Chapter 5

Phenotypic Variation amongst Populations of *Pennisetum clandestinum*

5.1 Introduction

The variation present in naturalised populations of Australian kikuyu grass ecotypes has not been studied in detail. Given kikuyu's early rapid and widespread distribution throughout the 1920s and 1930s, through to today's continuation of spread and naturalisation by means of natural dissemination and human agency, the grass can be found growing across Australia in a wide range of environments and micro-climates. As such, one could expect significant variation has developed between populations due to the biotic and abiotic stresses imparted to them, leading to the development of definite ecotypes.

The 1970 cultivar 'Whittet' was the first registered kikuyu grass to be released in Australia and its high seed production facilitated its extensive use. It was also promoted as a preferred pasture form on the basis that it had a more open growth habit which allowed combination growing with legumes. Today, commercial seed sold across Australia is primarily 'Whittet' in origin. Because of this dominance it is important to compare 'Whittet' with the naturalised ecotypes.

5.2 Materials and Methods

5.2.1 Selection of kikuyu lines.

A total of 16 selected kikuyu lines were used for this study. Twelve were presumed ecotypes selected in the field based on distinctive phenotypic traits and vegetatively propagated in large pots at the Plant Breeding Institute, Cobbitty, NSW. Another three were the product of chemical mutagenesis of c.v. 'Whittet', selected by NSW Department of Agriculture personnel on the North Coast of NSW in 1996 (Luckett

et. al., 1996) and supplied to PBI in 2002 as vegetative material by the Department's Wollongbar Agricultural Research Station. These lines were maintained at the Plant Breeding Institute's vegetatively propagated field plots, from which stolons were taken for vegetative propagation in large pots as for the ecotypes. The sixteenth line was the vegetative increase of a single seedling of cultivar 'Whittet' that I selected from a population raised from seed soured from the Eykamp Kikuyu Company. The reason for using a single seedling as the starting point was to avoid the genotypic variation that inevitably occurs in seedling populations grown from open pollinated seed.

The original aim was to include ecotypes representing each state and territory of Australia, however due to the lack of any material from Western Australia and the Northern Territory at time of planting, they were not represented in the trial. Multiple selections from one state were used, such as Queensland, where a selection from Weipa and a selection from Toowoomba were included, and NSW, where four accessions representing the north and south coasts, as well as the known original kikuyu line collected at Berambing. A full listing of material used in the trial is provided in Table 5.1.

Table 5.1. Schedule of the 16 lines used in the study.

Accession	Propagation Method and Source	Sexuality**
KC900	Vegetative – North Coast, NSW*	FF
KC901	Vegetative – North Coast, NSW*	FF
KC902	Vegetative – North Coast, NSW*	FF
KC903	Vegetative – Cobbitty, NSW	FF
KC915	Vegetative – Toowoomba, QLD	FF
KC924	Vegetative – Canberra, ACT	MS
KC930	Vegetative – Morphettville, SA	FF
KC932	Vegetative – Weipa, QLD	FF
KC934	Vegetative – Stanley, TAS	FF
KC941	Vegetative – Numbugga, NSW	FF
KC945	Vegetative – Tathra, NSW	MS
KC950	Vegetative – Berambing, NSW	FF
KC965	Vegetative – Grafton, NSW	FF
KC966	Vegetative – Cranbourne, VIC	FF
KC1099	Vegetative – Cobbitty, NSW	FF
KC1100	Seed – Single seedling selection, PBI ***	FF

* Selections from chemical mutagenesis of cv. 'Whittet' supplied by Wollongbar Agricultural Research Station, NSW.
** Denotes plant sexuality, FF – Fully Fertile, MS – Male Sterile
*** Propagated vegetatively from a PBI selected single seedling of commercial "Whittet" seed supplied by Eykamp Kikuyu Company.

Accessions KC900, KC901 and KC902 have all been derived by chemical mutagenesis of 'Whittet' seed using either sodium azide followed by diethylene sulphate or vice-versa as part of a study undertaken by Luckett *et. al.* (1996) in an attempt to induce the brown mid-rib gene (BMR) and improve protein content of kikuyu for grazing purposes. Several lines were kept at the completion of the trial for kikuyu yellows analysis (*Verrucalvus flavofaciens*), with the three mutants said to show good resistance (P. Wong, pers. comm., 2005). In the DNA analysis, Chapter 6, the three mutants grouped separately from the remainder of the selections, but remained within the first grouping containing the 'Whittet' selection (KC1100).

An unusual growth habit was observed following planting of ecotype KC945 in January, 2005, after its collection from sand dunes at the south coast township of Tathra, NSW. The ecotype maintained a tufted style of growth habit for a period of over 18 months with very little lateral spread whilst being maintained in the germplasm collection. Throughout this period as well, it only produced one flower, a

stigma, therefore was deemed unsuitable for inclusion in the hybridisastion studies but of great interest for the range of phenotype variation studies. In the DNA analysis, ecotype KC945 separated into a second grouping consisting of kikuyu grasses growing in predominately cool locations, but was not associated closely with any other accessions.

5.2.2 Germplasm Establishment

Vegetative germplasm was initially established in 20cm pots (one pot per line) by planting stolon material of at least 2 nodes. Once fully established, 3 plugs of 5cm in diameter were extracted from the pot. The roots were washed free of all potting mix and the verdure was trimmed to 5cm above the top of the visible thatch layer before planting into the plots, one plug per plot.

5.2.3 Plot Establishment and Layout

The plots were established at the Plant Breeding Institute's Lansdowne Farm, Cobbitty NSW, in the sandy soil towards the northern boundary of the property. The selections were planted in the centre of $4m^2$ plot (2m x 2m grid) laid out in a randomised design with 3 replications, Figure 5.1. Plots were allocated utilising a table of random numbers. The soil type was a sandy loam with a D_{50} particle size of 0.39mm. After leveling of the plot, it was heavily watered and weed seeds were allowed to germinate, before two applications of glyphosate at label rates were applied 14 days apart to kill any emerging weeds. Prior to planting, an application of the pre-emergent herbicide Ronstar® (a.i: Oxadiazon 20g/kg) was made at label rates for weed prevention, whilst any monocotyledonous weeds were controlled post planting either via mechanical or spot chemical means. Irrigation was applied to the plots daily to ensure successful establishment, and then as needed throughout the rest of the trial period. Phosphorus levels were tested prior to planting using the Bray No. 2 method: the soil was found to contain 196mg/kg of soil of available P, a more than adequate level. No fertiliser was applied to the plots throughout the duration of the trial, so that individual characteristics of each selection could be expressed and observed fully. Soil pH was 6.5.

1	**2**	**3**	**4**	**5**
KC1100	KC932	KC941	KC930	KC900
6	**7**	**8**	**9**	**10**
KC945	KC902	KC950	KC966	KC1100
11	**12**	**13**	**14**	**15**
KC901	KC945	KC915	KC924	KC950
16	**17**	**18**	**19**	**20**
KC965	KC1099	KC902	KC941	KC932
21	**22**	**23**	**24**	**25**
KC1099	KC901	KC934	KC930	KC934
26	**27**	**28**	**29**	**30**
KC903	KC965	KC900	KC924	KC934
31	**32**	**33**	**34**	**35**
KC903	KC1100	KC950	KC966	KC900
36	**37**	**38**	**39**	**40**
KC945	KC915	KC903	KC915	KC1099
41	**42**	**43**	**44**	**45**
KC901	KC924	KC930	KC932	KC965
46	**47**	**48**		
KC966	KC941	KC902		

↑
N

Figure 5.1. Plot layout showing ecotypes used in the study.

5.2.4 Plug Establishment

The plugs were planted (one plug per plot) within the trial plots on Wednesday January 3rd, 2007. They were left to establish for a period of 22 days until Thursday January 25th, 2007, when they were trimmed back to a consistent 5cm diameter using a short piece of 50mm PVC pipe with a bevelled edge. During the 22 days of establishment, the plugs had started to establish runners, which were removed from the plot. The verdure was again trimmed back to a height of 5cm above soil level and excess leaf material was removed. This procedure was followed to provide a uniform starting condition for the observational period, free of any transplanting shock.

5.2.5 Trial Period

Field measurements commenced Friday February 2nd, 2007, and continued every Friday for a period of 15 weeks until Friday May 18th, 2007. There were 16 measurements spanning a period of 15 weeks.

5.2.6 Field Measurements

Field measurements on the ecotypes within the plots at Lansdowne Farm, Cobbitty, NSW, included:

- Longest runner
- Foliage height
- Internode length
- Node width (the fourth visible node along the stolon from the tip)
- Stolon width (the centre of the stolon between the third and fourth visible nodes from the tip)
- Leaf width
- Coverage

Measurements for internode length, node width, stolon width and leaf width (thickness at the 4th nodal point from the tip) were recorded using a pair of digital calipers and recorded between the 3rd and 4th nodes on a single runner selected at random in each plot on the occasion of the first measurement. The same runner was used for all subsequent measurements. Measurements for longest runner and foliage

height were recorded using a measuring tape from the centre of the plug. Coverage was determined using a 2m x 2m quadrat divided into 100 squares. The plant was only counted covered when each square was fully covered.

5.2.7 Environmental data.

Environmental data was obtained from the Bureau of Meteorology website (www.bom.gov.au) using data recorded at Camden Airport, located adjacent to the Lansdowne Farm trial site. Data recorded included:

- Average temperature
- Relative humidity
- Rainfall

In addition, solar radiation data was obtained from the Bureau of Meteorology, Sydney Airport Recording Station, the closest radiation station.

5.2.8 Calculation of Relative Growth Rate

The application of the compound interest law to the analysis of plant growth problems was first promoted by Blackman (1919). Relative growth rates form a useful adjunct to absolute growth rates in the examination of the development of swards. This is particularly so when there is a marked change in the favourability of growing conditions over the period of observation, as in the present study.

The relative growth rate of the factors height, leaf width, runner extension and coverage were calculated. This was done using the equation:

$$\text{Relative Rate} = \frac{\log_e V_2 - \log_e V_1}{T_2 - T_1}$$

Where V_2 is the value at time 2

V_1 is the value at time 1

T_2 is time of second measurement in weeks

T_1 is time of first measurement in weeks

The relative rates are designated: Relative Foliage Height Growth Rate (RFGR) cm/cm/week; Relative Leaf Width Growth Rate (RLWGR) mm/mm/week; Relative

Runner Extension Rate (RRER) cm/cm/week, and Relative Coverage Rate (RCR) percent/percent/week.

