KIKUYU—(PENNISETUM CLANDESTINUM) AS A PASTURE GRASS—A REVIEW

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INTRODUCTION

Kikuyu grass (*Pennisetum clandestinum*) has often received more attention for its qualities which prevent soil erosion than as a pasture species. In Australia and in many other parts of the world where kikuyu has been introduced, the grass has colonized and encroached on many endemic pastures, but whether this has been desirable is often disputed. As the grass is now widely distributed throughout the subtropics, it is timely to review the available information and assess the value of kikuyu as an improved pasture species. The role of kikuyu for soil conservation purposes was reviewed by Cameron[25] and its introduction to Australia has been recently documented[14].

BOTANICAL DESCRIPTION

The grass was identified as *Pennisetum clandestinum* Hochst. ex Chiov.[99], although for a time it was confused with *P. longistylum Hochst.*[113]. The species has been adequately described and illustrated on several occasions.[14, 21, 25, 30, 113] Kikuyu is a prostrate perennial, which may form a loose sward up to 46 cm (18 inches) high when ungrazed, but under grazing or mowing assumes a dense turf. The grass spreads vigorously from rhizomes and stolons which root readily at the nodes and are profusely branched. Short, leafy branches are produced from stolons, with leaf blades strongly folded in bud, later expanding to 44.5-114.3 mm ($1\frac{3}{4}$-$4\frac{1}{2}$ inches) long and 6 mm wide, tapering to sub-obtuse tips. Leaf surface is sparsely and softly hairy. The ligule can be recognised by a ring of hairs and the collar by a prominent pale yellow colour. The flower is small, consisting of a spike of 2 to 4 sub-sessile spikelets which are partly enclosed within the uppermost leaf sheath. The spikelets are bisexual or functionally unisexual. The florets are protogynous and the stamens are rapidly exserted on long filaments, usually in the early morning. The stigma is branched and feathery. The large seed (2 mm long) is dark brown, flat or ellipsoidal with a prominent style.

ORIGIN AND GEOGRAPHIC DISTRIBUTION

Kikuyu grass occurs naturally as a forest margin species on the highland plateaux of east and central Africa at elevations between 1950 and 2700 m (6500-9000 ft) which include areas in Ethiopia, Kenya[14, 46, 83], Tanzania[108], Uganda[98], Ruanda[50], and the Congo[36, 66]. Mean annual rainfall ranges from 1000 to 1600 mm, which occurs either in a single wet season or is distributed over two 'rain' periods of shorter duration.[83] In Kenya the grass occurs throughout the Ecological Zone II[88], where upland forest is interspersed with grassy glades.

The species rapidly invades cleared areas in the first stage of succession and indicates a high level of fertility.[46] The grass is named after the Kikuyu people of Kenya who, traditionally, lived east of the Aberdare Mountains, where the grass thrives. Travellers and hunters who passed through the central African highlands in the early part of the century, were impressed by its vigour and some successful introductions were made by individuals to various countries in Africa and overseas. For example in 1910 Forbes collected a root at Lake Naivasha which he sent to the Botanic Gardens in Pretoria.[25, 99]

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Seed was introduced to Australia from the Congo in 1919.[21, 113] From one seed which germinated in the Botanic Gardens Sydney, sufficient vegetative material was bulked at Hawkesbury Agricultural College by November-December 1920, to enable many cuttings to be distributed throughout the state. Material was also sent to Queensland, Victoria, South Australia, Western Australia, New Zealand and Fiji. Separate introductions were also attempted in S. Australia,[85] from cuttings obtained in Kenya, and more recently 15 strains were obtained from Kitale and tested at Grafton in New South Wales.[116] Since these introductions were made, kikuyu has become distributed along the eastern seaboard of Australia where dairy farming is practised from latitude 17°-37°S.

