BREEDING, EVALUATION AND MANAGEMENT OF PASTURE SPECIES, FIELD MEETING, SAMFORD, OCTOBER 4, 1968.

BREEDING IMPROVED TROPICAL PASTURE PLANTS

by

E. M. HUTTON, C.S.I.R.O., DIVISION OF TROPICAL PASTURES, BRISBANE.

All new introduced tropical legumes and grasses can be improved. Some have been taken straight from the native habitat in overseas countries; these have a short history as pasture plants, and sometimes possess undesirable characters. By breeding and genetical techniques the different legumes and grasses can be adapted more closely to the needs of the grazing animal. The main criterion for a new bred line should be whether it increases animal production when compared with the original material. This yardstick is rarely used, if at all, because of the difficulties involved in setting up expensive large-scale grazing experiments.

The main character measured in breeding is dry matter yield, and it is important to measure yield throughout the season rather than total yield. Yield is usually not a problem at the height of the season, and is of most concern in our dry season and particularly in spring and early summer. Species like *Leucaena leucocephala* come into their own during this period.

Yield is more important in legumes than in grasses as legumes produce more digestible protein and energy throughout the season than grasses. The aim must be to breed legumes with as high a dry matter yield as possible and with an extended growing season to increase the quality of pastures. This is being done with *Phaseolus atropurpureus* cv. Siratro, *Desmodium*, and *Glycine* species. The question can be posed as to whether we require a very high dry matter yield in grasses, particularly at the height of summer. Perhaps we should breed grasses more compatible with our legumes.

Quality, as measured by digestibility and intake, is rather low in our tropical grasses, so increasing this is a main objective in our breeding work with *Setaria, Sorghum almum* and *Cenchrus ciliaris* (buffel grass). Where nitrogen fertilizer replaces legumes in pastures, in favoured moist areas, it is essential to have grasses of high feeding value which give a marked response in dry matter and protein build-up and which have an extended growing season. *Digitaria decumbens* (Pangola grass) meets these requirements except for its rather poor rate of growth in the winter.

High commercial seed production is essential in all new line of legumes and grasses if they are to be fully accepted and make a definite impact on pasture production. Lack of abundant quantities of relatively cheap pasture seed is at present a major factor retarding pasture development in north-eastern Australia. Siratro and Greenleaf *Desmodium* are two legumes with relatively poor seed yields, and increasing these is a main objective in our breeding work.

Persistence and competitive ability is not a problem in our tropical grasses but is a problem in the legumes. In the legumes new lines are being bred which start growth earlier in the season and so compete more effectively with the grasses. Persistence of tropical legumes may depend in part on their management and interesting work is being done at Samford by Mr. R. J. Jones and Dr. P. C. Whiteman on the factors involved.

Rapid and effective nodulation is the essential character in legumes. Nodulating ability is of a high order in legumes like Siratro and leucaena, but tends to be poor in glycine and greenleaf desmodium. Genetical work is in progress to improve the nodulating ability of these two latter legumes.

Tolerance to frost and dry conditions are very desirable characters. Although there is a high level of resistance to our somewhat severe radiation frosts in Miles lotononis, it is unlikely that a similar level of frost resistance will be achieved in our other tropical legumes, all of which are susceptible. There is some indication that a measure of frost tolerance could be bred into legumes like Siratro, glycine, and desmodium. With grasses like setaria and paspalum there is a greater possibility of obtaining a high degree of frost tolerance. The breeding work with frost-tolerant types of setaria is very promising and will result in the release of a new line.

Of our legumes, Siratro, leucaena, lucerne, and Townsville lucerne are the most drought resistant. The desmodiums lack drought resistance, but improvement in this character appears to be possible by incorporating genes from *D. sandwicense.*

Resistance to pests and diseases such as root-knot nematode, legume "little leaf", and *Rhizoctonia solani* is of great concern in the legumes. It is inevitable that the development of large areas of the new tropical legumes will result in a gradual build-up of a complex of pests and diseases. In the breeding work with *P. atropurpureus* a high resistance to root-knot nematode and legume "little leaf" is being maintained in the new bred lines. Increased tolerance to *Rhizoctonia* is also being sought. An attempt is also being made to breed lines of desmodium with resistance to legume "little leaf". Recently this disease has been shown to be due to a mycoplasma and not to a virus so a different approach may be needed in the breeding work.

Details concerning the breeding work with Siratro and Desmodium

A new cycle of crossing between Siratro and new introduced types of *Phaseolus atropurpureus* commenced early in 1964. In the 1968-69 season the F5 generation will be established in simulated pasture plots and as spaced plants. This has involved the raising of over 40,000 single plants. The F4 generation which involves 5,500 spaced single plants is now entering its second season of growth. During the first season plants were rated for dry matter yield and ability to grow during the cooler weather and also for seed yield. All the results have been computerized. These results have shown that it is difficult to combine all these characters and especially high dry matter yield and high seed yield. It is also of interest that only two out of the 24 crosses that were made have proved to be of any use.