5.2.9 Statistical Analysis of Data

The plot layout was in a completely randomised design with three replications. Weekly data of the three replicates from each selection across the range of field measurements were examined statistically and the significance of the means determined according to Fisher's protected LSD test at a 5% probability level using GenStat software.

5.3 Aims

The aims of this study were to:

i) Identify ecotypes which exhibit characteristics which would make them suitable for sportsturf usage (ie. fine leaf, fine stolon width, short internodes, etc.).

ii) Identify ecotypes which exhibit characteristics which would make them suitable for erosion control, pastoral use and racetrack usage (ie. aggressive nature, high top growth, etc.).

iii) Examine the general phenotypic differences between a selected range of ecotypes from Australia.

5.4 Results and Discussion

Detailed results of all the weekly gross observations will be found in Appendix 5. These results have been presented in graphical form in Figs. 5.2, 5.4, 5.7, 5.9, 5.10, 5.12 and 5.14 in the text which follows.

5.4.1 Environmental Data

Environmental data recorded by the Bureau of Meteorology sub-station located at Camden Airport adjacent to Lansdowne Farm for the duration is summarised in Table 5.2. Solar radiation data from the Bureau of Meteorology's Sydney Airport Station are summarized in Table 5.3.

Table 5.2. Weather data at Camden Airport for the duration of the 15 week observation period (commenced 2/2/2007, ended 18/5/2007). Rainfall is actual for the week, all others are weekly means.

Week	Average Temperature (°C)	Average Minimum (°C)	Average Maximum (°C)	Lowest Minimum (°C)	Highest Maximum (°C)	Relative Humidity (%)	Average Rainfall (mm)	Vapor Pressure Deficit (hPa)
1	23.2	16.2	30	12.2	37.2	52.8	0.4	13.6
2	22.9	15.4	30.5	16.4	33.9	56.2	4.8	12.2
3	21.6	16.5	26.7	14.6	32.2	70.1	152.6	8.0
4	24.4	17.9	30.8	16.6	32	59.9	6.2	12.0
5	23	18.2	27.8	17.5	31.3	67.8	54.8	8.6
6	22.9	17.7	28.2	15.1	35.4	64.4	63.8	9.3
7	20.2	13.7	26.6	11	31.4	65	2.6	8.6
8	22.7	18.5	26.8	17.1	29.6	77.9	18.8	6.0
9	18.9	13.7	24.1	8.7	34	62.2	12.4	8.6
10	16.5	11.9	21.1	8.7	27.3	60.3	1.6	8.0
11	17	10.6	23.4	6.3	26.9	62.5	6.4	7.3
12	17.6	10	25.2	9.5	22.4	66.6	0.6	6.6
13	16.7	12	21.4	8.5	25	69.1	18.8	6.0
14	16.8	9.5	24	7.8	27.5	58.9	9.4	8.0
15	16.1	9.2	23.1	5.9	25.9	68.4	6.4	6.0
16	16.2	9.7	22.8	5.6	24.4	71.7	14.6	5.3

Table 5.3. Solar radiation data at Sydney Airport, weekly totals in MJ/m^2 for the week commencing 5/2/2007 and ending on 26/5/2007.

Week	Total Solar Radiation (MJ/m^2/week)
1	160.52
2	165.45
3	151.82
4	127.25
5	134.5
6	111.4
7	103.18
8	118.23
9	110.25
10	122.28
11	103.6
12	61.49
13	99.6
14	74.5
15	77.05

5.4.2 Stolon Width

Stolon width results are shown in Figure 5.2.

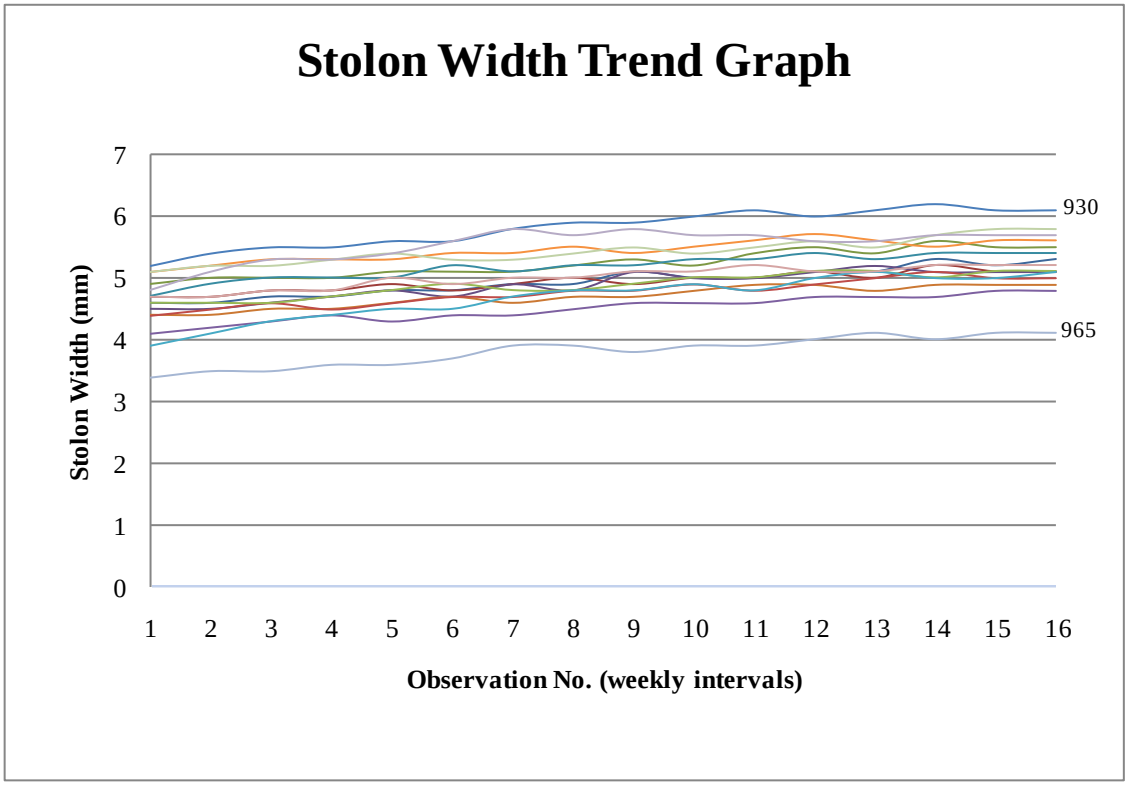

Figure 5.2. Stolon width trend graph of the 16 kikuyu accessions. Accession KC930 recorded the thickest stolon width, with KC965 recording the thinnest stolon width.

Throughout the period of the trial stolon width remained steady, which was to be expected given the relatively physiologically mature state of each of the cores planted when the observation period began. Overall, stolon width ranged between 4.1mm (KC965) to 6.1mm (KC930) with an average of 5.2mm. Statistically significant differences ($p \leq 0.05$) were recorded between lines at each weekly observation.

5.4.2.1 Stolon Width Increase

Over the fifteen week observation period there was a small increase in mean stolon width, the values of the first and sixteenth observations being 4.57 and 5.24 consecutively. Superimposed on this general trend, there were minor fluctuations from week to week in almost all lines throughout the trial period. Unlike some of the other attributes included in this study, fluctuations could not be attributed to changes in the environmental conditions, particularly temperature, experienced at the trial site. From weekly observation 9 of the trial, a cooler period of temperature set in, but stolon diameter still continued to fluctuate slightly. It should be noted, however, that the fluctuations in diameter experienced were never in excess of 0.3mm, and could be due to random variation in selecting the mid-point the location between the 3rd and 4th nodes of the stolon where the measurements were recorded. In general, the rank order of stolon width was fairly consistent, meaning that choices made on a broad basis (e.g. wide, medium, narrow) at any time during the trial would be reasonably consistent. On average each stolon diameter expanded by 0.6mm over the 15 week trial, with the greatest stolon width growth displayed by KC945.

5.4.2.2 Finest stolon diameter.

The finest stolon diameter was obtained from ecotype KC965 with a width after 15 weeks of 4.1mm. This recording was significantly different from all other ecotypes at the 5% confidence level. Whilst 4.1mm is still considered quite 'thick' from a turfgrass perspective, kikuyu displays a high degree of plasticity and under close mowing conditions (10 – 15mm) could realistically be expected to produce much finer stolons.

When compared to other cultivars and ecotypes, KC965 has a stolon diameter 28% finer than KC1100 (a selection from 'Whittet'); 29.3% finer than KC1099, the common kikuyu selection growing in the lawns at the Plant Breeding Institute; and 26.8% finer than the original Australian kikuyu grass KC950, Figure 5.13. Overall, KC965 is 21% finer than the mean (5.2mm) of the collection examined, and 14.5% finer than the next finest stolon diameter measured, KC941. Its natural propensity for turfgrass conditions are detailed elsewhere throughout this chapter.

Figure 5.3 An example of stolon diameter differences between KC930 (L) and KC965 (R).

5.4.2.3 Thickest stolon diameter.

At the opposite end of the scale, KC930, a selection from Morphettville Race Track, SA, produced the thickest stolon diameter at the completion of the trial, which was significantly different from all others. Since the scope given for the kikuyu breeding programme went beyond fine leaf kikuyu grass cultivars, KC930 offers a promising base for development of kikuyu hybrids for situations such as racetracks, and erosion control were mechanically strong (wide) stolons are desirable.

When comparing several ecotypes used in the study, KC930 has a stolon diameter 6.5% thicker than KC1100; 5% thicker than the KC1099; and 8.2% thicker than the original kikuyu grass KC950. In the DNA analysis, the difference between KC930 and 'Whittet' was the highest out of all selections examined. It also displays other morphological characteristics detailed throughout this chapter, which makes it well worth further examination for use in pastoral and erosion control settings.