Since 1920, kikuyu has been introduced to many countries in higher latitudes with humid subtropical climates and to countries with similar highland regions near the equator. Reports of the performance of kikuyu from early screening trials have varied according to the purpose of the introduction and the type of farming practised. Kikuyu grass has been listed a promising introduction for certain regions in Angola[89], Nigeria[51, 61, 107], Cameroon[87], Morocco[7, 71], Swaziland[11], South Africa[96], Rhodesia[115], St. Helena[3], Mauritius[10, 119], Madagascar[20], Madras[28, 91], Ceylon (Jayawardana pers. comm.), Taiwan (Huang Chia pers. comm.), Norfolk Island[100], Hawaii[62], Brazil[15, 44, 106], Paraguay[86], Costa Rica[81], Panama[74], Colombia[40], New South Wales[113] and Queensland[118].

Kikuyu has become a weed after being introduced to California[124], particularly in irrigation areas, and is considered of limited value in the North Island of New Zealand[17, 55], Jamaica[4], Fiji (Roberts pers. comm.) and in New Guinea (Conroy pers. comm.).

Highly productive kikuyu pastures have been developed over a wide geographical range, which includes ecologically suitable areas in South Africa[96, 104], the highlands of Rhodesia[115], Congo[36], Hawaii[123] and Colombia[40, 43]. The potential productivity of kikuyu when fertilized with nitrogen has been recognized in New South Wales by Strang[101] and Colman[31] and in Queensland by Gartner[52]. In Kenya, more attention has been given to selecting other grasses such as *Setaria sphacelata, Chloris gayana* and *Panicum maximum,* than kikuyu.[19] These grasses are more suitable for ley farming because seed can be harvested making establishment and eradication relatively easy. However, it has been noticed[9] that ley pastures of Nzoia Rhodes and Nandi setaria are often invaded by kikuyu or star grass (*Cynodon dactylon*) in the second year. At higher altitudes, short-term leys based on Italian ryegrass were recommended to counter the problem of kikuyu encroachment.[18]

RESPONSES TO CLIMATE

In the natural habitat of kikuyu at elevations above 2250 m, mean minimum and maximum temperatures range from 2-8°C and 16-22°C respectively.[83] Frosts occur sporadically at night. The present geographical distribution generally coincides with the mesothermal humid climates (equivalent to Köppen Cf and Cw types). Kikuyu will not survive sustained winter frosting. In the subtropics where frosts are light, exposed herbage is desiccated. Experience of the poor performance of kikuyu in low latitude tropical climates, suggests the species is not adapted to high temperatures. A reduction from 27° to 10° will inhibit exsertion of stamens in some strains[125], resulting in pollen of low viability. No other published evidence on the effect of temperature on growth of the species has been sighted.

Flowering in kikuyu does not appear to be sensitive to changes in daylength[125], a finding which is supported by numerous observations of flowering in localities from different latitudes (ranging from 0-38°).

Although rainfall in the native habitats of the grass is relatively high, kikuyu is able to utilize moisture at depth during dry periods in Kenya.[63] Transpiration of a kikuyu sward was measured daily at Mugaga by Glover and Forsgate.[54] Under the normal climatic conditions where evapo-transpiration is between 3.8-5.1 mm per day, the grass was able to extract moisture from the top 1.2 m of soil to wilting point and withdraw 17.7-20.3 cm, although rate of growth declined as moisture was exhausted. The capacity of kikuyu to utilize stored moisture indicates that the grass can mitigate the effects of dry periods, especially if nutrients are not limiting. The mean water use of a lawn in Israel was estimated to be 3.2 mm/day in the period June to October.[73] Without nitrogen more frequent irrigations had little effect on dry matter production. However, where nitrogen was applied at the rate of 42 kg/ha (37 lb/acre), dry matter yield was significantly increased from 750 to 2458 kg/ha which indicated that water was used more efficiently. Sixty per cent of the total water was extracted from the 0-60 cm layer, which contained almost 90 per cent of the total root weight. It was apparent from this investigation that relative root weight could not be used to indicate water use at the same depths.