Only a few of the best bred lines combine high dry matter yield and high seed yield and an extended growing season due to the ability to grow during the lower temperatures of early winter through to late spring. Seed yields three to four times that of Siratro have been obtained and this is due to greater development of pods and a lesser tendency to shatter. Variation of *in vitro* digestibility has been obtained among the bred lines so that it is possible to improve the digestibility of Siratro by breeding. It is possible that improved bred lines of *Phaseolus atropurpureus* will be available to the producer in about five years if the present material lives up to expectations.

In the desmodiums, 1,000 spaced plants are raised each year from crosses and selections. Crosses have been made between *Desmodium intortum, D. uncinatum,* and *D. sandwicense,* and selections have also been made within *D. intortum.* Most of the material grown during the 1967-68 season is in the F4 generation. During the 1968-69 season 10,000 single plants are being raised to grow in simulated pasture plots. The main characters being sought in desmodium are early flowering with high seed yields and high dry matter production. Improvement in drought resistance and nodulating ability is also being sought by breeding.

DISCUSSION

Is the non-shattering characteristic of the new P. atropurpureus *variety of much benefit to the ordinary farmer?*

Is the non-shattering characteristic of the new P. atropurpureus *variety of much* reduced and the time the pods take to shatter is much longer, up to 1 month. This allows the seed grower to wait till all the pods on a raceme are ripe before harvesting takes place. From a pasture point of view this could also be valuable as the pods containing seed are a source of concentrate protein available for the animals. This is one of the advantageous features of Townsville lucerne. Furthermore, medics provide a dry feed in the same way where even in the absence of any green material animals can do well simply on the pods.

You have mentioned the large differences in digestibility between various lines. I wonder if you could comment on whether the animals are actually eating more of these plants?

Dr. Hutton: It is generally true to say that increased digestibility results in increased intake. Dr. Minson says a 2% difference in digestibility is significant. With *P. atropurpureus* I don't think it will extend to a level comparable with *Vigna luteola* which is so palatable that the animals will eat it to the exclusion of all others. This has also happened here with Siratro-green panic pastures where the green panic has been grazed out over a period of years as a result of its superior palatability to Siratro and has now largely been replaced by blue couch. I think a measure of non-palatability in a legume is likely to be desirable.

Are the new leafy types likely to be of low seed yielding ability due to the general inverse correlation of leafiness at flowering and seed set?

Dr. Hutton: It is certainly true to say that where you have a lot of leaf growth you tend to have a lower seed set. It is a physiological balance. However, it is possible now to stop vegetative growth by spraying the plants with hormones or defoliants to achieve maximum seed set for seed production purposes.

Quite apart from the seed losses due to pod shattering is there anything likely to reduce seed setting?

Dr. Hutton: Yes. We do get conditions at Samford when Siratro does not set much seed, i.e. when there are cool nights and moist conditions. There can be plenty of pods but few seeds. This has caused us trouble at times with our programme.

Are any of the new lines going to be more tolerant of continuous grazing than Siratro?

Dr. Hutton: Siratro stands up to continuous grazing but it is a matter of grazing pressure. Grazed at a beast per acre here it probably disappears. At a beast to $1\frac{1}{2}$ acres it becomes rampant in Summer. I think we can predict that the new types will withstand a beast to the acre under continuous grazing. Of course, the way we ought to be selecting our material is to have a beast to the acre on all our plots. However, we have to look at various plant characteristics which make it necessary to allow them to grow out and so the best we can do is intermittent grazing.

Dr. Hutton, Siratro seems to be affected badly by halo blight on the north coast where winter green beans are grown. Have you considered this in your breeding programme?

Dr. Hutton: We do have contact with halo blight here but I have never seen a bad infestation of it.

BREEDING LEUCAENA LEUCOCEPHALA FOR QUEENSLAND

by

S. G. GRAY, C.S.I.R.O., DIVISION OF TROPICAL PASTURES, BRISBANE.

One of the salient features of the adaptation of grassland concepts to tropical and subtropical environments is the fact that we are not restricted to the use of the herbaceous sward. A substantial proportion of the natural grazing of animals in the tropics and subtropics consists not of herbaceous grasses and legumes but of browse shrubs and browse trees, that in many respects are better adapted to grazing pressure under somewhat difficult environmental conditions than are the more ephemeral herbaceous plants.

A feature that helps to determine whether a plant species is suitable for grazing is its growth form in relation to grazing damage and recovery afterwards. The browse shrub or tree fulfils this requirement admirably because of the unlimited number of potential growing points latent in the stem tissue, and because of the reserve capital left in the stem and root systems after grazing. The browse shrub is often capable of rapid immediate regeneration even under adverse conditions such as frequently occur in spring in S.E. Queensland, when even the best herbaceous plants are slow in getting started.

These points are illustrated with reference to an experiment with *Leucaena leucocephala* at Samford. This material, consisting of lines in the F5 generation derived from the cross "Peru" x "Hawaii", was established in December, 1966, and is now commencing its third season. On 9-8-68 it was cut back following a heavy frost a few days previously. After eight weeks growth it is now (4-10-68) at a stage where it could be grazed.