5.4.2.4 Fine turf environments.

Several lines displayed stolon width tendencies considered desirable for fine leaf turfgrass environments. Lines KC941 (4.8mm) and KC924 (4.9mm), although not significantly different, were the only other selections with stolon diameters under 5.0mm. These would be welcomed by turfgrass practitioners. Their tendencies for growth in cool environments and naturally dwarfed appearance would be of appeal to sports turf surfaces, such as football grounds. Other similarities between the two selections are detailed throughout the remainder of this chapter.

5.4.2.5 Stolon width summary.

- KC965 displayed the finest stolon width, with a final recording of 4.1mm.
- KC930 displayed the thickest stolon width, with a final recording of 6.1mm.
- The average stolon width for the 16 selections was 5.2mm.
- The average temperature did not have any obvious effect on stolon width.
- KC941 and KC924 (4.8mm and 4.9mm respectively) are of interest for fine leaf turf production.

5.4.3 Foliage Height

Foliage height results are shown in Figure 5.3.

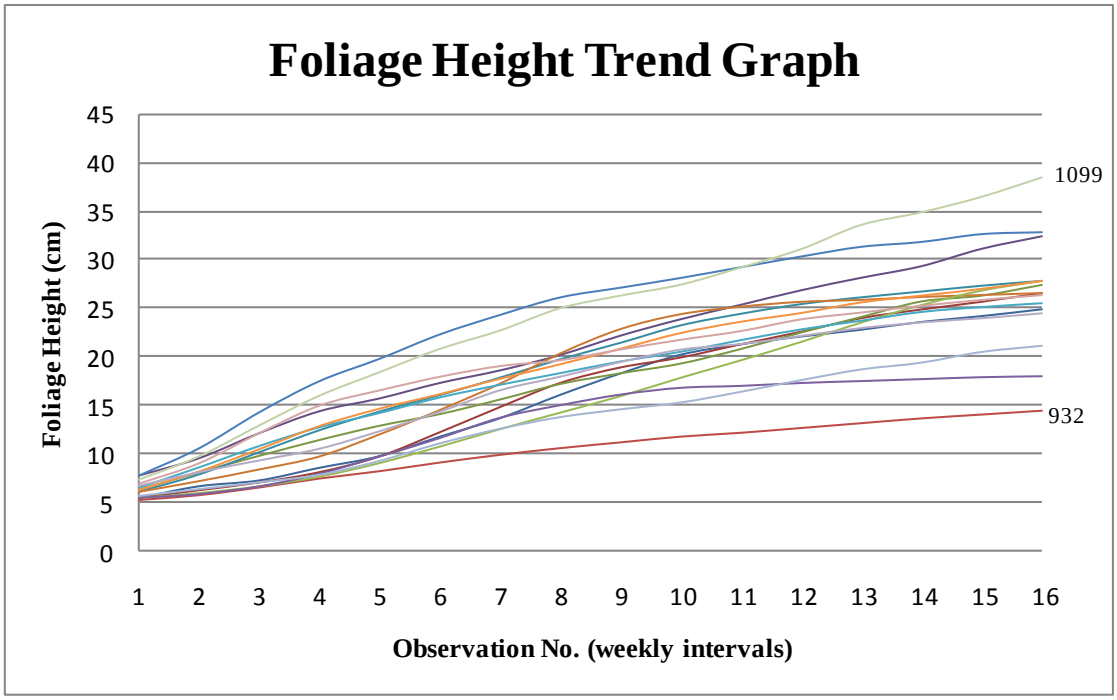

Figure 5.4. Foliage height trend graph of the 16 kikuyu accessions. Accession KC1099 recorded the highest foliage height recording, with KC932 recording the lowest foliage height.

The foliage height results highlighted how well kikuyu grass adapts to the local growing conditions around Australia, and no doubt worldwide. Commencing the trial at a height of 5cm, the final results ranged from a low of 14.5cm (KC932) to a high of 38.4cm (KC1099), with an average of 26.4cm. Statistically significant differences ($p \leq 0.05$) were recorded at each weekly observation

5.4.3.1 Foliage Height

Average gain over the trial period was 21.4cm and was relatively steady throughout the first 8 weeks, with 61.2% of the total growth of all selections being recorded during this period. However, when the average temperature dropped during week 9 and remained below 17°C for the final 8 week period, foliage height slowed to 38.8% of the final average growth experienced, with only selections adapted to cooler conditions maintaining steady growth.

5.4.3.2 Highest top growth.

Derived from a natural selection from the lawns at the Plant Breeding Institute (PBI), Cobbitty, the KC1099 selection recorded the highest increase in foliage height over the period of the trial, gaining 33.4cm, which was significantly different from all others. It was followed by KC930 (27.8cm) and KC903 'Crofts' (27.4cm). The origins of the KC1099 type at PBI are unknown, one thought being it had encroached from surrounding areas over time. In the DNA analysis, its closest relationship was with cv. 'Whittet', which suggests either that the law was seeded with 'Whittet', or that some seeding of 'Whittet' may have been undertaken in the surrounding area and introgressed with local material, or that it is derived from an introduction similar to that on which 'Whittet' is based. The lawns at the PBI are maintained to a low standard, with the KC1099 selection adapting to the local conditions.

5.4.3.4 Effects of average temperature on foliage height.

The average temperature for the first eight weeks of the trial was 22.6°C. During this period, KC930 provided the highest recording which was significantly different amongst the selections in foliage height with an increase of 21.1cm, followed by KC1099 (19.9cm), KC924 (15.3cm), KC903 'Crofts' (15.1cm) and KC966 (14.6cm) as the five highest. Derived from a selection growing at the Morphettville Racetrack, SA, KC930 displayed high recordings in several other parameters, which show how it has adapted well to conditions as a racetrack surface. While not suited for a golf course environment, the attributes KC930 initially displayed identified it as a potential candidate for further analysis in a pasture setting.

When the average temperature dropped to 16.9°C for the final eight weeks of the trial, KC930 slowed dramatically, only producing another 6.7cm of top growth. In a racetrack environment this is not a real concern provided wear is not excessive, as the sward is generally maintained around 10 – 12cm in length consistently year round. In a pasture environment though, top growth is the primary aim for ruminant grazing. Whilst KC930 displays aggressive lateral and top growth during warmer conditions, its top growth during cooler weather periods could require a higher input from the manager. When compared to pasture cultivar 'Whittet', however, KC930 showed a significant difference at 25.6% longer at the completion of the trial. Both 'Whittet' and KC930 produced similar top growth during the cooler period, being 6.5cm and 6.7cm respectively, but the growth KC930 produced during the warmer weather (21.1cm) compared to 'Whittet' (12.9cm) provides a positive base for further investigation, particularly in terms of dry matter production.

During this cooler period, four of the five top foliage height producing kikuyu grasses were derived from selections close to the PBI. Throughout the final eight week period when the average temperature was 16.9°C, the highest foliage height producing kikuyu was KC934, a selection from Stanley, Tasmania. Adding a further 59.6% (13.6cm) of top growth, it showed its preference for cooler conditions up from the 9.2cm it produced during the first eight weeks when the average temperature was 6°C warmer. Of the four lines two were collected from the immediate area of the PBI, KC1099 (13.5cm), KC903 'Crofts' (12.3cm), and two chemical mutagens of 'Whittet' KC902 (10.2cm) and KC901 (9.3cm).

5.4.3.5 Lowest foliage height.

The lowest recorded foliage height at the completion of the trial was KC932 gaining only 9.5cm over 15 weeks which was significantly different to the next lowest recorded heights being KC941 (12.9cm), KC965 (16cm), KC1100 (19.4cm) and KC900 (19.9cm). It was not the only measurement within the study where KC932 produced low results, indicating it simply was not suited to a temperate climate. KC932 originates from Weipa, QLD, a mining township located at sea level on the western edge of Cape York Peninsula at 12°37'40.84"S and 141°53'04.44"E. Theoretically, kikuyu grass would not be suited to such a location based on its originating highland preference in East Africa. It undoubtedly has been introduced

to Weipa, most likely as means of erosion stabilisation within the mining industry, as the tropical climate, soil type and isolated location are not conducive for pastoral grazing. The next two lowest recorded heights, KC941 and KC965, ecotypes in which low height is an inbuilt characteristic of their individual morphology.

Ecotype KC941 was selected growing along the side of the Monaro Highway at Numbugga, NSW. It was found in a small well defined patch of approximately 110m^2, Figure 5.10., and was surrounded by longer height kikuyu grass (>30cm). There was no evidence of grazing by rabbits either in leaf shearing or fecal matter, nor was it a drop off and collection point for a local bus route or postal delivery. Its dwarf nature continued to be expressed whilst being maintained in the germplasm collection at PBI.

Figure 5.5. The original selection location for ecotype KC941.

A concern for KC941 is the reduction in growth as soon as the cooler temperature arrived. Over the final eight weeks of the trial, KC941 produced only 3cm of top growth and was the slowest of all selections, which on average produced another 8.3cm. In a sports turf setting the reduction in growth would lead to wear concerns

given the major football codes conduct their main competitions throughout the winter months in Australia. Protecting the surface with an actively growing species, such as ryegrass (*Lolium* spp.) may be required.

Ecotype KC965 also displays a natural low growth habit, preferable for golf course and sports turf conditions. More important is its consistent growth habit during the cooler weather. During the first eight weeks KC965 produced 8.7cm of top growth, and another 7.3cm in the final 8 weeks of cooler weather. As noted, many of the other ecotypes slowed dramatically during this period. The top growth experienced during the cooler period by KC965, coupled with its excellent fine leaf and stolon results, indicate it would be a leading choice for continued analysis. Further, if planted in a sports turf situation, such as a football field, the top growth and general morphology could potentially abolish other inputs being undertaken at present by managers of current green couch (*Cynodon dactylon*) cultivars, such as winter overseeding. Observational analysis over several winter periods would determine whether KC965 is worthy of further investigation in this regard.

When considering a year round surface without the added necessity of overseeding as is currently the standard practice on couch (*Cynodon*) surfaces found at football grounds throughout southern Australia, the release of a fine leaf kikuyu grass which still produces active winter growth would be a tremendous step in turf management within the country. Winter overseeding is an expensive and time consuming practice wholly reliant on suitable temperature interactions to produce a successful result. Apart from the concerns of transition in late spring and potential colonisation of ryegrass in shaded locations, users of overseeded football grounds have to contend with a more ‘slippery’ surface when major events are scheduled during night periods.