GENETIC VARIATION AND REPRODUCTION

The somatic chromosome number of kikuyu is 2n = 36.[70] Edwards[47] initiated a search for strains of kikuyu in six ecological areas in Kenya. From this collection, Edwards recognized 3 ecotypes—Molo, Kabete and Rongai; mainly on leaf morphology and flowering behaviour, noting that Rongai did not exsert anthers. From original observations by Edwards, Carr and Ng[26] showed that repeated defoliation of the main shoots was essential to induce flowering from lateral shoots.

Conflicting evidence has been reported on the mode of reproduction in kikuyu. Taxonomists have established that bisexual and male sterile races exist, which has been confirmed recently.[124] Narayan[84] described the results of a limited number of pollinations of kikuyu on female-fertile Rongai strain. He observed that apomictic reproduction may have occurred from the formation of haploid aposporic embryo sacs. Carr and Ng[26] disputed this conclusion in favour of the hypothesis that some strains are genetically male-sterile. In Australia[85, 114, 117] and in other countries[47, 48, 91, 111, 124], flowering and seeding have been observed. Further work is required to confirm the possibility of apomictic reproduction. It is not surprising that considerable clonal variation exists in the Australian accessions[85] which are derived from seed and cuttings, but it would be difficult to recognize Edward's original ecotypes in the existing kikuyu pastures. It is suggested that future genetic improvement of kikuyu should be directed towards improved disease resistance (e.g. "yellow" disease) or possibly digestibility or cold tolerance, rather than qualities of vigour or free-seeding.

NUTRIENT AND SOIL REQUIREMENTS FOR GROWTH

Most reports stress the need for high fertility, if kikuyu is to be grown successfully. The soils where the grass is naturally distributed, are often characterised by deep, lateritic red loams, derived from volcanic parent material. Kikuyu readily adapts to similar soils in other countries where it has been introduced. In the subtropical dairy areas of Australia, kikuyu is often associated with *Paspalum dilatatum* and *Axonopus affinis*.[34, 52] The equilibrium of this association is sensitive to fertility changes, for example; around dairy bails and where fertilizer nitrogen has been applied at the minimum rate of 224 kg/ha, kikuyu rapidly becomes dominant.[53]

In the early 1930's, Taylor[104] initiated a programme of sustained research into the effects of fertilizers on the growth and chemical composition of kikuyu grass at Cedara Agricultural College, in South Africa. Intensively grazed and fertilized pastures of kikuyu contained exceptionally high protein contents—20.7 to 25.6 per cent. Dry matter production measured from caged areas, ranged from 7,280 to 11,200 kg/ha over the growing season October to May. These measurements appeared to under-estimate herbage production as the pastures were able to carry 3 cows on 0.4 ha, with some concentrate supplementation. Fertilizer was applied at the rate of 128 kg N, 34 kg P and 24 kg K per hectare which enriched the mineral content of herbage (Table 1). In other countries where kikuyu is endemic or has become naturalised, the potential productivity of kikuyu was largely overlooked until the 1960's. Reasons for this appear to be a pre-occupation with other grasses and companion legumes (particularly in Australia), the high cost of fertilizer nitrogen, lack of seed and a fear of the grass becoming a weed in cultivated areas.

There has been a revival of interest in the effects of fertilizer nitrogen on growth of kikuyu. Morrison[82] reported moderate growth responses of kikuyu to fertilizer nitrogen at high altitudes in Kenya (efficiency of response; 19-20 kg D.M./kg N applied) from infrequent harvests, but concluded that use of nitrogen might not be economical. A detailed study of the growth curves of kikuyu by Colman[31, 32] in northern New South Wales, showed that a ceiling yield of 30,000 kg D.M./ha/annum could be achieved in the environment by applying 1120 kg/ha fertilizer nitrogen. The efficiency of response ranged from 18-24 kg D.M./kg N applied. On the South Coast[120] and in the Hunter River Valley[112], nitrogen at the rate of 112-134 kg/ha stimulated autumn growth of kikuyu (efficiency of response 13-27 kg D.M./kg N applied). On the Atherton Tableland[53], a kikuyu dominant association produced 12,170 kg D.M./ha in a year (efficiency of response was 17-24 kg D.M./kg N applied). Kikuyu outyielded all other introduced species in test plots at Gympie in south eastern Queensland.[93] Younge and Ripperton[123] estimated that kikuyu pasture produced 9,500 kg D.M./ha over 14 months in Hawaii. In highland Colombia[43] pure swards of kikuyu have responded to increased applications of nitrogen (up to 150 kg/ha). However in other studies[29], kikuyu mixed with red and white clover did not respond markedly to nitrogen applied at rates ranging from 0-100 kg/ha and it was concluded that the effective clover component (25-60%) obviated the need for nitrogen, although increased nitrogen application reduced legume percentage.[29]

