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Agronomic variation in a collection of perennial *Urochloa* spp. and its relationship to site of collection

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Abstract

A collection of 76 *Urochloa mosambicensis*, 19 *U. oligotricha* and seven *U. stolonifera* accessions was grown at Samford from 1991 to 1994 to determine variation in a range of morphological and agronomic attributes. For *U. mosambicensis* and *U. oligotricha*, there was considerable variation in most attributes, especially in the time to maturity and in stolon development. The variation in *U. stolonifera* was largely limited to differences in time to maturity.

Provenance data were available for most accessions and indicated that *U. mosambicensis* and *U. oligotricha* were collected in southern Africa and came mainly from light-textured soils in semi-arid tropical and sub-tropical regions. However a number of high yielding accessions of *U. mosambicensis* had their origins in more mesic environments. Accessions of *U. stolonifera* had been collected from a limited geographic region so no inferences could be made about its adaptation.

U. mosambicensis and *U. oligotricha* accessions were grouped on the basis of their agronomic attributes using cluster analysis. For *U. mosambicensis*, the resultant groups were strongly correlated with geographic origin. Accessions from the southern limits of the collection were early flowering, had more stolons, were lower yielding and were shorter. Accessions from near the equator were late flowering, high yielding, taller but were still stoloniferous. Accessions from intermediate latitudes were less stoloniferous than those from either latitudinal extreme. For *U. oligotricha* the links between groups and geography were limited.

The study has identified a small number of accessions which displayed a combination of attributes that suggests roles in particular farming systems. In addition the examination of agronomic variation, together with provenance data, has enabled a core set of accessions to be identified for all three species. This core set represents the variation described in this study and provides researchers with a comprehensive set of germplasm to include in agronomic trials.

Keywords

Urochloa mosambicensis, Urochloa oligotricha, Urochloa stolonifera, classification, genetic resources, diversity, geographical distribution

Introduction

Urochloa mosambicensis was introduced into northern Australia in the early 1900s and has become an important grass for the northern Australian beef industry. A number of ecotypes have become naturalised through much of northern Australia (Burt *et al.* 1980a) and one of these was selected for commercial release in 1980 as cv. Nixon. Since that time another accession, CPI 60128, has been released as cv. Saraji on the basis of its performance in mine site rehabilitation (Harwood *et al.* 1996; Naidu *et al.* 1997). Several regional evaluation studies in northern Australia have identified other superior accessions of *U. mosambicensis* (e.g. CPI 46876) and other perennial species of *Urochloa*, principally *U. oligotricha* (Burt *et al.* 1980b, Anning *et al.* 1986). Although *U. oligotricha* had been well grazed and persistent in these trials on semi-arid light soils, no cultivars have been released. Nevertheless, the persistence of some accessions such as CPI 47122 in a range of environments suggests that it may have a role in some pastoral systems.

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Burt *et al.* (1980a) reported patterns of variation in a range of *U. mosambicensis*, *U. stolonifera* and *U. oligotricha* accessions held by the Australian Tropical Forages Genetic Resource Centre (ATFGRC) in 1971 based on a mixture of morphological and agronomic attributes. That study revealed considerable variation in *U. mosambicensis* and *U. oligotricha.* However, the individual characteristics of accessions were not reported. This lack of information on individual accessions limits the usefulness of that study for selecting appropriate germplasm for detailed evaluation studies. Furthermore they made no attempt to link the observed variation in agronomic attributes with environmental parameters at the sites of collection. The availability of information linking plant attributes and performance and site of origin is extremely important in management of genetic resource activities such as prioritizing further plant collection and the selection of core sets of accessions for distribution to agronomists. This paper reports on the variation within the collection of *U. mosambicensis, U. stolonifera* and *U. oligotricha* held at ATFGRC using a number of key attributes and links that variation to environmental parameters. The paper also considers variation in germplasm not available for study in the earlier work by Burt *et al.* (1980a).

Materials and methods

Plant geography

U. mosambicensis accessions included in this study originated from Kenya, Tanzania, Malawi, Mozambique, Zimbabwe, Zambia, Botswana, South Africa and Swaziland. Of the 76 accessions in this collection, some provenance data were available for 63. There were 19 *U. oligotricha* accessions included in the study. These originated from South Africa, Zimbabwe, Namibia and Angola. Only seven accessions of *U. stolonifera* were available. All originated from South Africa in the region adjacent to Swaziland.

The amount of provenance data available varied between accessions. In some cases no data at all were available and in others only latitude and longitude had been recorded without either edaphic or climatic information. Environmental attributes used in the study were latitude, altitude, rainfall and soil texture.

Cultural details

Two experiments were carried out over four years. In the first experiment, seed of 55 accessions of *U. mosambicensis*, 15 of *U. oligotricha* and six of *U. stolonifera* were sown into 6 cm peat cups in a glasshouse in November/December 1991 and transplanted into the field at Samford Research Station (Lat. 27°22'S, Long. 152°53'E) on 26th March 1992. The second experiment, which included 21 accessions of *U. mosambicensis,* four of *U. oligotricha* and one of *U. stolonifera,* was conducted in a similar manner, sowing in the glasshouse in October 1993 and transplanting into the same field as used in Experiment 1 on 18th January 1993. The soil was an alluvial prairie intergrade with a pH at the surface of 5.6 to 6.0 increasing to 7.5 at 1 m (C.H. Thompson pers. com.).

The field design consisted of ten plants of each accession spaced at 50 cm intervals within rows and 1.5 m between rows. The treatments (accessions) were not replicated. To enable comparison between experiments, eight accessions were common to both experiments. Plots were kept weed-free throughout. Each experiment was mown after the first winter and measurements were commenced in the following December and continued through to March. Agronomic and morphological data are the mean of measurements taken from the three plants in the centre of the row.

The agronomic attributes included in the study were those which were likely to be associated with field persistence and production, such as time to maturity, dry matter yield and stolon development. A small number of morphological attributes were also measured for each accession (Table 1). The same plant attributes were measured in both experiments.

Table 1. Details of attributes measured and date of measurement in the two experiments conducted at Samford Research Station.