An added benefit of a selection such as KC965 apart from its active winter growth, is its moderate growth habit during warmer periods of temperature. For the first eight weeks of the trial, KC965 recorded the second lowest foliage height gain behind KC932 with 8.7cm of top growth compared to the selection average of 13.1cm. The natural low growth habit would be of great appeal to turfgrass managers, as the surface would require a reduced mowing frequency and reduced applications of gibberellin inhibiting growth regulants. It would also be of appeal to home owners,

altering the current opinion that kikuyu grass is too high in maintenance for a domestic setting.

5.4.3.6 Foliage height summary.

- The foliage height results clearly indicate how individual kikuyu ecotypes adapt to their local growing conditions.
- KC932 has the lowest recorded foliage height growth with 9.5cm but is not suited to a temperate climate.
- KC941 exhibits a natural low growth habit and gained 12.9cm over 15 weeks, but exhibited very slow growth of only 3.0cm over the final eight weeks.
- KC965 exhibits a natural low growth habit and gained 16cm over 15 weeks, with consistent growth during cooler weather.
- The KC1099 selection recorded the highest growth with 33.4cm gained over 15 weeks.
- Four of the top five kikuyu grasses which produced the highest top growth during cooler weather were lines collected close (>2km) to the trial site although it must be pointed out that two of these (KC901, KC902), while grown for four years near PBI were actually selections from 'Noonan' made in the NSW North Coast.
- The top producing kikuyu grass during the initial eight weeks of warm weather was KC930.
- The top producing kikuyu grass during the final eight weeks of cool weather was KC934, originating in Stanley, Tasmania.

5.4.3.7 Relative Foliage Height Growth Rate

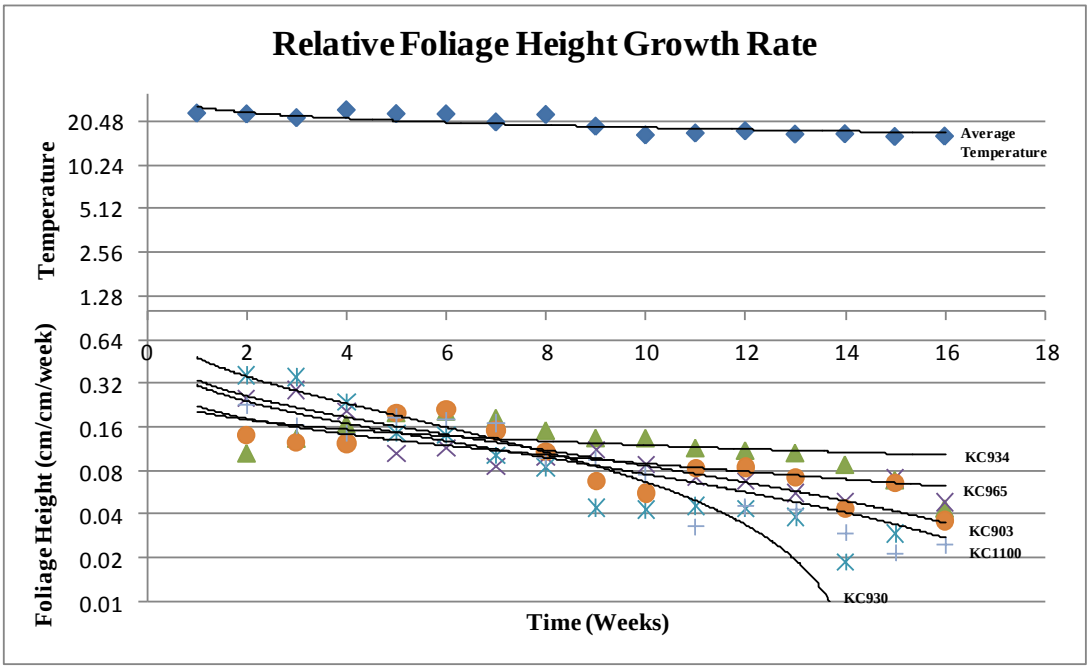

Figure 5.6. Relative foliage height growth rate ($\log_2$ scale) for several kikuyu grass accessions.

As mentioned, the average temperature dropped to under 17°C for weeks 9 – 16 of the observations which had an observed growth effect on some of the accessions. Relative foliage height calculations displayed several differences amongst the ecotypes. Accession KC934 from Tasmania maintained steady foliage growth through the cooler period, and together with KC965, provided more consistent top growth than the current registered kikuyu cultivars 'Crofts' (KC903) and the 'Whittet' Selection KC1100. This demonstrates further local adaptation amongst naturalised kikuyu grass ecotypes within Australia, as the cultivar 'Crofts' (KC903) was registered primarily for improved cool season growth (Barnard, 1983a). Accession KC930 from South Australia displayed its preference for warmer conditions with a distinct reduction in top growth. As some of its attributes displayed throughout the remainder of this chapter indicated that it may be worthy of continued analysis for pasture usage, the more consistent growth from KC1100 during cooler periods would be of more interest within the agricultural sector. This reduction in growth however could also be attributed to the plant reaching full maturity, also noted in the results in 5.3.6.6 (p.92).

5.4.4 Node Width

Node width results are shown in Figure 5.5.

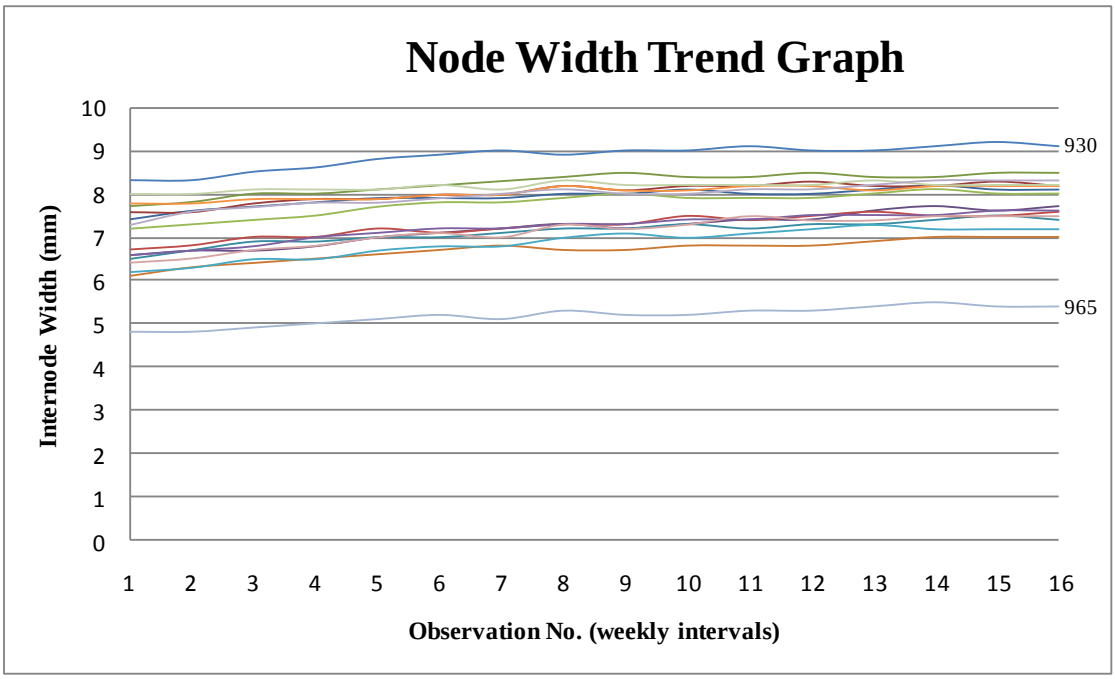

Figure 5.7. Node width trend graph for the 16 kikuyu accessions. Accession KC930 recorded the thickest node width, with KC965 recording the thinnest node width.

As with the stolon width, the node width remained steady throughout the course of the trial period reflecting the relatively physiologically mature state that the cores were in at the commencement. Overall, node width ranged between 5.4mm (KC965) to 9.1mm (KC930) with an average of 7.7mm. Statistically significant differences ($p \leq 0.05$) between lines were recorded at each weekly observation.

5.4.4.1 Node Width

The general trend was a very small increase over the course of the observation period. Minor fluctuations were again observed in the recording of node width throughout the trial period. This was not attributed to temperature changes at the trial site, as minor increases (not exceeding 0.3mm) were recorded throughout the cooler second half of the trial period. The highest increase in node width over the course of the trial was experienced on selections KC966 and KC903 'Crofts' with a gain of 1.1mm and the lowest increase was recorded on the KC1099 with a gain of 0.2mm. Average gain for all selections was 0.8mm. Speaking generally, the grouping of the lines into broad, medium and narrow, remained similar throughout the observation period.

5.4.4.2 Average gain after 15 weeks.

As noted, average gain across all lines was 0.8mm with the highest gains being KC966 and KC903 'Crofts' with 1.1mm. Both KC966 and KC903 displayed similar tendencies in a number of recordings through the trial, and in the DNA analysis where they were grouped together. KC903 'Crofts' was released in 1983 due to its improved growth during cooler periods of weather, and the similarities both morphologically and genetically with KC966 indicate that it may have been an attempt to introduce a more actively growing kikuyu during cooler weather into the Victorian region. During the final eight week period of the trial, KC903 'Crofts' produced the highest gain in node width at 0.4mm, highlighting its preference for cooler weather.

The two lowest gains over the 15 weeks were recorded in KC1099 (0.2mm) followed by KC950 (0.4mm). On average, each selection gained 0.6mm during the first eight weeks and a further 0.2mm over the final eight week period.

5.4.4.3 Thickest node width.

Selection KC930 displayed the thickest node width at 9.1mm, significantly different from all others. In comparison, KC930 was 8.8% thicker than KC1100, and 9.9% thicker than the KC1099 selection from the PBI as well as the original kikuyu KC950. Overall, KC930 had a node width 15.4% wider than the average of all lines examined. As in several other recordings within this chapter, KC930 displays

excellent tendencies for pasture and racetrack usage as well as erosion control. The only selection with a node width over 9mm, KC930 was followed by the mutant KC902 (8.5mm), KC1100 (8.3mm), KC901, KC1099 and KC950 (all at 8.2mm).