The results show that kikuyu is responsive to nitrogen fertilizer and in some cases the efficiency of response has been high. When nitrogen is applied, the competitive ability of kikuyu is increased in relation to other grasses such as *Axonopus, Paspalum* in Australia or rats tail fescue in Hawaii. Another feature is the ability of the grass to maintain a relatively high nitrogen content (ranging from 1.3-4.6 per cent) even when mature. Many workers also reported a significantly longer growing season when nitrogen was applied.

The phosphorus requirement of kikuyu alone has seldom been investigated. Morrison[82] reported a moderate response to triple superphosphate applied at 336 kg per ha in Kenya, which appeared to be greater where cultivation was practised. Phosphorus stimulated a twofold increase in yield of kikuyu in Colombia in the presence of 40 kg N/ha.[43] Superphosphate responses of kikuyu/clover pastures usually reflect increased growth and nitrogen yield from the legume component. Such responses have been obtained in Hawaii[92], Congo[36] and Queensland.[22] Response to phosphorus appears to be limited to extremely deficient soils. On other krasnozem soils in Australia, kikuyu has not responded strongly to applied phosphorus.[52] The grass appears to maintain a high P content ranging from 0.20 to 0.42%.[75, 110]

Potassium deficiency in kikuyu pastures is not likely to occur unless intensive cutting or dairy farming on a "day-night" paddock system has been practised. Potassium deficiency has been induced under plot-cutting experiments and high nitrogen application on the Atherton Tableland[53] and in New South Wales.[75, 109] Potassium deficiency symptoms in kikuyu appear as tip-burning and senescence of the lower leaves which is asociated with reduced potassium content in herbage (0.64-1.00 per cent).[75]

Kikuyu responded to sulphur on a krasnozen soil in Queensland after repeated cutting and heavy watering in pot experiments.[27] Usually superphosphate applied at 251 kg/ha would correct any marginal sulphur deficiency. It is not known whether the use of high rates of nitrogen as ammonium nitrate or urea, will increase the requirement for sulphur in kikuyu pastures.

The effects of micro-nutrients on kikuyu grass have not been studied in detail. The contents of micro-nutrients (p.p.m.) of kikuyu grown in Kenya were—Mn 48.5, Fe 117.0, Cu 8.0, Zn 33.8, and B 4.5.[12]

ESTABLISHMENT

Planting vegetative stem and root cuttings by hand has been the traditional method of establishing kikuyu in most countries where it has been purposely distributed.[21, 25, 113] Optimum spacing of sprigs has varied according to the purpose of the pasture and availability of planting material. Planting sprigs (each containing 2-3 nodes) on a 0.9 m grid has been recommended[25] and used successfully in Hawaii.[122] Over larger areas a method of broadcasting cuttings, followed by discing and rolling has been used successfully in Natal during misty weather (Edwards pers. comm.). In weed-free, prepared seedbeds satisfactory establishment has been obtained by mechanical methods of planting.[94] An establishment fertilizer containing nitrogen and phosphorus has been recommended.[25] While these methods served to introduce the species to a locality, it is clear that under grazing, kikuyu spreads from seedlings germinating in dung-pats. It is presumed that the present wide distribution of the grass in dairy areas along the eastern seaboard of Australia, has been due to this method of dispersal.

MANAGEMENT

Many attempts have been made to renovate so called "worn-out" or "degenerate" pastures by mechanical cultivation[36, 45, 82, 105], but beneficial effects proved to be short-lived, unless inorganic fertilizer nitrogen or a legume was incorporated.