Attribute	Date		Remarks
	Expt 1	Expt 2	
Agronomic			
Maturity (December)	15-12-92	23-12-94	Stage of development 1. Yet to flower 2. Flowers 3. Flowering and green seed 4. Seed but no flowering 5. Ripe seed
Maturity (March)	25-3-93	9-3-95	Stage of development (as above)
Plant yield (1-5)	24-3-93	9-3-95	Ratings 1 (lowest) to 5 (highest)
Plant height (cm)	25-3-93	9-3-95	Height from ground level to flag leaf ligule
Stolon length (cm)	27-3-93	4-4-95	Length of longest stolon
Stolon number	27-3-93	4-4-95	Number of stolons
Morphological			
No. of racemes	25-3-93	9-3-95	Number of racemes per inflorescence
Inflorescence axis length (mm)	25-3-93	9-3-95	Distance from lowest raceme to uppermost raceme
Length of longest raceme (mm)	25-3-93	9-3-95	Usually lowest raceme
Density of leaf sheath hairs	25-3-93	9-3-95	Rating 1-5 1=glabrous, 5 very hairy.

Data analysis

The *U. mosambicensis* and *U. oligotricha* data sets were analysed separately using the pattern analysis package PATN (Belbin 1987). Association measures between all pairs of accessions were generated using the Bray-Curtis option in the ASO module. Hierarchical agglomeration was achieved using the Flexible UPGMA option in the module FUSE. A hierarchical classification was generated for both species using the DEND function.

Results

Detailed agronomic and passport information for each accession is given in Appendix 1.

U. mosambicensis

Plant attributes. There was considerable variation in time to maturity, plant height, yield and stolon development. Fifteen accessions had reached maturity or had green seed by the December measurement of maturity while 31 accessions had yet to commence flowering (Figure 1a, Appendix 1). By March of the following year, only five accessions had yet to flower while 48 accessions had either ripe or almost ripe seed.

Plant height ranged from 29 cm (CPI 60116) to 150 cm (CPI 60115) (Figure 1b). Most lines had a plant height of between 60 and 100 cm with cv. Nixon and cv. Saraji having plant heights of 88 and 50 cm, respectively. Plant yield ranged from rating 1 to 4 (Figure 1c) with the highest yielding lines being the late flowering lines from East Africa. The cultivars Nixon and Saraji each had a yield rating of 3.

Stolon development (number and length), was also variable (Figure 1d) with cv. Saraji and P12749 having the strongest stolon development. Some accessions had very poor stolon development with 18 accessions having fewer than six stolons per plant. The length of the longest stolon was also variable, ranging from <10 cm to >70 cm. The two measures of stolon development were strongly correlated (r^2 = 0.65). Nixon had 10 stolons per plant while cv. Saraji had 52 stolons per plant.

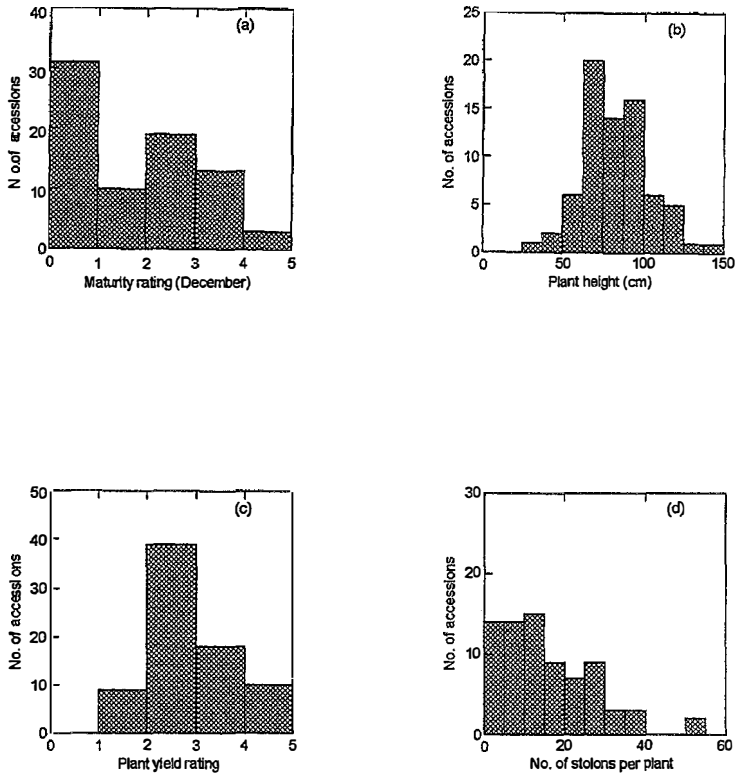

Figure 1. Variation in maturity stage in December (1=yet to flower, 2=flowering, 3=flowering and green seed, 4=green seed, 5=ripe seed) (a), plant height (b), yield (c) and number of stolons per plant (d) in a collection of 76 accessions of *U. mosambicensis*.

Plant geography. Most accessions were collected from > 15°S (Figure 2a) although a few were from low latitudes in Kenya and Tanzania. Annual rainfall at the collection sites for *U. mosambicensis* ranged from 400 mm to 1600 mm but most accessions were collected from between 600 and 1000 mm (Figure 2b). Most of the low rainfall sites were in northern South Africa. Altitude ranged from < 100 m to > 1500 m (Figure 2c). Information on soil type was only available for 47 accessions. In most cases soil texture ranged from sandy to loam (Figure 2d). Only six accessions were collected from clay-loam soils and none from clay soils.

The diversity in agronomic attributes was frequently related to origin of the collections. Accessions from the southern range of the collection, primarily those from South Africa, were earlier maturing than those from East Africa (Malawi, Tanzania, Kenya) (Figure 3a). The East African accessions were usually taller (Figure 3b) and had a higher yield than those from the southern limits of this collection. Stolon development also appeared to be related to origin. Accessions from South Africa (the most southerly and the drier sites) and those from Kenya and Tanzania (the most northerly accessions) usually had greater stolon development than those from Malawi, Zimbabwe, Zambia and Mozambique (Figure 3c).

U. oligotricha

Plant attributes. There was considerable variation in time to maturity in *U. oligotricha*. In December, maturity ranged from accessions which were yet to flower to those which had ripening seeds (Figure 4a). Unlike *U. mosambicensis*, no accession had reached maturity by that time. All accessions had flowered by the March measurement.