Estimates made during the 1967-68 season on this experiment indicate that potential annual edible forage production over about six cuts would be: for c.v. "Hawaii", about 1300 lb dry matter; for c.v. "Peru" about 4000 lb; and for the hybrid lines from 4000 to 6000lb. Protein content of young leaf material is about 28 to 30 percent.

Leucaena requires an annual rainfall of 30 inches or more, with summer incidence, and freedom from heavy frost. The area in Australia which is climatically suitable for leucaena has been estimated at about 300,000 square miles.

L. leucocephala is native of Mexico and Central America. Three types exist: (1) a shrubby type naturalized throughout the Pacific region, e.g. c.v. "Hawaii"; (2) very tall erect types, e.g. c.v. "Guatemala"; and (3) tall but well-branched at the base, e.g. c.v. "Peru". Crossing between these three types has produced wide segregation in growth type and vigour. Breeding objectives in selecting within this range of variation are high forage yield, branching habit suitable for grazing, medium to late flowering, and moderate seed yield late in the season.

DISCUSSION

What are the risks of mimosine poisoning when feeding leucaena?

Mr. Gray: With proper management there is very little risk with ruminants, particularly if the ruminant becomes accustomed to it gradually and also if leucaena does not constitute a very high proportion of its diet. In a mixed diet I don't think there's very much to fear as far as ruminants are concerned.

What varieties are you growing here and how much fertilizer have they received?

Mr. Gray: Hawaii is the strain already naturalized in Australia. We have Peru and a number of cross-bred lines. The area has only been fertilized once as a basal dressing two years ago. If we can get 6,000lb/ac with hardly any fertilizer then

I think we would get more with more adequate fertilizing. The whole question of fertilizer requirements for leucaena has not yet been looked at by the agronomists but I hope they will.

You say that if leucaena is to be used as a processing crop it is not necessary to worry about its form. How do you visualize the leafage being collected?

Mr. Gray: It has the feature that, once cut, the leaves fall off rather rapidly. We did this once simply by placing the branches on a bitumen road. Next day the branches were removed and all the leaves swept up! However, this would have to be done mechanically in order to be economical.

Would this not suggest that the plant form, the nature of the plant material and its growth habit be just as important in a processing crop as a grazing one?

Mr. Gray: Yes, except that in a processing crop it wouldn't matter so much if the crop grew out of the reach of the animal.

Dr. Hutton: I have seen the crop mown and it is no problem. It is very persistent — once you've got leucaena you've got it!

Mr. Gray: As long as there is some stem tissue left above ground to provide new growing points it will shoot again.

Would you then recommend frequent slashing as a means of stopping the proliferation of woody tissue?

Dr. Hutton: I don't know if you would benefit by doing this too often, particularly if the area was extensive. It might be possible in small areas.

What are the climatic limitations for growing leucaena?

Mr. Gray: Leucaena requires a rainfall of 30 inches or more distributed mainly in Summer. It will not stand heavy frosting and is roughly confined above the line of 50°F mean monthly minimum in July. Using this and the 30 inch isohyet we have calculated there are 144,000 square miles in Queensland, 95,000 in N.T., 50,000 in W.A. and 13,000 in N.S.W., or about 300,000 square miles climatically suitable for leucaena in Australia.

There seems to be considerable difficulty in establishing leucaena by simply seeding it into the ground as one would other legumes.

Mr. Gray: There are two problems to overcome. The first is hard-seededness. Without hot water treating the seed only about 5% germination could be expected. This treatment involves steeping the seed in water close to boiling point (80 deg. C) for two or three minutes. This seems to cause minute cracking in the seed coat which allows the seed to imbed and germinate. It is possible to use sulphuric acid but hot water is much simpler and the seed can be repackaged the same day and held for more than one year without loss of germination. The other problem is that in its first year leucaena is sensitive to competition from weeds and other plants. It is better to treat it as a crop, planted in a cultivated seed bed in rows eight or 10 feet apart at about 5lb seed per acre then inter-row cultivate for weed control. In the second year Pangola or some such grass can then be oversown.

Is inoculation of the seed necessary?

Mr. Gray: Definitely, yes. It is very important as it is not a legume which will nodulate naturally. It won't thrive at all without its specific *Rhizobium*.

BREEDING CREEPING-ROOTED LUCERNE FOR THE SUB-TROPICS

by

R. A. BRAY, C.S.I.R.O., DIVISION OF TROPICAL PASTURES, BRISBANE.

Creeping-rooted lucerne is being developed in an effort to provide a winter growing legume, with persistence under grazing, for use in mixed pastures over a large area of Queensland. It has been well established that creeping-rootedness does result in increased persistence, and therefore this character must be combined with desirable yield and seeding characters.

The breeding programme, started by L. A. Edye, involved the crossing of selected plants of Rambler (a Canadian creeping-rooted variety with little winter yield under Queensland conditions) with plants selected from the varieties Hunter River, Indian, Saladina, Hairy Peruvian and Pampa. After four generations of selection and intercrossing, about 30 plants combining high yielding qualities with creeping-rootedness were selected. These plants were divided into two groups on the basis of growth habit (erect or prostrate) and polycrosses made within each group.