Evidence on the management of kikuyu/legume associations has been mostly based on small-plot cutting experiments or from observations of grazed areas. *Trifolium burchellianum* and *T. semipilosum* occur naturally with kikuyu at high altitudes in East Africa.[46, 47, 56] When renovation and the application of phosphorus-containing fertilizer were combined, white and red clovers have been established in kikuyu pastures in Hawaii[92], S. Africa[105], Congo[36], Queensland[22], New Zealand[16], Colombia[43] and Madras.[90] Close grazing or cutting designed to avoid the build-up of a dense mat of stolons is necessary to maintain temperate legumes. This type of management is often difficult to sustain throughout the year under farming conditions which may explain why kikuyu pastures are often devoid of legumes. Time of application of phosphorus fertilizer may effect the legume response, but this aspect has not received detailed attention. At Maleny in Queensland, Bryan[22] reported that *Paspalum dilatatum* contained a higher proportion of white clover than kikuyu. The nitrogen yield of clover-kikuyu pastures does not appear to have been measured precisely on a yearly basis. In Colombia, maximum production of green herbage and protein content was obtained from clover/kikuyu pastures cut to 5 cm every 9 weeks.[41, 43]

Management of kikuyu pasture to maintain an effective tropical legume component, is likely to be different from white clover/kikuyu pastures. In New South Wales, Colman[33] reported that grazing every four weeks reduced the percentage of *Glycine wightii* cv Clarence compared with 8 or 12 weekly grazing. The effect of increasing the rate of nitrogen from nil to 224 kg/ha, was to reduce yield severely at the four weekly but only slightly at the 8 weekly and 12 weekly grazing intervals. The advantage of maintaining the tropical legume by adopting the strategy of infrequent grazing must be offset against the decline in quality of grass. In the same locality, a well managed kikuyu/glycine pasture yielded 207-159 kg N/ha over three summer-autumn seasons.[34] On the Atherton Tableland, kikuyu associated with Tinaroo glycine had a higher nitrogen content than without a legume, but yield of nitrogen in the mixture was 100 kg/ha, compared to 137 kg/ha in a pure sward.[60]

Despite the many references about the desirability of kikuyu/clover pastures, it is evident that kikuyu does not readily combine with legumes unless special management practices are undertaken to maintain effective associations. Under farming conditions these practices may be difficult to achieve.

Effective management of kikuyu grass with applied nitrogen demands a knowledge of the interaction of frequency and severity of defoliation with nitrogen application. Some information is available on kikuyu from cutting experiments. Colman[32] studied the effect of close-cutting a sward every 2, 4, 6 and 12 weeks at nil, 112 and 224 kg N/hectare. Frequent cutting every 2 weeks reduced dry matter yield by 54 to 25 per cent compared to the maximum yield at the 12 weekly cutting interval. The depression of dry matter yield was greater in the presence of nitrogen than in its absence. Mean yield of nitrogen of herbage, fertilized with 224 kg N/ha and cut every 2 weeks, was 176 kg/ha compared to 131 kg/ha when cut at 12 weeks. This response differed from the effect of frequency of defoliation on the nitrogen yield of pangola, another stoloniferous grass[23], where longer cutting intervals gave greater yields of nitrogen. The different response between the species may be explained by either the higher nitrogen content of kikuyu or differences in cutting height between the experiments.

Investigations have not been made to determine whether rotational or continuous grazing would result in more efficient use of nitrogen and greater animal production from kikuyu pasture. In most grazing experiments, rotational grazing has been used on the assumption that the practice is more efficient than continuous grazing. It is likely that maximum production will be obtained from frequent, hard grazing of kikuyu fertilized with nitrogen. The interaction of grazing management and fertilizer application for optimum animal production from kikuyu remains largely unexplored.