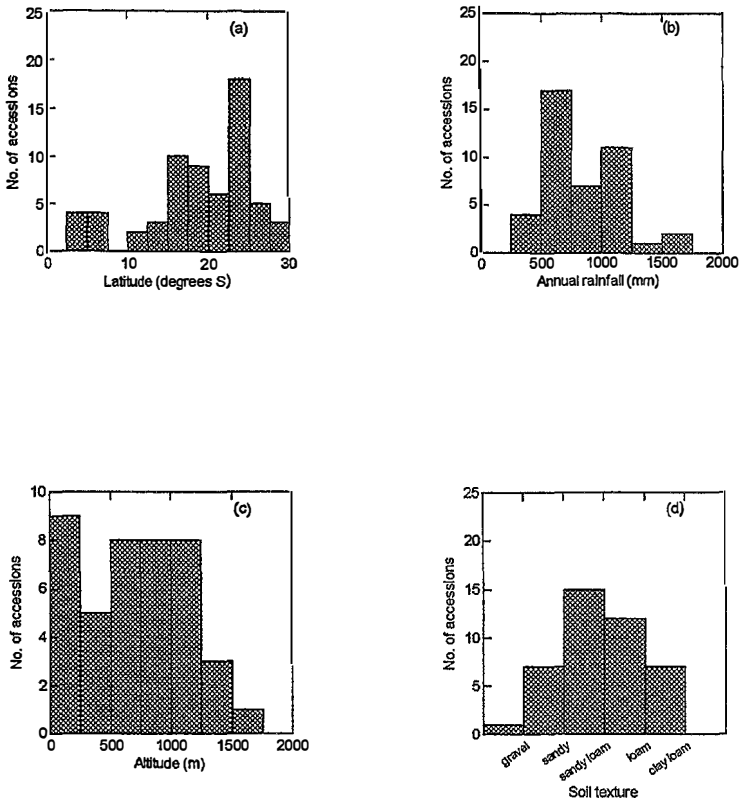

Figure 2. Summary of latitude (a), mean annual rainfall (b), altitude (c) and soil texture provenance data (d) from a collection of 76 accessions of *U. mosambicensis.*

Plant height ranged from 60 cm (CPI 43122) to 100 cm (CPI 40201 and CPI 60121) (Figure 4b). Yield ranged from rating 1 to 4 with the majority of accessions being rated at either 2 or 3 (Figure 4c). The highest yielding accession was CPI 60120 and the lowest yielding were CPI 43122 and CPI 43689.

Stolon development in this species was far less than in either *U. mosambicensis* or *U. stolonifera* with the majority of accessions having < 4 stolons per plant. Nevertheless there was considerable stolon development in some accessions (Figure 4d) with CPI 47121, 47129, 60120 and 60123 having > 10 stolons per plant. The maximum stolon length for these four accessions was 35 cm in CPI 47121.

Plant geography. Accessions of *U. oligotricha* originated from sites with an annual rainfall of between 450 mm and 850 mm and with altitude ranging from 800 m to 1500 m. For this species there was very limited soil data with two accessions from sandy loams, one from a loam and two from clay loams. It was not possible to associate the agronomic diversity with provenance data because of the scarcity of information.

U. stolonifera

Plant attributes. There were only 7 accessions of *U. stolonifera.* Plant height ranged from 60 cm to 100 cm while yield either rating 2 or 3. There was some variation in maturity with CPI 47171 and 47172 being the earliest maturing accessions and CPI 47177 and 47179 being late flowering.

There was also considerable variation in stolon development with some accessions having as few as five stolons per plant (CPI 47172, 47178 and 47179) while CPI 47171 and 47180 had 22 and 16 stolons per plant respectively and maximum stolon length of > 25 cm.