Progeny from these polycrosses were established as spaced plants at Eskdale (spear grass), Taroom (brigalow), and near Beaudesert, to obtain data on their performance in several environments. Data on yield and creeping-rootedness over several seasons has permitted the selection of 12 parent clones whose progeny performed consistently well. Intercrosses between these 12 are currently being tested at Lawes, in order to select those which combine well together. Also, outstanding plants were selected from the plots at Beaudesert, Eskdale, and Taroom, and crosses between these plants are being evaluated at Samford.

Preliminary data (on yield, creeping-rootedness, and seed set) from these crosses has enabled the formation of several preliminary synthetic varieties. Seed is being produced this summer of 8 or 9 synthetics, with a view to establishing small (0.01 acre) yield trials at the Narayen Research Station, Mundubbera. Release is unlikely for several years.

The choice of a synthetic variety as the end product of the breeding programme implies more complex methods of seed production than currently exist, since several generations of seed must be produced under supervised isolated conditions. Seed costs may be higher than for Hunter River but not unreasonable.

DISCUSSION

How was the synthetic variety formulated?

Dr. Bray: I formulated about ten preliminary synthetic lines using parents from different sources and from different parts of the breeding programme. Seed increase from these synthetics is being carried out here in small 40' x 10' plots which are caged in order to maintain isolation and a high bee population for maximum fertilization of flowers. Yield trials will then be established at Narayen Research Station, Munduberra. They will be grown with grass as a normal sward and regularly grazed. In fact, all of our plots at Beaudesert and Eskdale have been grazed intermittently in the past.

Would you recommend sowing this creeping rooted lucerne as a sward with grass or as a pure stand?

Dr. Bray: I don't know at this stage. I am at present looking at it as a sward legume with grasses such as Rhodes grass or Buffel grass. With Cancreep it seems that it is planted as a pure stand rather than as a pasture component. However, it has been bred for the cool climates of the New South Wales tablelands but it does not do well in Queensland, South Australia or Western N.S.W.

How does the seasonal dry matter production of the creeping lines compare with Hunter River lucerne?

Dr. Bray: At this stage we have only taken dry matter yields on spaced plants. Last winter at Gatton there was one line equal to Hunter River lucerne. When creeping rooted lucerne is allowed to spread over an area it will produce more than Hunter River. As spaced plants most creeping types have a longer vegetative period. This sort of thing makes it difficult to know when best to sample the different lines as one may be preferentially favoured by one sampling procedure over another.

How frequently can these creeping rooted strains be grazed?

Dr. Bray: I have no information on this matter yet. The main aim initially is to produce a high yielding and reasonably creeping rooted variety first. Then we'll be ready for agronomic testing.

Has the creeping rooted lucerne been tried in phytophthora soils?

Dr. Bray: No, at least not intentionally. Again the primary objective is to produce a good "broad-spectrum" variety. Once achieving this there is generally still sufficient variability to select for resistance to such specific restrictions as phytophthora and witches broom disease. Bacterial wilt has so far only turned up in Victoria. However, it is not difficult to screen for resistance.

When will creeping rooted lucerne be available commercially?

Dr. Bray: At the earliest in two or three years. This depends on the success of the next stage — the preliminary yield trials of the synthetics.

BREEDING IMPROVED SETARIAS

by

J. B. Hacker, C.S.I.R.O., Division of Tropical Pastures, Brisbane.

Before initiating a breeding programme on a plant, it is necessary that something is known of the basic biology of the plant to be improved. Particularly important are breeding system and chromosome numbers and relationships.

There are three broad systems by which plants may reproduce—by apomixis, self-pollination and cross-pollination, although in many cases intermediate or modified types may occur. Plants that produce apomictically or vegetatively, such as buffel grass, avoid going through the sexual process and hence are remarkable for their uniformity. Even in the presence of variability, useful characters cannot be combined unless sexual individuals are located. Self-pollinating plants, for example *Phaseolus atropurpureus* have a higher level of variation and emasculation and hand pollination is necessary for the production of hybrids, which may then be self-pollinated indefinitely, and the useful segregants selected.

Setaria is an open-pollinated grass, and emasculation is hence unnecessary. Hybrids may be produced simply by enclosing inflorescences from two plants in a pollen-proof bag. However, at least several plants are necessary for the basis of a variety, rather than the single plant required for an inbreeding species. Also the large amount of variability common to most outbreeding species while providing a source of variation for incorporating in a new variety breeding programme has the disadvantage that it is difficult to restrict.

A knowledge of chromosome numbers is essential as hybrids between plants with different chromosome numbers are mostly of very much reduced fertility, if not completely sterile. In setaria strains with chromosome numbers of 18 (diploid), 36 (tetraploid), 54 (hexaploid), 72 (octaploid) and 90 (decaploid) are known. Although hybrids between plants with different chromosome numbers may be produced and characters transferred from one level of polyploidy to another—for example from hexaploids to tetraploids—such techniques are laborious and need not be exploited until alternative sources of variation have been worked over.