SEED INCREASE

The difficulty of harvesting seed which is set close to the ground[48], has prevented seed prduction on a commercial scale for many years. Most attention has been focussed on vegetative propagation. Recently Wilson[117] used a rotary mower and catcher to harvest medium quantities of seed. Seed yields were high (range 252-445 kg/ha) which suggests that commercial seed production is feasible, provided that harvesting machinery can be modified. Wilson stated that separating seed from herbage material can be achieved by hammer milling (1255 RPM) and winnowing, although the technique requires further study.

ERADICATION

The ability of the grass to spread by vigorous stolons and rhizomes has led to ambivalent attitudes about its desirability. Where land is used for cultivated plantation crops such as tea and coffee[57] or for irrigation crops[126], the grass can be a weed which could only be eradicated laboriously in the past by hand. Repeated mechanical cultivation can be successful during dry weather.[68] Recently it has been shown that several herbicides, including "dalapon",* have been used successfully to kill kikuyu swards in California[126], Madras[102], East Africa[57] and New Zealand.[55] Complete eradication will depend on suppressing the successive seedling regenerations. At this stage of knowledge, kikuyu should be reserved for permanent pasture, although the use of chemicals, combined with minimum tillage methods for cropping in a ley system, should not be completely discounted in the future.

*Registered trade name.

DISEASES AND PESTS

Larvae of the pasture scarab beetle (*Rhopea magnicornis*), *Tarsonemus* mites and soldier fly *Atlermetapomia rubiceps,* have caused temporary damage to kikuyu in Australia.[1] The effects are usually shortlived.

A disease known in New South Wales as "Kikuyu Yellows" is the major disease of the grass.[1] Symptoms can be recognised by patches of yellow, chlorotic leaves which develop and expand in a pasture. Although it was known to occur for many years, the increased use of fertilizer nitrogen has focussed attention on the disease. The pathogen causing the disease has not been identified with certainty, although the evidence suggests that the agent is a soil-borne fungus. The disease is receiving attention by workers in northern New South Wales.

CHEMICAL COMPOSITION AND FEEDING VALUE

On the basis of chemical composition, kikuyu grass compares favourably with other tropical grasses, although there are few reports where kikuyu has been compared with other species under similar soil and climatic conditions. In Kenya, the grass consistently appeared to produce herbage low in fibre and high in crude protein.[5, 6, 8] Frequency of defoliation affects the chemical composition of kikuyu in the predictable manner; with increasing age of regrowth, crude protein and mineral content declines while fibre content increases.[95, 97]

A range of mineral contents of kikuyu is given in Table 1.

Generally phosphorus, potassium, calcium and magnesium levels in herbage have been adequate compared with other species, although critical values, which have been set for phosphorus in legumes[2], have not been determined for kikuyu. Several workers have followed the seasonal fluctuation in nutrient content of kikuyu.[38, 75, 104, 121] Results showed that the mineral requirement of grazing animals could be satisfied from fertilized kikuyu grass, with the possible exception of calcium for beef cattle in Hawaii.[121]

Protein

An outstanding feature of kikuyu is the high crude protein content in the leaves. This seems to apply in most countries where feeding value has been assessed. Milford and Haydock[76] showed that crude protein content could be used to predict crude protein digestibility ($r = 0.885$) and that animals were likely to succumb to negative nitrogen balance, when protein level in feed declined to 8 percent. Crude protein level in kikuyu grass which was cut at 31-150 days of regrowth, never fell below 12 percent and was consistently maintained above all the grasses in the study. This indicates that kikuyu should be able to maintain stock in good condition with the advance in the season, provided that sufficient feed was available. These results have been confirmed by Holder[58, 59] in northern New South Wales, where crude protein levels remained above 12 percent even after 99 days regrowth, except for one instance where winter carry-over only contained 6.3 percent crude protein in the following November. In Hawaii[97], crude protein declined with increasing age to a level of 7.3 percent at 126 days regrowth. In most situations animal production from kikuyu pasture, including milk[42], would not be limited by protein intake.

