MORTALITY OF SOME TROPICAL GRASSES AND LEGUMES FOLLOWING FROSTING IN THE FIRST WINTER AFTER SOWING

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ABSTRACT

The death of plants of the Eastern Darling Downs of Queensland, following frosting in the first winter after summer and autumn sowing, was measured for a range of summer growing legumes and grasses. The lowest terrestrial minimum recorded over two winters was 15°F.

There were extreme survival differences between species ranging, for example, from good survival of Chloris gayana *and* Panicum coloratum *var* makarikariense *to poor or no survival of* Panicum maximum *var.* trichoglume *and* Panicum coloratum *(kabulabula). Siratro had the best survival of all sub-tropical legumes, although siratro is extremely susceptible to frost injury.* Teramnus uncinatus *and* Dolichos axillaris *had negligible survival although these species are reported to have a greater resistance to frost injury than siratro.*

INTRODUCTION

A wide range of tropical grasses and legumes is currently under evaluation and commercial use for pasture in Queensland and northern New South Wales. Frosting during winter is widespread over much of this region (Coleman, 1964). Usually only plant top growth is frosted and established plants form new shoots in the following spring. However severe frosts have also caused appreciable death among both commercial and experimental sowings of some cultivars in the first winter after establishment (J. K. Cull, J. K. Leslie and R. J. Jones; personal communications).

There is no published comparison of mortality of commonly sown tropical pasture species due to frosting in the first winter after establishment. This report records depth due to frost in four sowings of tropical pasture species made in 1967-68 in the Eastern Darling Downs of Queensland.

MATERIALS AND METHODS

The altitude of the experimental area, approximately 1,500 feet, is typical of the Eastern Darling Downs. The average annual rainfall at Pittsworth, seven miles west of the experimental area, is 25.6 inches and at Cambooya, eight miles east, is 26.5 inches (Anon, 1956).

Two species evaluation trials were sown in January and February 1967 and two smaller sowings in January and February 1968. The main aim of these trials was to screen pasture species for persistence and production. The recording of plant death due to frosting was a secondary objective. The effect of frosting was measured indirectly by comparison of autumn and spring plant density counts in the year of sowing.

Three of the four sowings were on a Beauaraba sedentary black earth (Thompson and Beckmann, 1959) but a restricted number of species in sowings (1) and (2) were sown on the same dates on an adjacent Irving colluvial black earth (Thompson and Beckmann). The fourth sowing was on a Southbrook neutral krasnozem (Thompson and Beckmann), approximately three-quarters of a mile from the Beauaraba site.

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Rainfall was measured during 1967 and 1968 half a mile away from the Beauaraba soil site, as was screen temperature on a seven day thermohygrograph. Terrestrial minimum temperatures were measured at approximately weekly intervals through both winters on the Beauaraba, Irving and Southbrook sites. The three terrestrial minimum thermometers (British Standard 692) were checked prior to being placed out in each winter. The recording bulbs were between one to two inches above ground level.

Listed in Table 1, for each sowing, are the dates of sowing, seedling emergence, late autumn density counts, late autumn yield sampling and spring density counts.

TABLE 1.

Sowing No.	Species Sown	Date Sown	Date Emerged	Date of Density Counts Autumn	Spring	Autumn Yield Sampling	Soil Types
1	Legumes	23.1.67	6.2.67	26.3.67	17.10.67	26.4.67	Beauaraba (sedentary black earth)
2	Grasses	27.2.67	5.3.67	10.4.67	17.10.67	10.5.67	Beauaraba (sedentary black earth)
3	Grasses	22.2.68	21.3.68	23.4.68	1.10.68	12.6.68	Beauaraba (sedentary black earth)
4	Grasses	17.1.68	14.2.68	12.3.68	14.11.68	9.5.68	Southbrook (sedentary neutral (krasnozem)

Each cultivar or strain in each sowing was sown in plots of 800 square links in a randomised block layout with three replicates. *Panicum coloratum* (kabulabula) was the companion grass to the legumes in sowing (1). Both autumn and spring density counts were made with 25 random throws of a 4 x 1 link quadrat in each plot. The spring density counts of rhodes grass may be slightly exaggerated as it was necessary to decide which rooted points corresponded to autumn seedlings. Visual assessment of frost damage and regrowth was made on all species throughout each winter.

Sowings (1), (2) and (4) were yield sampled in the autumn after sowing at a cutting height of 1½ inches, except for rhodes grass (*Chloris gayana*) which was cut more closely. These sowings were subsequently grazed to approximately three inches height prior to and during the following winter, partly as a weed control measure. Sowing (4) was heavily grazed to approximately one inch above ground level.

Sowing (3) was sampled without cutting to avoid any possibility of frosting differentially affecting plants which would have been cut either by standard sampling techniques or subsequent grazing. This sowing was not grazed or cut during the autumn or winter after sowing, but was sprayed with 2,4-D to control weed growth. The sampling to ground level was by visual assessment, using grass leaves cut from outside the plot. A separate bunch of cut leaves was assessed as equalling the bulk of each plant in the sampling quadrants. These bunches were then bulked for each plot and equated as the weight of sown grass in the sampled area of each plot.

RESULTS

Temperatures during the 1967 and 1968 winters were reasonably typical of the Eastern Downs, as shown by the temperature data for Pittsworth (Table 2), with the exception that June 1967 was unusually mild. The screen temperatures near the experimental site were slightly colder than those recorded at Pittsworth.