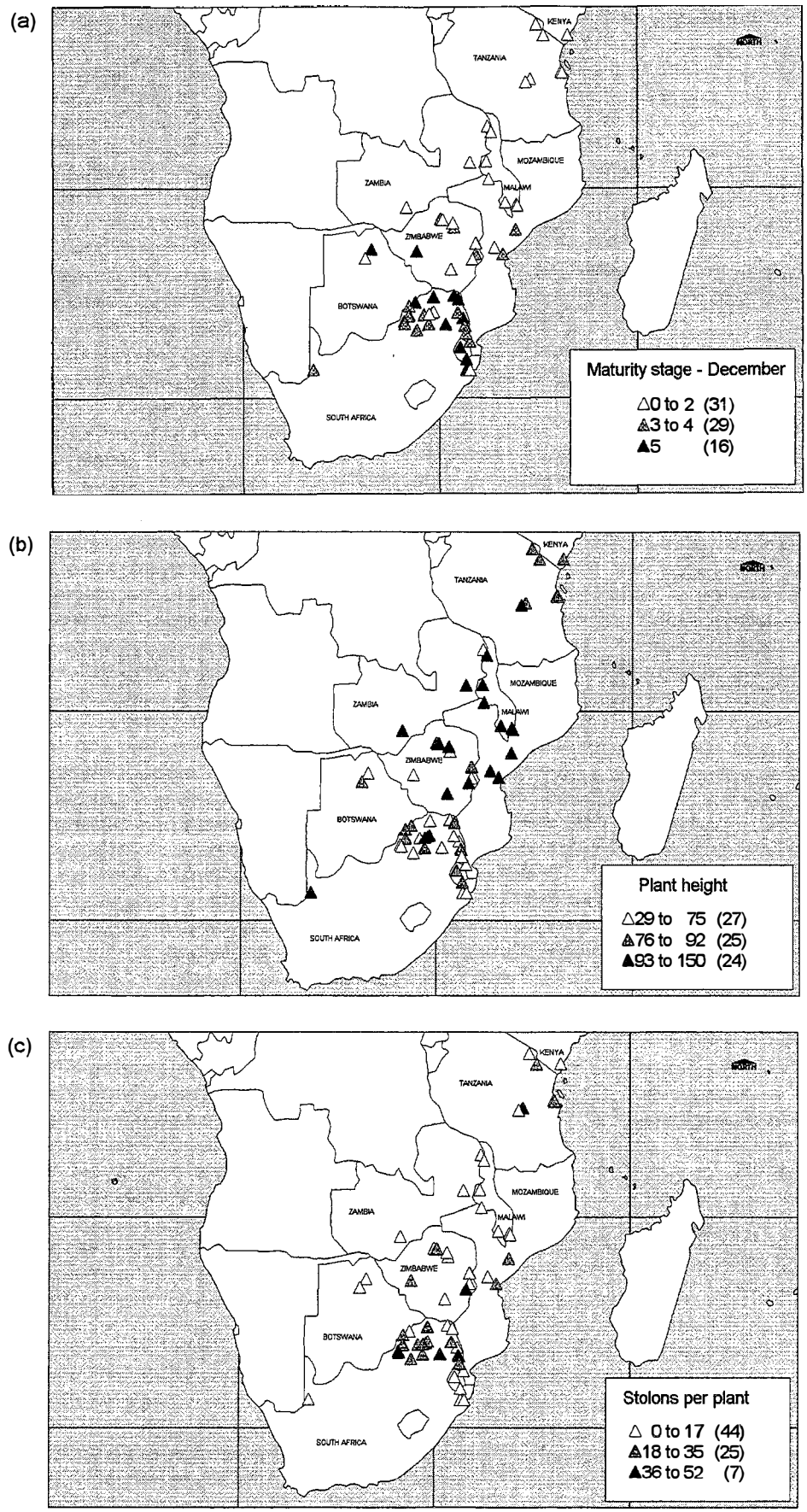

Figure 3. The association between geographic origin of 76 *U. mosambicensis* accessions and December maturity (a), plant height (b) and number of stolons per plant (c).

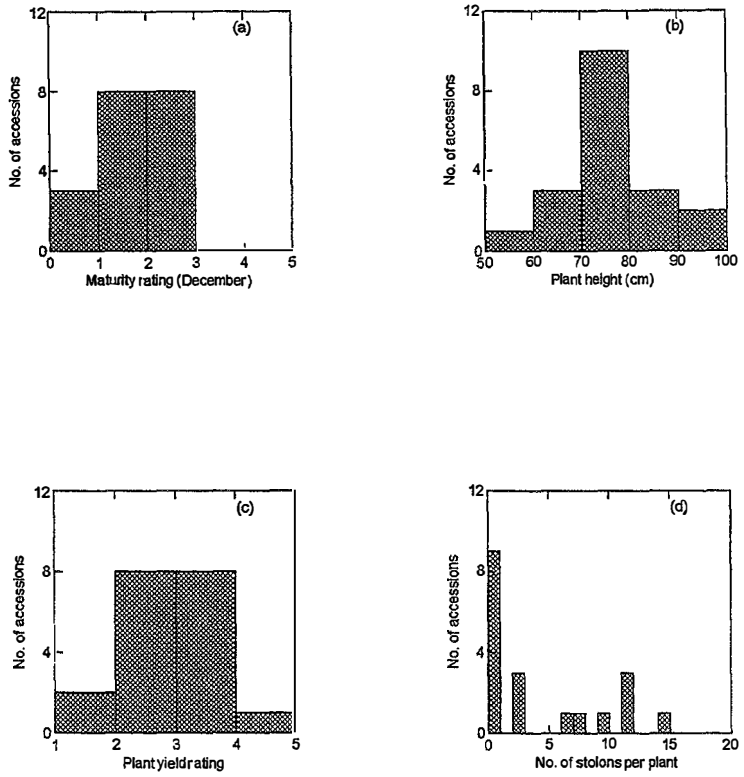

Figure 4. Variation in stage of maturity in December (1=yet to flower, 2=flowering, 3=flowering and green seed, 4=green seed and 5 = ripe seed) (a), plant height (b), yield (c) and number of stolons per plant (d) in a collection of 19 accessions *of U. oligotricha*..

Plant geography. Annual rainfall for all accessions ranged from between 800 and 1000 mm and altitude from 200 m to 1000 m. The earliest flowering accessions (CPI 47171 and 47172) were collected from the highest altitudes (800 and 1000 m). Soils at the site of collection were in most cases sandy loams, with the exception of CPI 47180 which was collected from a clay loam and CPI 47171 which was collected from a gravelly soil.

Group classification.

There was a strong relationship between some of the morphological attributes such as length of raceme and longest raceme and the general size of the plant (plant height and yield). The use of both morphological and agronomic attributes would have resulted in an unintentional weighting of attributes which related to plant size. Hence only agronomic attributes were included in the analysis.

Using the six agronomic attributes, four major groups could be identified in *U. mosambicensis* and these could be further divided into nine smaller but well-defined groups (Figure 5). The major groups were amalgamations of: Groups M1, M2 and M3, Groups M4, M5 and M6, Group M7, and Groups M8 and M9. The most important attributes in formulating these groups were, in order of importance, stage of maturity in December, plant yield, stolon length, maturity in March, stolon number and finally plant height.

For *U. oligotricha*, six groups were defined with the most important attributes being maturity in December, stolon number, maturity in March, stolon length, plant yield and plant height. In this species the major groups were made up of Group O1 plus the amalgamations of Groups O2 and O3 and Groups O4, O5 and O6 (Figure 6).