Dry matter intake and digestibility

The measurement of voluntary intake by pen-fed animals has been shown by Milford and Minson[77] to be a suitable method of evaluating different pastures or species. The same workers[78] tabled figures of intake (g/kg LW $^{0.73}$) of several species, including kikuyu by pen-fed animals. Intake of kikuyu grass was 73 and 70 g/kg LW $^{0.73}$ at 30 and 80 days regrowth, which compared favourably with other

TABLE 1

Chemical composition of kikuyu leaves from various sources

Country	Height cm	% dry matter										Notes
		N	EE	NFE	Fibre	P	K	Ca	Mg	Na	Cl	
Natal (110)*	10-15	2.18	—	—	29.1	0.29	2.73	0.41	—	0.30	1.87	fertilized
Natal (104)††	—	3.77	—	—	—	0.36	3.39	0.29	—	—	—	with NPK
New South Wales (70)††	10-15	4.60	—	—	—	0.28	2.40	0.67	0.24	—	—	fertilized NPK
New South Wales (70)††	22-30	2.35	—	—	—	0.38	3.15	0.39	0.35	0.08	—	fertilized PK
Kenya (24)	22-30	3.76	3.0	35.6	24.5	—	—	—	—	—	—	—
Hawaii (93)	—	1.88	1.9	46.3	31.8	0.28	—	0.26	—	—	—	6 wk regrowth fertilized NPK

( )*Refer to Bibliography
††grazed pasture

grasses. With high application of nitrogen fertilizer, depressed intake has been recorded.[77] Dale and Holder[42] suggested that the lower digestible energy intake of a kikuyu/glycine pasture compared to a lucerne and concentrate ration, was the main reason for low milk production.

Several workers[58, 59, 77, 78, 97] have published figures on digestibility of dry matter of kikuyu which compare favourably with other tropical grasses listed in the review by Butterworth.[24] The range of values from different countries is given in Table 2, which are lower than values generally obtained with temperate species at equivalent stages of growth.

TABLE 2

Maximum and minimum dry matter digestibility of kikuyu grass pasture

Country	Maximum	Minimum
	% digestibility	
New South Wales	73.9 (36)	53.3 (180)
Hawaii	60.4 (42)	40.2 (168)
Queensland	63.0 (20)	53.0 (150)

( ) days regrowth

Studies on kikuyu silage[60] revealed that although the feed was palatable to dairy cows, a considerable loss of dry matter occurred and digestibility of dry matter of silage was about 19.5 units lower than the freshly cut grass.

It is clear that the feeding value of kikuyu ranks high among the available tropical grasses at present. The ability of the grass to retain a relatively high crude protein content at various stages of growth, led to the proposal that grasses could be improved by selecting for this charactistic.[76]

ANIMAL PRODUCTION

Although kikuyu/clover pastures have been recommended for dairy production in Natal[104], eastern highlands of Rhodesia[13], New Zealand[16] and for beef production in the Congo[103] and Hawaii[122], there is little published evidence on animal performance from these areas.

The earliest records of dairy production were reported from Natal.[104] An area (0.4 hectare) of fertilized kikuyu was grazed by three Jersey cows on a "put and take" system from October to May. The cows were fed supplementary maize meal at the rate of 0.45 kg at each milking time. Over seven years 1933-40, production ranged from 15,550 kg-8260 kg milk per hectare (764-442 kg butterfat per hectare respectively).

Colman and Holder[35] reported the first account of the effect of stocking rate on butterfat production from a kikuyu-based pasture fertilized with nitrogen at the rate of 336 kg/ha. At stocking rates of 1.64, 2.47 and 3.29 cows/hectare, production per cow varied from 99 kg at the high stocking rate to 118 kg at the low stocking rate in 1966-67 lactation. This medium performance was reflected in production per hectare which ranged from 183 to 327 kg B.F./ha. They suggested that further increases could be expected at a higher stocking which was achieved in the following two lactations. At 4.94 cows/hectare, total annual butterfat production was 447 and 361 kg/hectare respectively.[67] It has been suggested[79] that animal production obtained from grazing pastures at a low grazing pressure, could be used to measure differences in quality between various species. This approach has been used to compare milk production from kikuyu and other species. Kikuyu has not shown a consistent superiority over other grasses, and per cow production has also been mediocre. In Queensland, Minson and McLeod[80] reported that milk production on kikuyu pasture averaged 16.6 kg/day compared to 14.7 kg/day on rye grass. In New South Wales, there was no significant difference in daily milk production (which ranged from 9-12 kg) when kikuyu was compared with setaria, pangola and a green panic/ Rhodes grass mixture.[64] The results suggest that it may not be possible to sustain high production per cow from kikuyu grass, which infers that high stock density should be aimed for, if intensive systems are to be economic.