5.4.4.4 Narrowest node width.

Selection KC965 recorded the narrowest node width with 5.4mm, significantly different from all others, and over 40% narrower than KC930, and 29.9% narrower than the average of all lines. It again highlights the natural tendencies KC965 displays, making it well suited for a fine leaf turfgrass environment. When compared to the KC1099 collected at the PBI and KC950, KC965 has a node width 34.1% finer.

KC965 was also the only kikuyu selection with an internode width under 7mm. The next finest internode width was recorded on the selection from Canberra, KC924 (7.0mm), which was 22.9% wider than KC965. Again, the natural plastic tendencies of kikuyu grass under close mowing should see the internode width of KC965 become even finer.

Figure 5.8. An example of the natural dwarf nature of KC965

5.4.4.5 Node width summary.

- The widest node width recorded was KC930 with 9.1mm.
- The smallest node width recorded was KC965 with 5.4mm.
- Average node width of all lines was 7.7mm.
- Highest gains during the trial period were selections KC966 and KC903 ‘Crofts’ with a gain of 1.1mm.
- Lowest gain was recorded in KC1099 with a gain of 0.2mm.

5.4.5 Internode Length

Internode length results are shown in Figure 5.6.

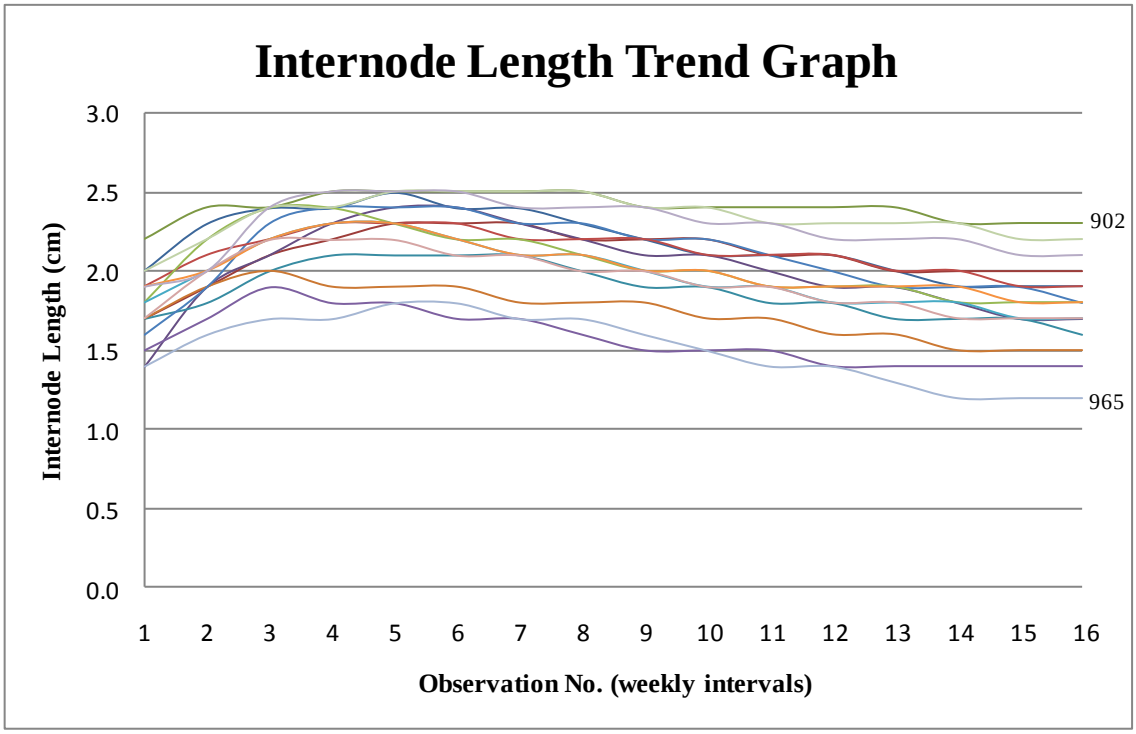

Figure 5.9. Internode length trend graph of the 16 kikuyu accessions. Accession KC902 recorded the longest internode length, with KC965 recording the shortest internode length.

The internode length reflected the interaction of increasing maturity of the runner on which the internode was measured and the deteriorating weather conditions after weekly observation number 5. A decrease in the length of the newly differentiated internodes was observed across all lines after 4 – 5 weeks as the plant matured further, with internode lengths ranging at the final recording from 1.2cm (KC965) to 2.3cm (KC902). Overall, the average internode length across all selections was 1.8cm at week 16. Statistically significant differences ($p \leq 0.05$) were found at each observation.

5.4.5.1 Internode Length

Despite a calculated average gain in internode length of 0.09cm (<1mm) over the 15 week period, reference to the graph (Figure 5.5) shows that for many accessions the internode lengths increased at first and then shrank. In KC930 a gain in internode length of 0.6cm was observed, whilst ecotype KC924 recorded a reduction in internode length of 0.2cm over the same period.

5.4.5.2 Internode Length Gains.

As detailed earlier, the lines were trimmed back after a 22 day establishment period to a diameter of 5cm one week before the commencement of the first observation, to give a uniform 'core' from which stolons could be produced. As a result of this, a fast production of stolon material was experienced in the first several weeks. After the first four weeks of the trial, each internode had increased in length an average of 0.5cm, but an average reduction of 0.1mm was observed during weeks 5 – 8, 9 – 12 and 13 – 16 across all lines.

This minor reduction could potentially be attributed to several factors or various combinations of them. These factors include:

- Overall nutrient drawdown within the soil.
- Nutrient leaching from the soil due to 282.6mm of rainfall on the trial site in the first six weeks of the trial period, and 374.2mm overall.
- The changing of season resulting in a reduction in day length.
- The temperature change experienced at the trial site.
- The overall maturing state of the plant.
- A compensatory shortening of the internode as interval maturation caused an increase in internode diameter (Figure 5.4).

5.4.5.3 Longest Internode Length.

The longest internode length was recorded on ecotype KC902 at 2.3cm, followed by KC1099 (2.2cm), KC1100 (2.1cm), KC901 (2cm) and KC900 (1.9cm), however these results were not significantly different. Ecotype KC902 recorded an internode

length 21.7% longer than the average of all selections. As described earlier, KC900, KC901 and KC902 are results of chemical mutagenesis of 'Whittet' seed.

5.4.5.4 Shortest Internode Length.

At the final observation, the shortest internode length was recorded on ecotype KC965 at 1.2cm, followed by KC941 (1.4cm); KC924 (1.5cm); KC915 (1.6cm) with KC903, KC945 and KC966 all with 1.7cm, again not significant. Significant differences were recorded between the three mutants, as well as between KC930, KC932, KC934, KC950, KC1099 and KC1100. Ecotype KC965 again showed its natural tendencies for a fine leaf turfgrass environment with an internode length 33.3% shorter than the average of all accessions. When compared to 'Whittet' and KC1099, the internode length of KC965 was 42.9% and 45.5% shorter respectively.

5.4.5.5 Other Factors Influencing Internode Length.

As mentioned, kikuyu grass is highly plastic in nature, and the accessions examined within this study were not cut for the duration of the trial period. With kikuyu under regular cutting, shoot density is increased and leaf width is reduced when compared with an uncut sward.

In a turfgrass sense, the three chemically treated mutants did not display any positive attributes in this parameter applicable for use as a turfgrass cover, as there is no appreciable difference between them and the KC1099 form of kikuyu.

5.4.5.6 Internode Length Summary.

- The shortest internode length was recorded on ecotype KC965 at 1.2cm (week 15).
- The longest internode length was recorded on ecotype KC902 at 2.3cm (week 15).
- Average internode length across all lines was 1.8cm (week 15).
- A reduction of internode length occurred across all selections after weeks 4 – 5.
- The reduction in internode length was on average under 1mm, if taken from first observation to the last observation
- Internode length increased for the plant 4-5 weeks.
- Reduction in length from maximum length to final length did not exceed 1mm for any lines. The greatest reduction was recorded in KC903 'Crofts' (-0.7mm).

5.4.6 Leaf Width

Leaf width results are shown in Figure 5.7.

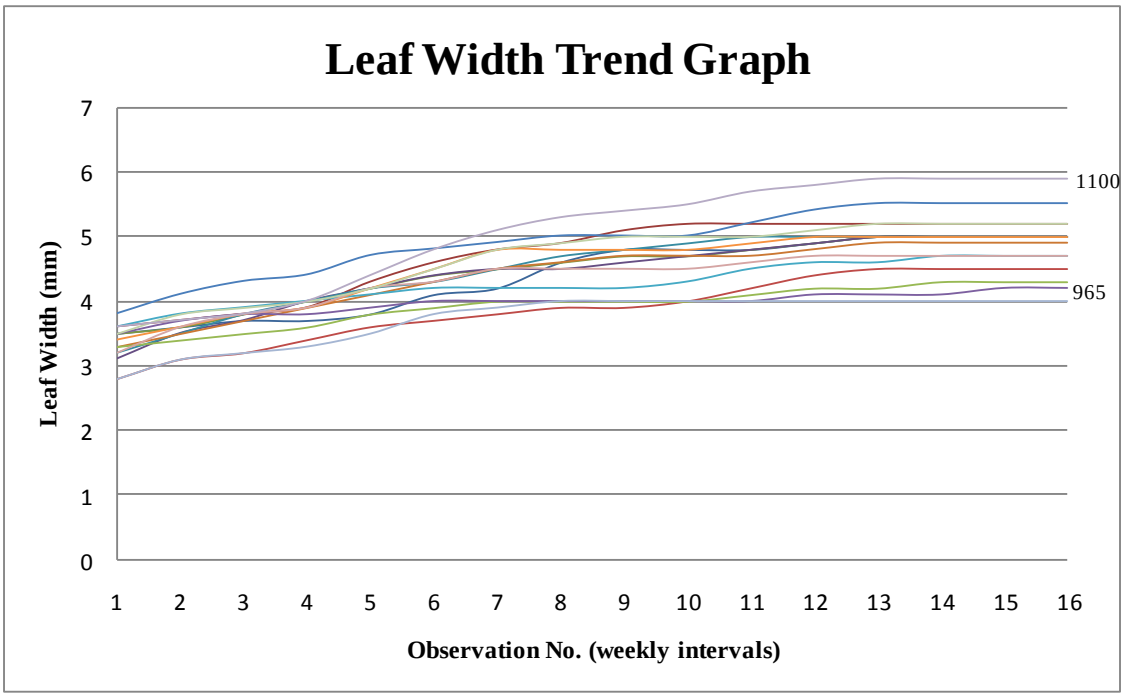

Figure 5.10. Leaf width trend graph of the 16 kikuyu accessions. Accession KC1100 recorded the broadest leaf width, with KC965 recording the finest leaf width.