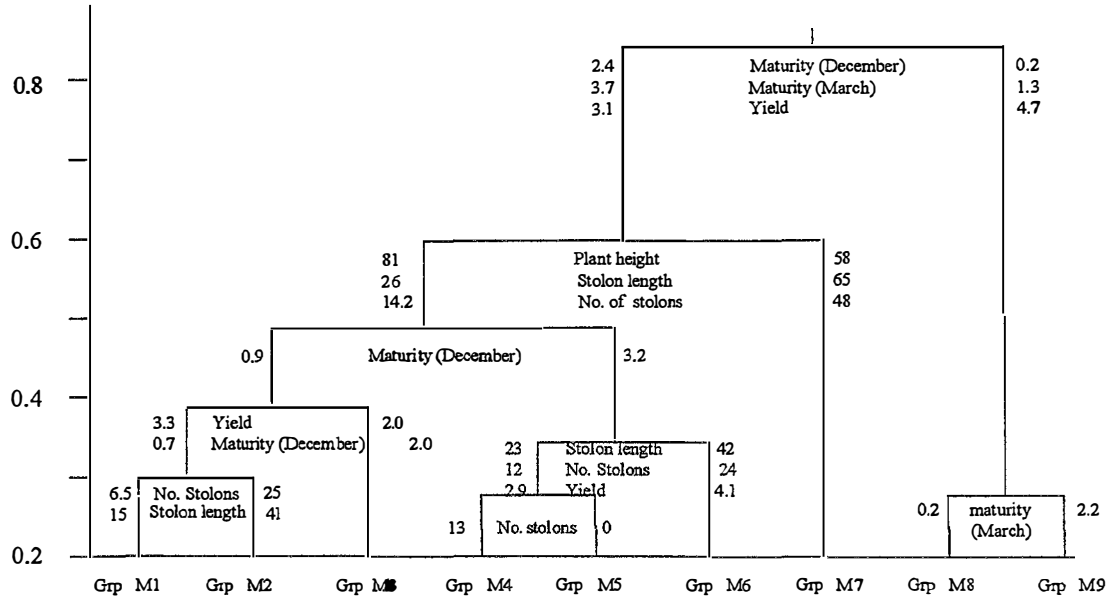

Figure 5. Dendogram of the classification of 76 accessions of *U. mosambicensis* with attributes which contributed most at each level of the hierarchy and the mean values at that level. Attribute details are listed in Table 1.

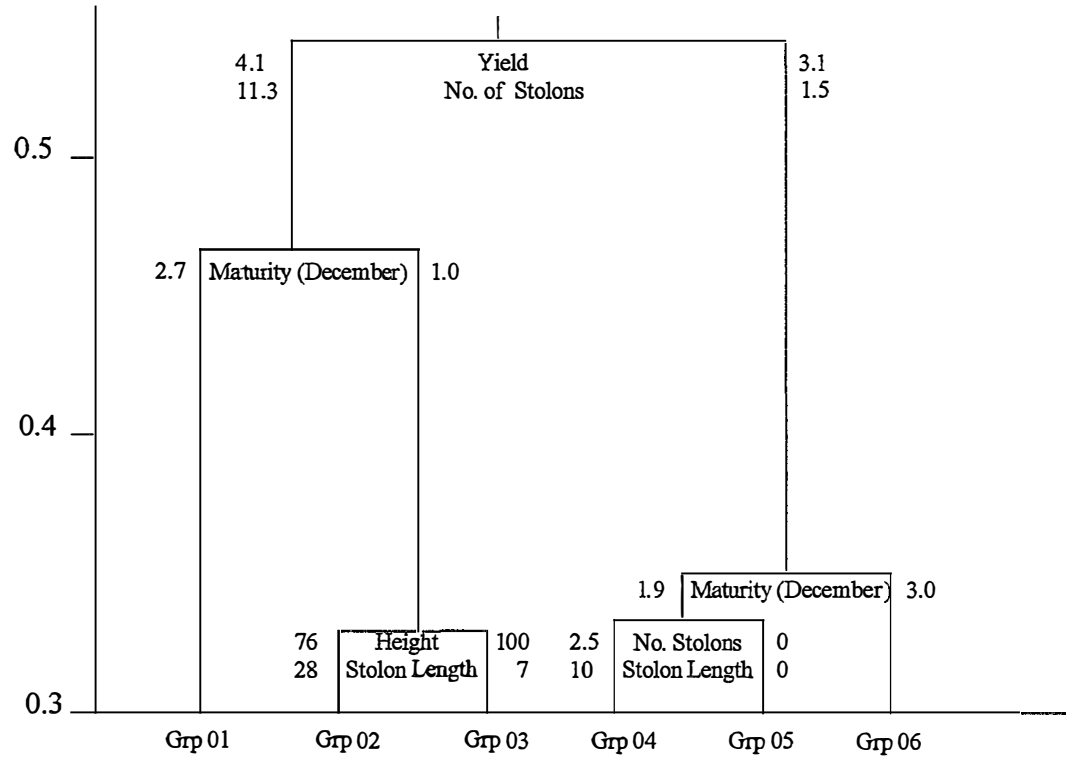

Figure 6. Dendogram of the classification of 19 accessions of *U. oligotricha* with attributes which contributed most at each level of the hierarchy and the mean values at that level. Attribute details are listed in Table 1.

Group means of all attributes, including morphological attributes not used in the analysis, are shown in Table 2 (*U. mosambicensis*) and Table 3 (*U. oligotricha*). Means for *U. stolonifera* are in Table 4. No classification of the *U. stolonifera* collection was carried out because of the small number of accessions. Details of the morphological-agronomic variation in this species is shown in Appendix 1.

Table 2. The number of members of each group of *U. mosambicensis* and the group means for the six agronomic attributes used in the classification and for four morphological attributes.

Group	M1	M2	M3	M4	M5	M6	M7	M8	M9
No. members	14	6	4	28	1	9	3	5	6
Maturity (1)	0.8	0.5	2.0	3.3	5.0	2.7	4.0	0.4	1
Maturity (2)	3.2	2.7	2.7	4.3	3.0	4.1	5.0	0.2	2.2
Yield	3.4	3.1	2.0	2.9	3.0	4.1	3.3	5.0	4.5
Height	90	97	71	73	88	85	58	92	121
Stolon length	15	41	28	24	0	42	65	44	41
No. of stolons	6.5	25	16	13	0	24	48	24	13
No. of spikes	5.9	6.4	5.2	5.1	5.0	5.7	5.7	4.5	6.5
Infl. axis length (mm)	79	84	46	61	67	66	60	65	90
Longest raceme (mm)	58	66	40	48	56	49	43	51	76
Sheath hairs	1.8	1.0	3.0	3.1	3.0	2.6	3.7	1.0	1.7

Table 3. The number of members of each group and the group means for *U. oligotricha*. Means are provided for the six agronomic attributes used in the classification and for four morphological attributes.

Group	O1	O2	O3	O4	O5	O6
No. members	4	1	1	6	2	5
Maturity (1)	2.7	1.0	1.0	2.0	1.5	3.0
Maturity (2)	3.7	2.0	3.0	2.9	4.0	3.4
Yield	4.2	4.0	4.0	2.8	3.5	3.2
Height	79	76	100	78	73	73
Stolon length	21	28	7	10	0	9
No. of stolons	12	12	7	2.5	0	1
No. of racemes	12.7	17	12	15.5	14.5	13
Infl. axis length (mm)	111	160	102	128	100	115
Longest raceme (mm)	83	80	82	95	80	92
Sheath hairs	4	1	1	2.2	3	0.6

Table 4. Means for all agronomic and morphological attributes measured from seven accessions of *U. stolonifera.*

Attribute	**Mean of all accessions**
No. members	7
Maturity (1)	3.1
Maturity (2)	4.3
Yield	3.1
Height	72
Stolon length	22
No. of stolons	10
No. of racemes	5.4
Infl. axis length (mm)	58
Longest raceme (mm)	43
Sheath hairs	2.9

U. mosambicensis

Group M1 - 14 members.