Little published information is available on beef production from kikuyu pasture. Taton[103] stated that 2 ha of kikuyu/white clover pasture in the Congo would support three bullocks weighing 300 kg provided some supplement were given in the dry season. In Hawaii, beef production was compared on four pastures, each sown with *Desmodium canum* and fertilized with lime (6 ton/ha) nitrogen (39 kg), phosphorus (73 kg), potassium (146 kg), boron (6 kg) and molybdenum (2 kg) per hectare. The average annual liveweight gain over four years from native grass, kikuyu, *Paspalum dilatatum* and pangola were 587, 644, 706 and 806 kg/ha/year respectively.[122] In Rhodesia, irrigated kikuyu/clover pastures have been productive in the spring months and could be used in a forage sequence with native and sown pastures for beef production (Addison pers. comm.).

In view of the encouraging increases in beef production resulting from the use of nitrogen fertilizer on pangola grass[40], setaria and Rhodes grass[65], more information is required from kikuyu pastures.

ANIMAL DISORDERS

There have been few reports of animal disorders after kikuyu pastures have been grazed. Where rapid pasture growth follows a period of drought, cattle deaths have occurred in New Zealand[39] and disorders suffered in northern New South Wales (Kaiser pers. comm.). Clinical symptoms of the disorder in both cases were abdominal distension, inco-ordination of hind legs followed by recumbency, sunken eyes, salivation and death in extreme cases. Causes of the disorder are only tentative at this stage. Cordes *et al*[39] reported acute ruminal indigestion and alkalosis from post-mortem investigations. In New South Wales, the disorder occurred on pastures which had previously received 336 kg N/ha as sulphate of ammonia over four years.

FUTURE ROLE OF KIKUYU

Since kikuyu was dispersed to many countries in the early 1920's, the grass has become naturalised in many regions with humid mesothermal climates. It is likely that kikuyu will become more important in pastoral economies, particularly where greater amounts of fertilizer nitrogen are used. In Australia, where plantation agriculture has not been practised, the introduction of kikuyu was welcomed by farmers who regarded it highly. It is surprising that a species which has been known for nearly 50 years, has received so little attention from research workers.

The late J. Griffiths Davies proposed the following characteristics which a desirable tropical pasture grass should display:— high dry matter yield for the environment, ability to respond to fertilizer, retention of high mineral content, long period of vegetative growth, maximum digestibility and intake of dry matter, ability to withstand heavy grazing, a degree of cold tolerance and a growth habit which is compatible with legumes. It is clear from the review of literature that kikuyu possesses these attributes, except the latter.

The same characteristics which make kikuyu a desirable pasture grass, also make the grass a weed, particularly in developing countries where reliance is placed on plantation crops. The future use of herbicides (e.g. dalapon) may lessen the menace which the grass poses in this situation. Although at present kikuyu is unsuitable for a ley farming system, the possible use of herbicides and minimum tillage should be considered in the future.

There is a need to verify the many observations on kikuyu grass by obtaining critical evidence on:— the mode of reproduction, pattern of nutrient uptake and distribution through the plant, reaction to defoliation and subsequent effect on bud initiation, growth responses to variation in temperature, moisture and daylength, long-term animal performance and seed production.

In the case of kikuyu, the problems associated with the introduction and adaption have been largely solved through natural ecesis, both in Australia and in many other countries. In line with the thought propounded by Lamond[72], it seems opportune to devote as much attention to kikuyu, as to newer exotic species.

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