Leaf width increased gradually over the period of the trial as the plants matured and as foliage height increased. An increase was observed across all lines, and at the completion of the trial KC965 recorded the finest leaf width at 4.0mm, with KC1100 (the 'Whittet' Selection) recording the coarsest leaf width at 5.9mm. Average leaf width across all selections at the final observation was 4.9mm. Statistically significant differences ($p \leq 0.05$) were recorded at each observation.

5.4.6.1 Leaf Width

Average gain across all selections was recorded at 1.5mm. The majority of this growth was experienced during the first eight weeks in the warmer weather, with 80% (1.2mm) of the leaf width increase occurring.

5.4.6.2 Average leaf width increase.

The greatest leaf width increase was recorded on KC1100 with an increase of 2.3mm; in total 34.8% wider than the average of 1.5mm recorded across all of the selections. The next highest gain was recorded in KC903 'Crofts' (1.9mm) followed by KC915 with 1.8mm. Ecotype KC941 recorded the lowest increase due to its naturally dwarf habit, gaining 0.7mm over the 15 weeks, followed by KC934 (1mm) and KC945 (1.1mm).

5.4.6.3 Finest leaf width.

Ecotype KC965 recorded the finest leaf width results with the final recording of 4.0mm, which was significantly different from the next two finest leaf ecotypes KC941 (4.2mm) and KC934 (4.3mm). Apart from its consistent natural low growth habit, the leaf width results are of the most interest in an end user sense. From a commercial aspect, arguably the first and most important impression of a turf grass for consumers and end users is its general appearance, in particular its fineness and density, followed by colour. The natural fine appearance of KC965 would be of great appeal to a wide range of consumers in a commercial environment, and would be a great step forward in the production of new cultivars of kikuyu grass in Australia.

Kikuyu grass has always been at a disadvantage within Australia at a consumer level due to its generally coarse appearance. In recent years, the domestic home lawn market has shifted from predominately couch (*Cynodon dactylon*), due to its high maintenance requirements, to lower maintenance 'children friendly' lawns, which exhibit coarser leaves and are cut higher to provide a cushioning effect such as buffalo grass (*Stenotaphrum secundatum*). Effective marketing campaigns have seen the release of several cultivars of buffalo, however visually it is very difficult to differentiate between them.

Consumers within the home lawn market have a love/hate relationship at present with kikuyu grass, due to its general appearance and invasive nature. This is where a potential new release, such as KC965 exhibiting a naturally low growing verdure, would provide an alternate to the buffalo 'revolution'. Buffalo grass is promoted as highly drought tolerant, however Ford (2006) found that there is no significant difference in drought tolerance between kikuyu and buffalo.

In a golfing context, a fine leaf, low growing kikuyu grass which is less invasive than the current common or seeded 'Whittet' strains would result in a reduction in maintenance. Surface-wise, a more upright leaf growth that is the result of a finer, denser sward is preferred by golfers as the ball sits up enabling clean shot making. In times of heightened environmental awareness and a general reduction in golfing membership and play across Australia, new releases such as KC965 would appeal to a wide range of sporting bodies. As a comparison, KC965 displays a leaf width 32.2% finer than KC1100 (a selection from 'Whittet'), and 18.4% finer than the average of all selections.

As described earlier, ecotype KC941 also displays a naturally fine leaf dwarf appearance, but as the foliage height results showed, it slows considerably in cooler weather. Thus, if used in a sporting context potential high wear injury could occur.

5.4.6.4 Coarsest Leaf Width.

The coarsest leaf width was recorded on KC1100 (5.9mm) which was significantly different to KC930 (5.5mm), KC1099 and KC901 (both 5.2mm). Against the mean of all selections, KC1100 displays a leaf width 16.9% wider making it preferable for the grazing situations for which its parent 'Whittet' was originally released. The slightly finer leaf on KC930 (6.8%) is accompanied with a higher visual density, but is unusual given the higher stolon and node width results than KC1100. The DNA analysis showed that KC930 and KC1100 had the least similarity (29.2%) amongst all selections screened, further highlighting the distinct variation experienced within the species across Australia.

In a pastoral grazing context, the minimal reduction in leaf width would be of no concern for a grass like KC930, given its foliage height results. If anything, it could

appeal further to organisations constructing and maintaining vegetation along roadsides. One main drawback would be efforts in trying to grow legumes in combination with kikuyu in pastures, as the density and aggressiveness of the kikuyu would crowd out any legume planting. Apart from production of seed, this was one of the main attributes claimed in the release of 'Whittet', however attempts to produce poly-stands within 'Whittet' pastures have generally not been successful.

5.4.6.5 Leaf Width Summary.

- The finest leaf width recorded was ecotype KC965 with 4.0mm.
- The coarsest leaf width recorded was KC1100 with 5.9mm.
- The average leaf width across all selections was 4.9mm.
- Ecotypes KC941 (4.2mm) and KC934 (4.3mm) were next finest.
- Ecotypes KC930 (5.5mm), KC1099 and KC901 (both 5.2mm) were the next coarsest.

5.4.6.6 Relative Leaf Width Growth Rate

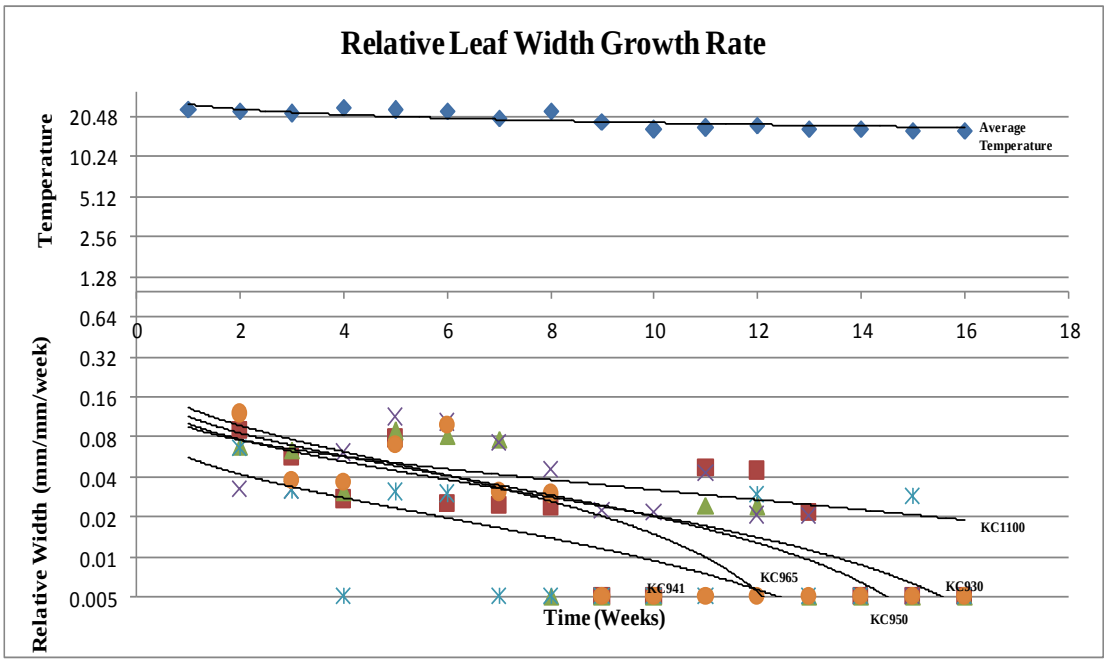

Figure 5.11. Relative leaf width growth rate ($\log_2$ scale) for several kikuyu grass accessions.

The retention of a reasonable rate of relative leaf width increase into the cooler weather displayed by KC1100 (the 'Whittet' seedling selection) is consistent with its performance in foliage height growth rate (5.5.1), attributes that were probable factors when the material which was ultimately released in Australia as 'Whittet' was originally selected by the Grassland Research Station in Kenya. Accession KC930 again slowed as it did with foliage height, as well as, interestingly, KC950, the original form of kikuyu grass successfully introduced into Australia. The decline in relative growth in leaf width over time for these two lines could be weather induced or may be simply attributed to their reaching full maturity in the trial. Accessions KC965 and KC941, the two finest leaf ecotypes in the study, showed differing responses after week 8, the first skewing of sudden decline, the other continuing to decline at a steady rate.

5.4.7 Longest Runner

Longest runner results are shown in Figure 5.9.