In setaria the most useful chromosome level is probably that of tetraploidy, though the commercially useful cultivar Nandi is a diploid. Frost-tolerant tetraploid strains have been introduced from Kenya, and this character is the major criterion for selection in our breeding programme at Samford. In general, however, the frost tolerant strains lack the summer vigour of some of the strains of southern African origin, and work is in progress to improve this character. Two approaches are being used.

First, the various frost tolerant strains were compared under cutting regimes. The one that appeared to combine frost tolerance with reasonable vigour was subjected to two generations of selection and at each generation the best plants were selected for propagation. The 87 plants selected in the second generation will be the mother plants for a new frost-tolerant variety to be released when sufficient seed supplies are available.

Secondly, hybrids have been produced between frost tolerant strains, and the more vigorous southern African strains, and these will be crossed amongst each other and subjected to several cycles of selection, paying particular attention to frost tolerance, vigour and digestibility, the latter being a measure of the quality of the grass to the grazing animal. This approach, it is hoped, will give a much superior variety to intra-varietal selection, but it will necessarily take considerably longer.

DISCUSSION

Dr. Hacker said that he has finally selected a frost tolerant setaria for a more erect or upright habit of growth. Is this to help presentation of the grass to the cattle so that they can get at it easier?

Dr. Hacker: I am working on the assumption that this will allow better light penetration and thus tend to encourage higher growth rates. Furthermore, a plant with an upright habit of growth would carry its yield over a smaller land area.

TEMPERATE SPECIES EVALUATION

by

R. Roe, C.S.I.R.O., Division of Tropical Pastures, Brisbane.

In the dairy pastures research programme of C.S.I.R.O. some attention has been given to the evaluation of temperate species for complementary use with tropical pasture species. Pastures consisting of temperate species could be particularly useful in providing feed in the winter and spring months where frosts reduce the feed available from tropical species.

In sowings made at various regional centres during the past seven years the most successful species have been hybrid phalaris (now available as Siro 1146), various cultivars of cocksfoot, prairie grass and tall fescue. Of the legumes the most promising have been white clover, lucerne and Kenya white clover (*Trifolium semipilosum*). In some situations annual medic species, particularly barrel medic, have been outstandingly successful.

In an experiment sown in the autumn of 1966, mixtures of temperate species which had been the most successful up to that time are being compared. The mixtures consist of one grass—one legume combinations of the following: hybrid phalaris, Currie cocksfoot, Brignoles cocksfoot and prairie grass each with Ladino clover, Kenya white clover, African lucerne or Hairy Peruvian lucerne.

During 1967 the highest yields of dry matter were obtained from hybrid phalaris (2800 lb/ac), Kenya white clover (3140 lb/ac) and Ladino clover (1300 lb/ac). These were obtained from four samplings which were made in May, June, August and September.

All of this experiment except one corner is on very shallow soil, so that soil conditions are very wet after heavy rain and very dry during periods without rain. Following exceptionally heavy rains in August, 1967, the area was waterlogged and the lucernes were killed out. Also the two cultivars of cocksfoot have not survived.

During 1968, conditions since January have been dry. For the period February to September inclusive only 50% of the normal rainfall has been received. For the period during which production from these species might be expected, i.e. from May to the present, only 544 points of rain have been received which is only 60% of that normally expected.

These adverse conditions are reflected in the present condition of the pastures. Very low yields have been recorded and the survival of some species has been affected. Hybrid phalaris has survived with possibly no loss but the prairie grass has been thinned out. It has also been very unproductive. Ladino clover has virtually disappeared. The survival of Kenya white clover has been much better.

The survival of this latter species has always been much better than that of the cultivars of white clover (Ladino, Louisiana, N.Z. white) in several comparisons that have been made. This is probably because it has a well developed tap root. It also seeds prolifically so that regeneration from seed may be expected. White clovers on the other hand do not persist in this environment except in favourable situations, e.g. low lying river flats. The stand will regenerate from seed, however, so that once a sowing has seeded and provided soil fertility is adequate, white clover may be expected each year if average rainfall conditions are experienced.

Until recently only a limited range of temperate species has been examined. However, in a sowing made in autumn, 1968, the range was extended to include a small collection of species and strains from south eastern U.S.A. where the summer conditions are somewhat similar to S.E. Queensland. In most cases it is the lack of adaptability to the summer conditions of S.E. Qld. which causes the failures of sowings of temperate species.

The new material under test consists mainly of strains of white clover, Kenya white clover, cocksfoot, phalaris and tall fescue. Observational plots have also been sown of a number of miscellaneous legumes including red, crimson, rose, berseem and arrowleaf clovers (*Trifolium versiculosum*) and some annual and biennial ryegrasses.

The plots are being maintained with irrigation in the first season to ensure that they become well established and that the legumes set seed. After the first season no irrigation will be used. The persistence of the perennial legumes will be closely observed. The regeneration from seed of the perennials that fail to persist and the annual species, will also be studied. The ingress of weeds, particularly grass weeds, is often the cause of failure of temperate grasses in the S.E. Queensland environment. In this experiment it is planned to study the production and persistence of stands of perennial grasses, without competition from weeds. In this way their adaptability to the S.E. Queensland environment can be observed, without the complication of competition from weeds.