Members of this group were early flowering, moderately high yielding and had the shortest and fewest stolons of any group. This group included cv. Nixon. Most accessions were collected from mid-latitude range (between 10 and 20°S) and from relatively mesic environments (mean annual rainfall > 1000 mm).

Group M2 - 6 members

This group was also early flowering but had moderately long stolons. Stolon number was variable, ranging from 13 to 36 per plant. Members of this group were collected from sites ranging from 4 to 23°S but most were from > 16°S. As in Group 1, rainfall at the site of collection usually exceeded 1000 mm.

Group M3 - 4 members

This group was distinguished by their very low yield rating (2). All members were moderately early flowering and had moderate stolon length and number. Members of this group were from sites with latitude > 17°S.

Group M4 - 28 members

Members of this group were also early flowering and had moderately low yield but usually possessed moderate stolon length and number. Most of these accessions were from sites with latitude > 22°S and rainfall <800 mm.

Group M5 - 1 member

This accession, ATF796, was very early flowering and lacked stolons. It was collected at 22°58′S.

Group M6 - 9 members

Accessions were early flowering, had high yield and both a high stolon length and a large number of stolons. They originated from sites between 16 and 25°S Rainfall at the site of collection ranged from 450 - 1200 mm.

Group M7 - 3 members

Members were also early flowering, they were the shortest accessions and had the greatest number and longest stolons of any group. This group includes cv. Saraji. Collection data was available for 2 of the 3 accessions. Both cv. Saraji and CPI 47163 were collected at or near 24°5′S and 500 - 600 mm rainfall.

Group M8 - 5 members

Members of this group were very late flowering. They were also very high yielding, with moderately strong stolon development. The members of this group were collected from low latitudes, < 8°S and from moderately high rainfall, > 800 -1250 mm .

Group M9 - 6 members

This group was similar to Group 8 except that they had stronger flowering in March and were the

tallest accessions in the collection. As in group 8, these accessions were collected from relatively higher rainfall regions (> 700 - 1600 mm) but at slightly higher latitude (usually 7 - 16°S)

Group descriptions: *U. oligotricha.*

Group O1 - 4 members

This group was characterised by being very early flowering but having high yield and the longest and most stolons per plant.

Group O2 - 1 member

CPI 47129 was very late flowering together with a high yield, stolon number and stolon length.

Group O3 - 1 member

This single accession, CPI 60122, was high yielding, was the tallest of all accessions and did not flower until late March. It differed from Group 2 in having only a few short stolons.

Group O4 - 6 members

This group had few, short stolons and was low yielding and early flowering, flowering in spring.

Group O5 - 2 members

This group lacked stolons. One accession (CPI 73436) had not flowered and the other (CPI 73435) had just commenced flowering in spring.

Group O6 - 5 members

This group was early flowering, had low to moderate yield rating, few stolons and only moderate stolon length. This group included the three accessions from approximately 13°S in Angola, CPI 45604, 45607 and 45608.

Selecting a core collection

The identification of a core collection has two main benefits. It provides researchers with a selected set of entities for agronomic studies whilst still ensuring that the available diversity is represented. It also allows more efficient genebank management as the number of accessions that need to be maintained in sufficient quantity for distribution is reduced. A core set of 25 accessions which represents the diversity in the three species has been selected (Appendix 1), using the results of the pattern analysis as well as passport data. At least one, and usually two accessions have been selected from each group. The cultivars Nixon and Saraji as well as CPI 46876 have been included as representative accessions.

Discussion

There was considerable diversity within *U. mosambicensis* and *U. oligotricha* in time to flowering, stolon development, plant height and yield, and the results provide a sound basis for selecting accessions for more detailed evaluation. For instance, in selecting accessions for soil stabilisation and reduction of soil erosion, selection of accessions which have the potential for strong stolon development would be a priority. This was a prime criterion in the development of the cultivar Saraji (Harwood *et al.* 1996). Similarly, selecting accessions for cut and carry systems would require high yield and, in regions of higher rainfall, late maturity.

A number of accessions have a combination of attributes which may be of particular agronomic

interest. Some East Africa accessions of *U. mosambicensis* such as CPI 60147 are both late flowering and have high dry-matter yield and were collected from the more mesic sites (e.g. 1600 mm). These accessions may have a role in smallholder farming systems where cut and carry grasses are required or in higher rainfall permanent pasture systems. Similarly some accessions of *U.oligotricha* (principally groups O2 and O3) were late flowering and high yielding. This species is known to be very palatable (Burt *et al.* 1980b) and so these tall growing accessions may have a role as either cut and carry grasses or in short term pasture plants. However their palatability may limit their use in more extensive pasture systems.

U. mosambicensis CPI 46935 differed considerably from any other accession. It failed to flower at all during the experiment, was decumbent rather than erect or semi-erect and had a very high number of stolons (25) and the maximum yield rating. This same accession also appeared as an extreme form in previous trials (R.L. Burt and B.C. Pengelly unpublished data), although in that study, conducted near Townsville, the accession successfully flowered and set seed. It also performed relatively well in regional evaluation studies in north Queensland (Burt *et al.* 1980b). Although provenence data for this accession are not available, its probable origin is northern Tanzania as it was reported as having been donated from Ilonga Research Station, Tanzania.

Cv. Saraji had the best stolon development of any accessions but a further seven accessions *of U. mosambicensis* had an outstanding combination of high dry matter yield, stolon number and stolon length. These were CPI 60115, 60148, 60144, 60159 60132 and 115793 (Groups 6, 8 and 9). All of these had the maximum yield rating, between 12 and 37 stolons per plant and stolon lengths of about 50 cm.