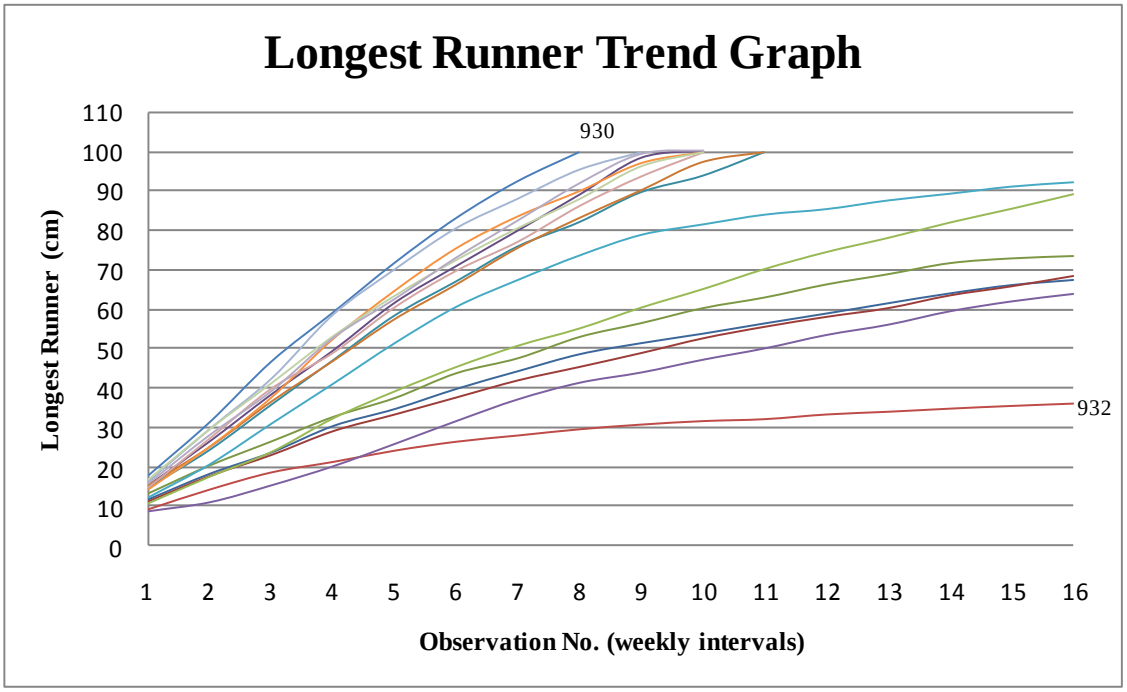

Figure 5.12. Longest runner trend graph of the 16 kikuyu accessions. Accession KC932 recorded the longest runner, with KC932 recording the shortest runner.

The longest runner results were recorded by measuring from the centre of the plant core to the tip of the longest runner extending from it. The longest runner of KC930 reached the perimeter of a notional one metre radius circle inscribed within the plot during week eight, while at the completion of the trial, the longest runner on ecotype KC932 measured 31.3cm. Statistically significant differences ($p \leq 0.05$) were noted at each observation.

5.4.7.1 Longest Runner

Strong growth was experienced in several selections over the first eight week period. Over the period of the trial, a total of nine out of the 16 lines reached the perimeter of the examination plot between weeks 8 – 11. Once a selection had reached the perimeter, no further recordings were undertaken for a longest runner measurement on that particular plot, or its replicates. The selections that reached the perimeter (defined as a circle 1m from the centre of the plot in any direction) during the trial period are listed as follows:

- Week 8: KC930
- Week 9: KC965
- Week 10: KC1100, KC1099, KC966, KC903, KC950
- Week 11: KC915, KC924

5.4.7.2 Fastest runner extension.

Ecotype KC930 reached the perimeter during week nine of the trial, the first selection to do so. Its general aggressiveness has been outlined in other recordings within this chapter, and if utilised in some of the outlined potential areas (pastures, erosion control, etc.) quick establishment of the area would be expected in suitable growing conditions. Ecotype KC930 has shown a general aggressiveness throughout the entire study not equalled by any other selection. Before reaching the perimeter during week eight, its average longest runner extension was recorded at 13.2cm per week during weeks 1 – 7.

The second fastest runner extension was recorded on ecotype KC965, which reached the perimeter of the trial plot during week eight, growing on average 11.95cm per week. The runner extension displayed would be of value in a high standard turfgrass environment as it demonstrates a natural ability, (ie. unfertilised), to cover ground at a consistent rate. This would be of benefit, for example, in divot recovery on golf courses and football grounds.

The remaining selections which reached the perimeter of the trial plots, together with their average weekly extension rates, are listed as follows:

Week 10:

- KC1100: 11cm per week
- KC903 'Crofts': 10.9cm per week
- KC950: 10.8cm per week
- KC1099: 10.7cm per week
- KC966: 10.4cm per week

Week 11:

- KC924: 9.7cm per week
- KC915: 9.4cm per week

5.4.7.3 Slowest runner extension.

The slowest runner extension was recorded on ecotype KC932, the selection from Weipa, QLD, recording a final average longest runner measurement of only 36.3cm, or approximately 2.3cm per week, which was significantly different from the remaining lines. It again demonstrated its inability to adapt to a temperate climate. Even though it separated into a sub-cluster with KC966 and KC903 in the DNA analysis, it firstly displays little morphological or behavioural similarity with the two other ecotypes and secondly, even in the DNA dendogram it is separated by itself into a sub-sub-cluster.

The next slowest average runner extension was recorded in ecotype KC941 with a final recording of 64cm. Even though it was selected in January of 2005 within its originating location, the ecotype seems to enter a state of semi-dormancy when cooler weather is encountered. The foliage height results showed how it only produced a further 3cm of top growth in weeks 9 – 16 when the average temperature was 18.5°C, the slowest of all examined. Based on these two recordings, the ecotype may best be suited for a sub-tropical climate if utilised further.

Apart from ecotype KC932, the remaining selections (including KC941, but excluding KC934) that had not reached the perimeter by the completion of the trial, giving a range of average growth during weeks 9 – 16 of between 2.3 – 2.9cm per week. Ecotype KC934 from Stanley, TAS, again displayed its preference for cooler weather by growing on average only 4.3cm per week during weeks 9 – 16. The ecotype showed in the foliage height results that it preferred a cooler environment by

being the highest producer of top growth in the last eight weeks, adding another 13.6cm.

5.4.7.4 Longest Runner Summary.

- The longest runner was recorded on ecotype KC930 reaching the perimeter during week 8, averaging 13.2cm of extension per week.
- The lowest runner extension was recorded on ecotype KC932 with 36.3cm averaging 2.3cm of extension per week.
- A total of nine selections reached the perimeter before the end of the trial period.

5.4.7.5 Relative Runner Extension Rate

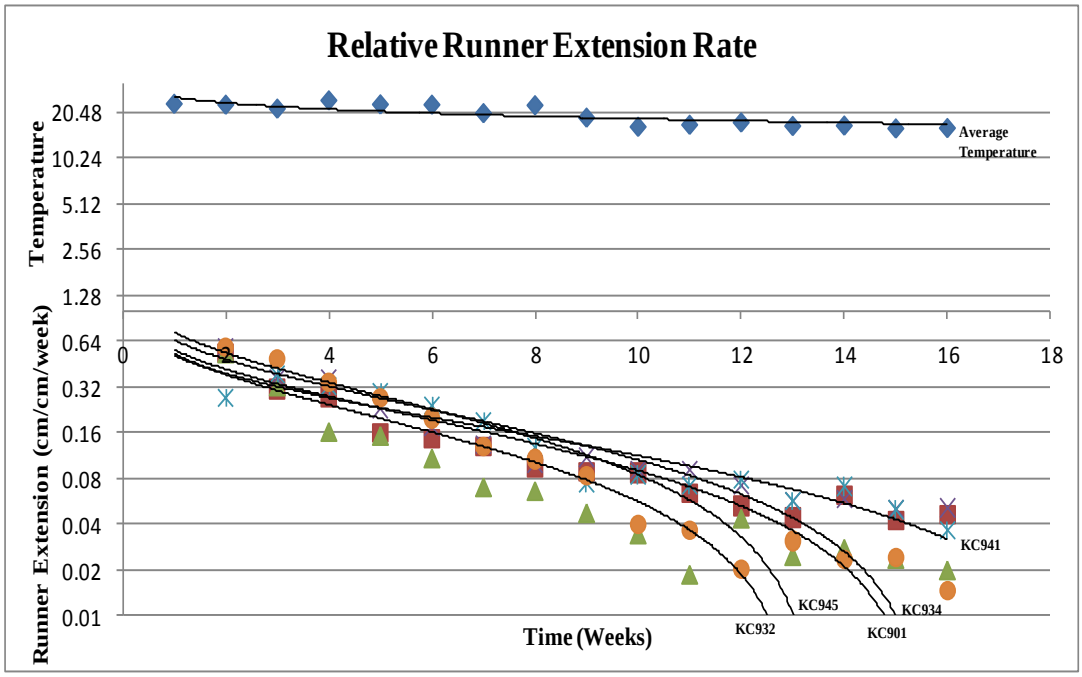

Figure 5.13. Relative runner extension rate ($\log_2$ scale) for several kikuyu grass accessions.

Accession KC941 continued its slow growth throughout the cooler period, which was demonstrated in several of the observations within the study, along with several of the kikuyu accessions which had not reached the perimeter of the trial plot by observation number 16. Of these, KC934 which produced consistent foliage growth in cooler conditions, but poor runner extension, again demonstrates the importance of examining individual traits separately in any new material.

5.4.8 Coverage.

Coverage results are shown in Figure 5.11.

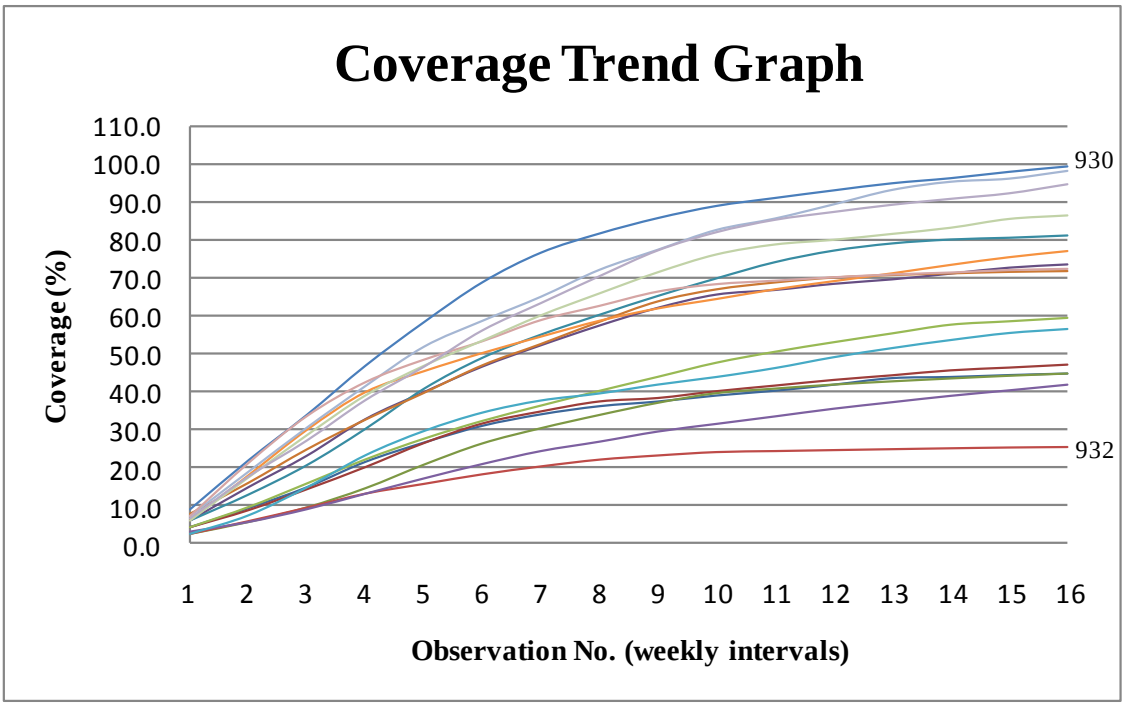

Figure 5.14. Coverage trend graph of the 16 kikuyu accessions. Accession KC930 recorded the greatest coverage result, with KC932 recording the lowest coverage result.