DISCUSSION

Do you have trouble getting effective nodulation on the temperate legumes?

Mr. Roe: Yes, it is a problem, especially to get consistent results with small plot sowings. If the inoculated seed is sown into the soil rather than broadcast on the surface the chances of nodulation failure are greatly reduced. This is particularly so of a difficult species like *Trifolium semipilosum*. On a farm scale there are implements that will drill or sod seed effectively but for small plots there is not much available and we have to resort to hand sowing seed into tyned furrows and then knocking the soil back over the seed. All seed is inoculated prior to sowing and *Trifoliums* are all lime pelleted.

Does Lotus corniculatus require a special inoculant and lime pelleting of the seed?

Dr. Norris: *L. corniculatus* does require a specific inoculant and it is desirable to lime pellet the inoculated seed.

Does it make any difference to apply lime?

Mr. Roe: There was possibly some effect with lucerne, but the lucerne did not persist here long enough to be sure. There is certainly an effect from lime pelleting lucerne seed and at Gympie 2 tons per acre were necessary to give a substantial increase in lucerne yield. It appears that lime pelleting is probably all that is economically justified.

In your white clover plots did you include any naturalized white clover?

Mr. Roe: No. There was one plot sown with seed of white clover harvested on Samford. However, it is really not naturalized white clover since the area had been sown with Ladino white or other types not too long ago. I doubt that the population has yet adapted to this environment.

LEGUME MAINTENANCE IN PASTURE

by

R. B. WAITE, C.S.I.R.O., DIVISION OF TROPICAL PASTURES, BRISBANE.

Several experiments have been carried out which have dealt to a greater or lesser extent with legume maintenance in pastures.

An experiment to test a number of *Setaria* ecotypes in a mixture with Siratro (*Phaseolus atropurpureus*) under light and heavy intermittent stocking showed that the legume disappeared from the plots with the heavier rate of grazing.

A trial was then carried out on Siratro to test cutting frequencies (4, 8 and 12 weeks) and cutting height ($1\frac{1}{2}$in and 3in). The siratro was completely eliminated with the lower cutting height at the four week interval and seriously retarded at the eight and twelve week frequencies.

It was then decided to plant a modified version of the previous trial with four cutting frequencies (4, 8, 12 and 16 weeks), two cutting heights (3 inches and $4\frac{1}{2}$ inches), and legume sown alone and sown in a mixture with Nandi setaria.

Broadly the results of this trial were:

1. Cutting height (3 inches) affected the yield of Siratro.
2. Cutting frequency affected the yield of Siratro.
3. The combination of frequent defoliation and low cutting was the most severe treatment on the legume.
4. The legume grew better when sown alone.

Yet another trial was carried out on a mixture of Siratro and Nandi Setaria — to study legume seeding rate, amount of superphosphate and stocking rate. Siratro was sown at 2, 4 and 8lb of seed per acre. Superphosphate was applied at the rates of 2, 4, 8 and 12cwt per acre.

The two levels of intermittent grazing pressure were fixed by grazing one portion at double the rate of the other.

Briefly, this experiment showed that in the first two years—

(1) Legume seeding rate had the greatest increasing effect on the yield of legume, and total yield of nitrogen of the grass.

(2) In the first year there was an interaction between phosphate rate and legume seeding rate.
(3) Low legume seeding rate and high phosphate rate actually decreased the yield of legume in the first year.
(4) In latter years, the seeding rate effect has faded and the phosphate level has become more important.
(5) The higher grazing pressure has lowered yields of sown species (particularly legume).

Summary:
(a) Present varieties of tropical legumes should be lightly grazed as they are susceptible to severe defoliation.
(b) Although seed cost is a major economic consideration early yields of legume and associate grass can be improved by higher seeding rates.
(c) An adequate phosphate level is necessary for satisfactory legume maintenance.

NITROGEN ON INTENSIVE PASTURES FOR BEEF CATTLE

by

P. C. WHITEMAN, C.S.I.R.O., DIVISION OF TROPICAL PASTURES, BRISBANE.

In the absence of Mr. Raymond Jones who is responsible for this work, I shall in the short time available attempt to cover the main points of these trials. This work was started in 1962 to investigate the potential of nitrogen fertilised grass pasture for beef production. It was started in the belief that the cost of nitrogen would decline as the supply and demand increased, as has, in fact, happened.

The first stage of the trial compared two grass species, *Setaria sphacelata* cv. Nandi (Nandi setaria) and *Chloris gayana* cv. Samford (Samford Rhodes grass) fertilized with 300 lb of N per acre per annum as urea. The paddocks were continuously grazed at two stocking rates — 1 beast to ½ acre and 1 beast to ⅔ acre. Conservation of hay was carried out on half the area where excess grass growth in summer was cut and baled and fed back over winter. The experiment was replicated twice, one area on a north facing hill slope, and the other on the flat running up to the creek.