Provenance data indicate that most accessions of all three species are well adapted to semi-arid environments and to light textured soils. Only a few of the accessions were collected from clay loams and none from heavy clay soils. There is little or no information available for soil pH or soil fertility at the sites of collection. However *U. mosambicensis* has been collected in the Kruger National Park from soils with a pH ranging from 5.9 to 8.4 and phosphorus levels usually ranging from 5 to 20 ppm (A.J. Kruger and B.C. Pengelly unpublished data). These data suggest that *U. mosambicensis* is well adapted to slightly acid to alkaline soils of low fertility.

A number of accessions of *U. mosambicensis* were collected from altitude of > 800 m or from latitudes > 25°S suggesting that some accessions may have limited tolerance to cool temperatures. Almost all accessions of *U. oligotricha* were collected from > 1000 m altitude in low rainfall regions. This would indicate that this species generally is tolerant to cool temperatures. Similar low temperature tolerance might be found in *U. stolonifera* where all accessions were collected from between 25 and 29°S.

The majority of accessions of *U. mosambicensis* in this collection originated from northern South Africa. Few have been collected from East Africa. Accessions from Kenya and Tanzania are late flowering, high yielding and possess strong stolon development. The poor representation of East Africa germplasm makes acquisition of further collections from this region a priority, especially if germplasm is required for higher rainfall regions. The poor representation of *U. oligotricha* and *U. stolonifera* in the collection highlights the need to acquire further representatives of these species.

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Appendix 1. Provenance and agronomic data and group membership for *U. mosambicensis, U. oligotricha* and *U. stolonifera*. Highlighted accessions have been selected as representative and core accessions for these species.

Accession*	species	Group No.	Soil texture	Latitude (S)	Longitude (E)	Altitude (m)	Rainfall (mm)	Maturity (1)† (1-5)	Maturity (2)‡ (1-5)	Yield (2-5)	Height (cm)	Stolon length (cm)	Stolon no.
52320	*mosambicensis*	M1	sandy loam	13°07′	32°15′	600	750	1	2	3	97	0	0
60117	*mosambicensis*	M1	loam	17°14′	30°01′	1212	750	2	3	4	86	20	3
60126	*mosambicensis*	M1	loam	18°58′	32°04′	1061	900	1	4	4	80	25	8
60133	*mosambicensis*	M1	loam	10°33′	33°33′	1303	1100	1	2	3	45	17	10
60135	*mosambicensis*	M1	loam	13°04′	33°29′	1030	1200	0	4	4	116	7	6
60137	*mosambicensis*	M1	loam	16°22′	27°27′	1152	725	1	4	4	106	6	5
60143	*mosambicensis*	M1	sand	4°04′	39°04′	300	1200	0	2	3	81	21	11
60145	*mosambicensis*	M1	loam	14°02′	33°37′	1121	1175	1	4	3	95	10	2
60149	*mosambicensis*	M1	loam	19°16′	34°06′	152	1100	0	3	4	109	5	2
60151	*mosambicensis*	M1	clay loam	20°51′	30°49′	667	700	0	4	3	99	20	11
73439	*mosambicensis*	M1		28°01′	32°17′			1	5	3	66	20	14
ATF358	*mosambicensis*	M1		17°31′	30°58′			1	3	3	105	20	4
CQ3359	*mosambicensis*	M1		20°02′	146°02′			1	3	3	91	25	6
cv. Nixon	*mosambicensis*	M1						1	3	3	88	10	10
60110	*mosambicensis*	M2		17°18′	30°07′			0	2	3	92	43	36
60139	*mosambicensis*	M2	loam	23°53′	29°31′	1303	450	1	4	3	115	38	25
60142	*mosambicensis*	M2	sandy loam	4°04′	39°04′	30	1250	0	1	3	86	41	16
60146	*mosambicensis*	M2	loam	16°01′	35°45′	606	1300	1	4	3	98	40	13
60150	*mosambicensis*	M2	sandy loam	20°07′	32°27′	758	800	1	4	3	112	40	35
60158	*mosambicensis*	M2	sand	6°46′	38°14′	45	1100	0	1	4	78	45	28
16094	*mosambicensis*	M3		27°59′	153°22′			2	2	2	93	15	8
30654	*mosambicensis*	M3						2	3	2	91	60	32
60116	*mosambicensis*	M3	clay loam	17°05′	31°03′	1515	850	2	3	2	29	10	1
60153	*mosambicensis*	M3	sandy loam	25°25′	31°55′	61	575	2	3	2	70	27	25
41200	*mosambicensis*	M4						4	5	2	82	23	12
43123	*mosambicensis*	M4						3	4	3	73	23	10
43124	*mosambicensis*	M4						2	4	3	87	23	15
46876	*mosambicensis*	M4		26°24′	31°32′			4	4	3	91	12	10
47146	*mosambicensis*	M4	sandy loam	23°58′	29°24′	1350	700	4	4	3	69	25	17

* Numbers without prefix are Australian Commonwealth Plant Introduction accessions; "ATF" refers to Australian Tropical Forages GRC accessions; "CQ" refers to CSIRO Tropical Agriculture Introduction accessions; "P" refers to NSW Agriculture Introduction accessions; "Q" refers to Qld Department of Primary Industries accessions

† Maturity stage in December (see Table 1)

‡ Maturity stage in March (see Table 1)