The greatest coverage at the completion of the trial period was recorded on ecotype KC930 (99.1%) with KC932 recording the least with just 25.5% coverage. Average coverage across all lines after 16 weeks was 67%. Statistically significant differences ($p \leq 0.05$) were recorded at each observation.

5.4.8.1 Coverage

The majority of the selections reached over 50% of their final coverage from the original 5cm plug during weeks four to five of the trial. The gradual slowing in coverage is attributed to temperature, as well as lack of mowing and fertiliser application. Within the turfgrass industry newly established areas are primarily planted via sprigging or solid turf rolls or slabs, not by plugs. However, plugging provides a good insight into the lateral spread of the grass species being examined, and is relevant to the behavior to be expected from sprigs.

5.4.8.2 General Coverage.

Spread varied amongst the ecotypes, with some displaying consistent radial coverage, Figure 5.12., while others displayed irregular radial coverage which influenced the coverage results, Figure 5.13. Only five ecotypes failed to achieve over 50% coverage by the completion of the trial, being KC900, KC901, KC902, KC932 and KC941; a further six ecotypes achieved over 75% coverage.

Figure 5.15. An example of consistent radial coverage displayed by ecotype KC965.

Figure 5.16. An example of inconsistent radial coverage displayed by KC903

5.4.8.3 Greatest Coverage.

Greatest coverage was recorded by KC930 with 99% and KC965 with 98% at the completion of the trial. While not significantly different from each other, they did display a significant difference ($p \leq 0.05$) from the remainder of the selections.

In a practical sense, the results of KC930 achieving coverage across the plot without fertilisation would again be of interest to pastoralists and other industries; while the results of KC965 in the same growing environment producing the same results has to be of interest to commercial turf producers. The ability of both grasses to cover in a sandy soil prone to leaching of nutrients indicates again that they are still productive with fewer inputs. However it must be noted that this soil had very high levels of available phosphorus. From other PBI studies in the same soil type at Lansdowne Farm it is known that there is an adequate supply of NEAK potassium (non-exchangeable available potassium) (P. Martin, personal communication), so in this experiment the main limiting nutrient was nitrogen.

5.4.8.4 Lowest Coverage.

Lowest coverage at the completion of the trial was recorded on KC932 with 25.5% recording a significant difference from all others. It was not the first time during the trial that the ecotype from Weipa produced poor results.

5.4.8.5 Coverage Summary.

- Ecotypes KC930 and KC965 had the fastest coverage out of all lines assessed.
- Ecotype KC932 displayed the slowest coverage.
- A total of five ecotypes failed to reach 50% coverage by the completion of the trial.

5.4.8.6 Relative Coverage Rate

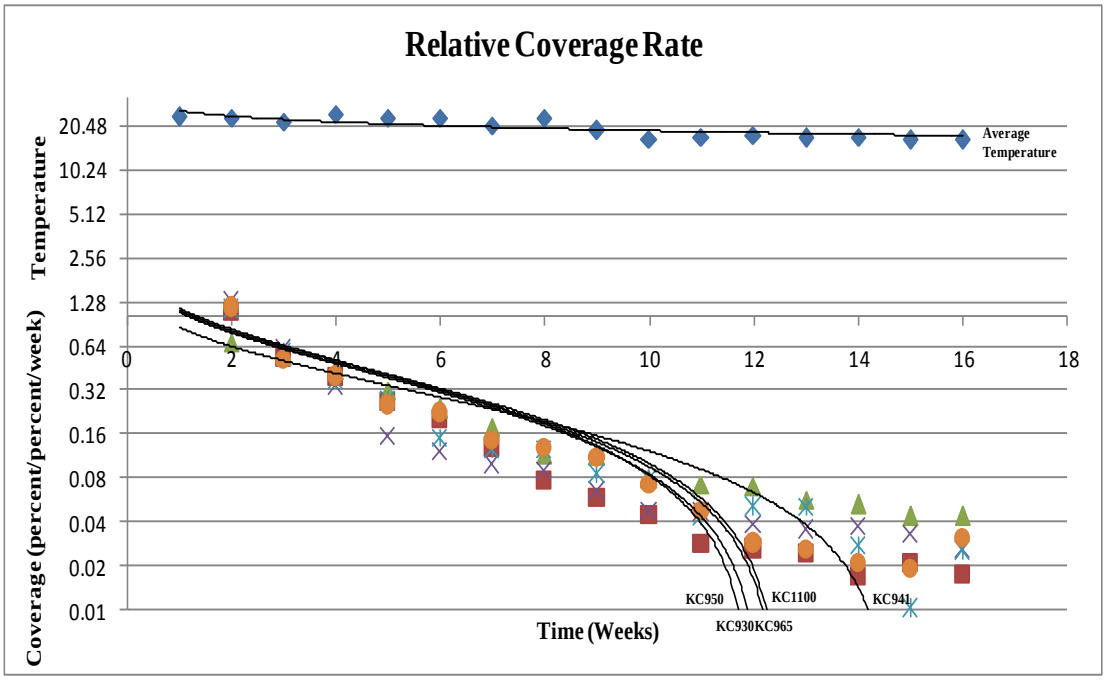

Figure 5.17. Relative coverage rate ($\log_2$ scale) for several kikuyu grass accessions.

The gradual growth of accession KC941 was again evident in the relative coverage rate. Only six of the sixteen accessions in the study reached over 75% coverage after 15 weeks (see Table 5.9 in Appendix 4 for details). Of these six, KC1100, KC965, KC950 and KC930, all displayed similar coverage rate tendencies, with a marked decline in relative coverage rate as cooler conditions developed after week 7.

5.5 Relationship between some of the parameters (R^2 Values).

Table 5.4. R^2 values for the kikuyu grass lines at observation 16

R^2 (%)	Coverage	Height	Internode Length	Node Width	Leaf Width	Stolon Width
Coverage	100	28.17	3.69	1.30	12.57	5.94
Height		100	14.36	18.20	27.11	37.15
Internode Length			100	57.46	40.79	49.45
Node Width				100	46.26	77.07
Leaf Width					100	65.65
Stolon Width						100

Regression analysis shows that coverage, which may be taken as a rough indicator of aggressiveness, is not, for practical purposes, correlated with morphological features such as internode length, node width, leaf width or stolon width, and only very widely associated with growth in height. This means that none of these parameters may be used as surrogate for coverage potential in the screening of germplasm collections and hybrid populations. In other words, coverage potential is a quality dependent on numerous attributes both morphological and physiological, and can only be assessed by coverage potential trials. To what extent coverage potential is sensitive to G x E effects, whether climatic or nutritional remains to be assessed.

These were fairly high coefficients of determination (r^2 values) for node width and stolon width (77%) and in future work it would probably be sufficient to score only one of these attributes. There was also a fairly strong link between leaf width and stolon width (66%) but a weaker one (46%) with node width which probably relates to the way in which the breadth available for the base of the developing leaf bud is conditioned by the ultimate width that the developing node will achieve. Given the stronger link with stolon width than node width, it would seem that stolon width could be used as a reasonable guide to both node width and leaf width. None of the other coefficients seemed sufficiently high to suggest that they could be usefully employed as indicators of each other. Rather like coverage potential, growth in height, being the result of numerous physiological processes, was not strongly associated with any of the other parameters measured. The lack of a strong

association between height and coverage highlights the independence of these two processes and the need to assess them separately in all trials of new material.

An important goal in the further study of naturalised populations is to determine to what extent particular environments have selected genotypes with desirable attributes which may still be well expressed when cultivated in a different environment. For example, in *Poa pratensis,* where significant variation amongst selections throughout the United States were noted by Smith *et al.* (1946), differences, such as density and colour, were only found within certain areas of the United States. This allowed the identification of locations which plant breeders could focus on enabling them to select the traits they desired. To date, DNA analysis, of a limited number of selected ecotypes of kikuyu have, however, shown that similar traits in naturalised kikuyu grass are not limited to specific areas of Australia. However, exploration on a wider scale may well modify this conclusion.

5.6 General Summary.

There is considerable morphological and behavioural variation amongst the kikuyu grass selections examined in this study, Figure 5.18. The results obtained in this experiment, however, only provide a snapshot of variation experienced, as further variation would be expected within localised growing environments, ie. a genotype by environment interaction. Two ecotypes stood out during the course of this study, namely KC930 from the Morphettville Race Track in South Australia and KC965 from Grafton in New South Wales.

Figure 5.18. Stolons of some of the kikuyu grass lines used in the study.

In a sportsturf perspective, ecotype KC965 is well worthy of continued analysis. Its natural dwarf morphology across a range of attributes provides an outstanding opportunity to produce a commercial fine leaf kikuyu, and one which potentially could adapt to a range of climatic growing conditions around Australia given its consistent growth in the range of temperature experienced. In a pastoral, racing and erosion control perspective, the naturally aggressive KC930 would be well suited to continued study, particularly in relation to nutritional value for grazing ruminants. Both ecotypes provide a solid starting benchmark for future kikuyu grass breeding programmes.