for whole day.
October 27th — Bright till noon, thereafter rain.
October 28th — Bright till noon, thereafter rain.
October 29th — Bright till noon, thereafter rain.
October 30th — Bright till noon, thereafter rain.
October 31st — Bright till noon, thereafter rain.

N.B.—A bright morning with afternoon rain is characteristic of the weather during the early north-east monsoon period.