Accession*	species	Group No.	Soil texture	Latitude (S)	Longitude (E)	Altitude (m)	Rainfall (mm)	Maturity (1) (1-5)	Maturity (2) (1-5)	Yield (2-5)	Height (cm)	Stolon length (cm)	Stolon no.
47162	*mosambicensis*	M4	clay loam	24°33'	27°18'	1000	600	3	4	3	59	27	11
60118	*mosambicensis*	M4	sandy loam	25°58'	32°14'	30	700	3	4	3	69	9	2
60119	*mosambicensis*	M4	sandy loam	18°59'	32°42'	1061	1200	3	4	2	59	23	5
60127	*mosambicensis*	M4	sandy loam	19°45'	32°04'	848	850	3	5	3	70	19	4
73437	*mosambicensis*	M4		22°05'	29°32'			4	4	3	69	21	22
73438	*mosambicensis*	M4		28°01'	32°00'			4	5	2	62	26	12
73440	*mosambicensis*	M4		27°14'	31°59'			4	5	3	83	22	12
73442	*mosambicensis*	M4		22°43'	31°02'			4	5	3	74	15	6
73447	*mosambicensis*	M4						3	5	4	68	33	8
ATF793	*mosambicensis*	M4		24°18'	31°44'			4	3	3	60	30	12
ATF794	*mosambicensis*	M4		23°55'	31°18'			3	3	3	71	25	20
ATF797	*mosambicensis*	M4		24°54'	31°52'			3	4	2	67	26	9
ATF798	*mosambicensis*	M4		24°53'	31°05'			3	4	3	75	20	35
CQ3352	*mosambicensis*	M4		19°24'	146°49'			3	5	4	81	10	2
CQ3353	*mosambicensis*	M4		19°24'	146°49'			4	5	3	72	20	12
CQ511	*mosambicensis*	M4						5	5	3	74	33	14
P12750	*mosambicensis*	M4						3	4	3	66	30	17
Q2447	*mosambicensis*	M4						3	4	3	67	37	18
ATF796	*mosambicensis*	M5		22°58'	31°22'			5	3	3	88	0	0
47136	*mosambicensis*	M6	loam	24°47'	29°09'	1000	750	3	4	4	75	43	22
47157	*mosambicensis*	M6	sandy loam	23°25'	27°41'	450	450	2	4	4	77	32	30
47158	*mosambicensis*	M6	gravel	24°05'	27°41'	450	450	4	5	4	92	39	17
47167	*mosambicensis*	M6	sandy loam	25°08'	28°17'	1160	670	3	4	3	71	48	26
60136	*mosambicensis*	M6	clay loam	17°58'	35°42'	45	1000	2	4	4	104	54	18
60148	*mosambicensis*	M6	sandy loam	19°44'	34°45'	15	1250	2	4	5	97	51	28
72977	*mosambicensis*	M6		19°31'	28°17'			4	4	4	58	38	29
73441	*mosambicensis*	M6		22°43'	31°01'			3	5	4	99	34	18
115793	*mosambicensis*	M6		16°16'	35°51'			1	3	5	94	42	28
47163	*mosambicensis*	M7	sand	24°41'	27°21'	1000	600	3	5	3	65	63	39
cv. Saraji	*mosambicensis*	M7	loam	24°46'	30°27'	1000	500	5	5	3	50	73	52
P12749	*mosambicensis*	M7						4	5	4	60	59	52
46935	*mosambicensis*	M8						0	0	5		52	25
60111	*mosambicensis*	M8	clay loam	3°19'	37°18'	758	1250	1	0	5		29	5
60132	*mosambicensis*	M8	sandy loam	4°06'	37°51'	697	750	1	0	5		31	23
60144	*mosambicensis*	M8	sandy loam	7°14'	36°49'	697	800	0	0	5		50	37
60159	*mosambicensis*	M8	sand	6°42'	39°01'	45	1100	0	1	5	92	56	30
60112	*mosambicensis*	M9	sandy loam	7°24'	36°29'	606	750	0	2	4	119	28	14
60115	*mosambicensis*	M9	loam	16°01'	34°54'	61	700	0	2	5	150	46	12

Accession*	species	Group No.	Soil texture	Latitude (S)	Longitude (E)	Altitude (m)	Rainfall (mm)	Maturity (1) (1-5)	Maturity (2) (1-5)	Yield (2-5)	Height (cm)	Stolon length (cm)	Stolon no.
60134	*mosambicensis*	M9	sandy loam	10°59´	33°05´	1061	1000	0	2	5	117	35	8
60141	*mosambicensis*	M9		24°03´	29°12´			0	4	4	113	32	26
60147	*mosambicensis*	M9	clay loam	16°16	35°51	606	1600	0	1	4	128	57	7
60147A	*mosambicensis*	M9	clay loam	16°16´	35°51´	606	1600	0	2	5	104	51	14
73443	*mosambicensis*							3	5	3	87	16	23
16734	*oligotricha*	O1		18°45´	26°08´			3	3	4	79	16	10
47121	*oligotricha*	O1		23°01	29°31	1000	450	3	4	4	80	35	15
60120	*oligotricha*	O1	clay loam	17°05	31°03	1515	850	2	4	5	74	17	12
60123	*oligotricha*	O1	clay loam	18°19´	26°19´	788	550	3	4	4	84	15	12
47129	*oligotricha*	O2		19°41	17°19´	1600	700	1	2	4	78	25	12
60122	*oligotricha*	O3	sandy loam	17°21	25°09	1242	700	1	3	4	100	7	7
41201	*oligotricha*	O4						2	3	3	75	12	3
43689	*oligotricha*	O4						2	3	2	69	13	3
45143	*oligotricha*	O4						2	3	3	76	0	0
47122	*oligotricha*	O4		20°13	16°02´	1200	500	2	2	3	93	12	1
47124	*oligotricha*	O4		19°39´	17°02´	1200	500	2	3	3	72	21	8
60121	*oligotricha*	O4	loam	16°46´	29°37´	1364	850	2	3	3	83	0	0
73435	*oligotricha*	O5		17°17´	30°12´			2	4	4	69	0	0
73436	*oligotricha*	O5		23°42	30°03			1	4	3	78	0	0
43122	*oligotricha*	O6						3	3	2	55	0	0
45604	*oligotricha*	O6		13°02´	14°04´			3	4	3	74	14	3
45607	*oligotricha*	O6		13°02´	14°04´			3	3	4	90	0	0
45608	*oligotricha*	O6						3	4	3	75	14	1
60140	*oligotricha*	O6	sandy loam	2°06´	34°44´	1364	650	3	3	4	69	19	1
47171	*stolonifera*	S1	gravel	25°28	30°52	1000	900	5	4	3	66	32	22
47172	*stolonifera*	S1	sandy loam	25°28´	30°52´	700	800	5	4	3	58	20	4
47173	*stolonifera*	S1	sandy loam	29°00´	30°47´	200	800	3	4	3	67	24	9
47177	*stolonifera*	S1	sandy loam	28°23´	31°22´	200	800	1	4	3	100	10	16
47178	*stolonifera*	S1	sandy loam	28°04´	31°34´	200	800	4	4	3	63	17	3
47179	*stolonifera*	S1	sandy loam	28°12´	31°56´	200	1000	2	5	4	74	16	4
47180	*stolonifera*	S1	clay loam	28°12	31°56	200	1000	2	5	3	60	33	12