TABLE 1.
Mean liveweight gain (lb/acre/annum)
(Summary of four years data)

		Setaria	Rhodes	%Difference
Conserved	Low Stock (1 to ⅔ acre)	501	525	
	High Stock (1 to ½ acre)	540	475	
Control	Low Stock	424	422	
	High Stock	479	472	
	Mean	486	474	2.5
	Mean: Low Stock = 468,	High Stock =	492	5.0
	Mean: Conserved = 510,	Control =	449	13.5
	Mean: Hill Site = 419,	Flats Site =	540	29.0

The main results are summarised in Table 1. There was little difference between species, but under the intensive grazing the swards tended to become mixed. Nor was there any real difference between stocking rates, suggesting that 1 beast to ½ acre was about optimal under the conditions.

The hay conservation treatment resulted in 13.5% higher live weight gain over the controls. The greatest benefit of feeding appeared in wet winter periods, and under the more normal dry winters there was little difference in animal performance between the conserved and control.

The largest differences were due to site, with the replicate on the hill producing 29% less live weight than the replicate on the flat. Since both areas received high rates of N, P and K the difference may have been largely due to better water availability on the flat.

After 4 years of applying 300 lb of N per acre, we wondered whether live weight gain could be maintained at a lower rate of nitrogen input. A new phase of the trial commenced in 1967 to compare two rates of nitrogen input, viz 150 lb and 300 lb N/acre/annum, again on setaria and Rhodes grass. Stocking rate was 1 steer to ½ acre. Stocking was begun in May with 8-month old weaners which were set stocked on the pastures for 12 months and turned off at 20 months of age. In this trial Herefords and Droughtmasters are being compared.

In 1967/68 there was no overall difference in live weight gain between the Droughtmasters and Herefords, but a large effect from level of nitrogen fertilizer. The live weight gains per acre are as follows:

	LOW N (150 lbN/ac)	HIGH N (300 lbN/ac)	MEAN
Setaria	580	745	662
Rhodes Grass	409	723	615
Droughtmaster	450	768	609
Hereford	532	698	615
Mean	491	733	

It is evident that production could not be maintained at the low nitrogen level. The setaria paddocks suffered heavily from the effects of frosts and grazing and the setaria content was reduced to about 10%.

The question arises whether Nitrogen fertilized grass is economical for beef production in this area. On some very approximate economics, from the first year's results, the high nitrogen paddocks produced approximately $90 in animal live weight for a total fertilizer cost of about $34. Based on experience in the Wallum, Mr. Tony Evans finds that 1½ lbs live weight gain/acre for every 1 lb of nitrogen input is required to meet fertilizer costs. On both calculations, admittedly very approximate, there does seem to be a margin for profit from the live weight gains achieved.

DISCUSSION

What do you consider is the reason for the animals doing better over the last couple of years following the first three years of rather poor animal growth?

Dr. Whiteman: I think it could well be attributed to superphosphate since the input has now exceeded 10 cwt and the fertility is improving all the time. Initially the pastures were predominantly setaria and Rhodes grass and I think setaria gave us greater live weight gains than Rhodes grass. Later on the pastures became a rather mixed bag of species with blue couch becoming particularly prominent in one replicate and the animals did well on it. This doesn't really say, one way or the other, that improved pasture species or "weedy" species are better.

How was the nitrogen applied?

Dr. Whiteman: It was applied in six applications throughout the year but with five of them over the summer period. We tried to do this each time before rain but it is difficult to achieve.

What was the quality of the hay you made from the conserved treatments like, when it was fed back to the animals?

Mr. Waite: It was sufficient to maintain live weight gain of the animals being fed throughout the winter period. The hay was about 13% crude protein. Feeding commenced when the animals on pasture ceased to gain weight.

Dr. Whiteman: Feeding back conserved hay has had quite a remarkable effect for without it there has been no live weight gain. This is particularly so in wet winters when the quality of the standing feed is severely reduced by the wet conditions.

In the new phase of the experiment, using Droughtmasters and Herefords, all treatments include hay conservation and feeding back. The maximum period for live weight gain is from December to March and then we get 2½ to 3 lb per animal per day.

Mr. Waite: The period of feeding back is from late May-June till about October or when the conserved feed runs out; nor do we feed back when we get abundant spring growth. I suppose the animals take about 15 lb per head per day during the feeding period.

At what rate of seed per acre was the setaria sown?

Mr. Waite: At about 3 lb per acre. The Rhodes grass on the top replication was planted vegetatively as opposed to the other replication where it was seeded. This was the replicate which reverted to blue couch after the first year. I do not think any of the species were very suitable for this trial because they have no cold resistance and after the first frost they became hayed-off.

Do you plan in future to use the frost tolerant setarias?

Dr. Whiteman: Yes, definitely. In experiments we are planning next season (1968/69) we hope to use the winter-green setarias. I am not yet sure about the grazing management. Frequent defoliation has a detrimental effect on Siratro while *Desmodium intortum* seems to resist frequent low defoliations better.

MEASURING PASTURE QUALITY IN TERMS OF MILK PRODUCTION

by

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The value of a pasture to the dairy farmer depends on its capacity to produce milk, which is, in turn, a function of its ability to satisfy the nutritional requirements of the herd. In meeting these requirements, factors related to both quantity and quality of the pasture are involved.

The premise of the studies conducted at Samford, is that where quantity of the pasture available is not limiting, then any differences in animal production will be due to differences in quality. It is this aspect of total production with which we are concerned, i.e. the production per animal. Do the species differ in their ability to produce milk? Can we detect the differences?

The first experiment compared the two grass species — *Chloris gayana* cv. commercial (Rhodes grass) and *Setaria sphacelata* cv. Kazungula (Kazungula Setaria) when grazed at 3 weeks and 5 weeks of age. A fresh strip was allotted daily so that quantity of feed available was not limiting and uniform quality was maintained. The animals used were first-calf Jersey heifers. They calved on a high plane of nutrition and varied from 3-9 weeks in lactation at the beginning of the experiment. Significant differences (.05 level) were recorded in FCM, Fat, Protein and total solid production per animal per day between setaria grazed at 3 weeks versus 5 weeks. However no differences occurred between setaria and Rhodes grass at 3 weeks or at 5 weeks.

A further series of studies was conducted in 1968, but data are not completely analysed. Additional individual animal measurements of intake using chromium (Cr_2O_3) and digestibility using (fecal nitrogen) were obtained daily over a 16 week period. 800 lb dry matter of each treatment was fed to sheep for intake and digestibility measurements at Gatton. Frequent plant samples have been analysed by both chemical and *in vitro* techniques.

Dolichos lablab cv. Rongai was the first legume evaluated in 1968. Sowings of Siratro and greenleaf desmodium were also made, and it is hoped that a three-way trial with these three legumes can be conducted in 1969. Early results with *D. lablab* have demonstrated the "high" quality of this legume. Dairy cattle maintained an average yield of 2.3 gallons per animal per day over a 60 day period on a sole feed of *D. lablab*. This resulted in an approximate gross return of \$112.00/acre on the Brisbane market for quota milk or approximately \$60.00/acre for butter from a 5 acre paddock.

Also of interest, was the response of this legume to grazing management. When "tightly" grazed with both leaf and stem consumed, regrowth was seriously reduced. If only the leaflet and petiole were grazed, rapid regrowth from the axillary buds resulted. Three or four weeks was sufficient for regrowth and the paddock was ready for the second grazing. Further grazing was prevented by frost on June 13. With the use of irrigation and management (grazing and use of *D. lablab* with grass or other pastures) this legume undoubtedly will make a very valuable contribution.

Grazing managment of tropical grass pastures with high input of nitrogen is very critical if high quality is to be achieved. "Quality" never increases, it may hold level, but never gains. With the tremendous rate of growth of the pastures accentuates the rapid decline in quality and this occurs in a sequential manner. That is stem, leaf blade and leaf sheath regrowing at different rates within each internodal segment of the stem. The parts of plant of lowest quality are the leaf sheath and older stem parts. Young stem tissue is equal in quality to young leaf tissue, but declines much more rapidly, while leaf tissue declines the least of all. If one then uses the criterion of 70% digestibility as a satisfactory level of quality, it is apparent that tropical grass pastures must be grazed more frequently than every three weeks for a large part of the summer season. Not only will quality be high but in addition, this is the most important method of achieving maximum utilization.

The clipping height of the grass stubble is also important in this respect. If a high (greater than 2") stubble remains, cattle tend to avoid tight grazing because of the physical impediment of the needle-like projecting stems. They do not have access to the young leaf material developing within this stubble and generally a high proportion of high quality feed is wasted. To obtain complete utilization of a high quality grass pasture, therefore, one must graze frequently and tightly if high production per animal is desired and efficient conversion of pasture to milk achieved.

Supplementary Feeding

The needs for supplementary feeds and definition of critical periods are considered of importance where rainfall is seasonal and winter temperatures low. Experiments with tropical grass as silage, hay and autumn pasture have been conducted to assess the response of lactating animals to additions of energy and protein alone and in combination. Lucerne chaff has been used as the control treatment supplemented with both protein and energy. Preliminary results indicate that level of digestible energy intake is highly correlated with milk production and that supplemental feeding of high energy feeds (e.g. sorghum) will increase production. These data augment the initial studies on grasses in pure stand and emphasize this important characteristic of high quality. This suggests that digestible energy intake is perhaps the most important measurement in describing quality from the standpoint of animal production.

DISCUSSION

Dr. Hamilton how do you regard Kikuyu grass?

Dr. Hamilton: I did not use Kikuyu in my work but I'm quite an admirer of the grass. It does have a low growing habit with the stems prostrate. This requires continuous heavy grazing, but I haven't seen Kikuyu grass grazed properly around here. If it is grazed hard then all the green leaf produced is used and is high quality feed. If you let it go its value declines and it is hardly better than any other grass.

Would you say it might be economically profitable to mow the paddocks right down to ground level occasionally?

Dr. Hamilton: Without doubt, this should be done if you want to use the material growing below stubble height. The degree to which you do this depends on what sort of pasture you want to have. Generally grass-legume pastures cannot be grazed too hard or the legume will disappear. This seems to be the case with some tropical legumes. The fact of the situation is this, that if you are producing milk then the grass must be at around 70% digestibility otherwise it will be necessary to supplement with concentrate feed.