TABLE 2.
climatic data
(a) Pittsworth

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Aver. monthly rainfall (in.)	3.69	2.33	2.24	1.62	1.22	1.86	1.73	0.96	1.30	2.08	2.70	3.89	25.62
Aver. monthly min. temp. (°F)	62.4	61.8	59.2	53.5	47.0	43.2	41.3	42.8	48.0	53.5	58.3	60.9	
1967 monthly min. temp. (°F)	62.7	61.9	57.9	53.2	48.1	49.5	40.0	39.4	45.7	56.3	57.9	59.8	
1968 monthly min. temp. (°F)	64.2	63.2	61.6	57.4	46.7	40.4	41.3	42.2	47.8	53.1	61.5	59.6	

(b) Experimental Site

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
1967 monthly rainfall (in.)	2.53	2.48	3.92	0.46	1.83	5.35	0.43	1.08	0.22	1.67	2.50	0.35	22.82
1968 monthly rainfall (in.)	3.94	1.04	2.73	1.99	1.39	0.50	3.71	2.85	0.71	0.36	2.59	4.01	25.82
1968 monthly min. temp. (°F)	62	61	60	56	47	38	39	40	46	52	59	59	

From mid July 1967 to the end of September 1967, there were seven out of ten weeks during which there was at least one terrestrial minimum of 25°F or less. From late May to the end of September 1968 there were eleven out of eighteen weeks with a terrestrial minimum of 25° or less. Consequently frosting was both severe and regular.

The lowest terrestrial minimum recorded in each of the two years was 17°F in September 1967 and 15°F in July 1968. Terrestrial minima were usually 1 to 2° lower on the Irving than Beauaraba site and 1-2°F higher on the Southbrook than Beauaraba site, although these relationships were sometimes inverted.

Seedling growth in the four sowings, particularly in the two February sowings, was checked by dry conditions in late March and April. There was sufficient subsoil moisture to maintain seedlings but growth was severely restricted.

Survival of cultivars or strains has been expressed as the percentage survival in spring, of plants counted in the previous autumn (Tables 3, 4 and 5). Strains in these tables have been ranked in order of increasing mortality within each sowing. The vertical lines at the right hand edge of the tables connect survival percentages which were not significantly different. Strains which did not have an initial autumn density of at least 0.025 seedlings per square link in two of three replicate plots have not been included in the tables or in the statistical analysis. The statistical test used was a modified Duncan's multiple range test and this technique did not allow for analysis of strains with no survival.

TABLE 3.
Survival Percentages over the First Winter
Sowing (1)

Species	Cultivator or Strain	Plant weight (grammes) 0.7	Survival Percentage	Significant Differences (5% levels)
Medicago sativa	Hunter river	02	98	]
Phaseolus atropurpureus Ig	Siratro	02	83	
Phaseolus atropurpureus	Siratro	1.2	65	
Desmodium uncinatum	Silverleaf desmodium	2.6	56	
Phaseolus bracteatus	C.P.I. 27404	0.8	55	
Glycine javanica	Cooper	0.4	53	
Glycine javanica	Clarence	< 01	48	
Lotononis angolensis	C.P.I. 26293	0.5	46	
Desmodium intortum	Greenleaf	4.4	36	
Phaseolus lathyroides	Phasey bean (Murray)	1.0	21	
Dolichos axillaris	C.P.I. 17814	1.2	4	
Teramnus uncinatus	C.P.I. 25937	0.1	0	
Dolichos baumanii	C.P.I. 24972	9.3	0	
Dolichos biflorus	C.P.I. 26260	15.0	0	
Dolichos lablab	Rongai	< 0.1	0	
Alysicarpus vaginalis	Alyce clover		0	

TABLE 4.

(*Ig* denotes a species sown on an adjacent colluvial Irving soil and this cannot be included in assessment of significant differences of the Beauaraba site. All measurements on any plot on Irving soil were made on the same day as on the Beauaraba soil.)

Survival Percentages over the First Winter Sowing (2)

Species	Cultivar or Strain	Plant weight grammes	Survival Percentage	Significant Differences (5% levels)
Chloris distichophylla	C.P.I. 26785	< 0.1	103	
Chloris gayana	Pioneer	3.2	97	
Paspalum notatum	C.P.I. 9073	< 0.1	90	
Panicum coloratum	Pollock	< 0.1	85	
Panicum coloratum Ig	Burnett	—	62	
Panicum coloratum	Burnett	0.1	61	
Setaria sphacelata	Kazungula	0.1	24	
Setaria sphacelata	Nandi	0.2	23	
Cenchrus ciliaris	Gayndah	1.0	23	
Sorghum almum	Crooble	1.1	22	
Panicum coloratum	Bambatsi	< 0.1	22	
Panicum antidotale	Giant Panic	0.8	20	
Paspalum guenoarum	C.P.I. 20324	0.1	19	
Cenchrus ciliaris	Molopo	1.8	12	
Cenchrus ciliaris	Biloela	1.9	9	
Panicum maximum var. *trichoglume*	Petrie (Green Panic)	0.8	6	
Brachiaria brizantha	C.P.I. 15890	0.6	5	
Sorghum sp.	Krish	1.1	5	
Paspalum notatum	C.P.I. 11863	< 0.1	4	
Paspalum plicatulum	Rodd's Bay	0.1	3	
Panicum coloratum	C.P.I. 14375 (kabulabula)	0.9	0	
Paspalum plicatulum	Hartley	< 0.1	0	
Panicum maximum var. *trichoglume Ig*	Petrie (Green Panic)	—	0	
Panicum coloratum Ig	C.P.I. 14375 (kabulabula)	—	0	
Panicum coloratum	C.P.I. 16796 (kabulabula)	0.8	0	

Ig denotes a species sown in the Irving site and this cannot be included in the assessment of significant differences of the Beauarba site.

TABLE 5.

Survival Percentages on the First Winter 1968 Sown Grasses Sowing (3)

Species	Cultivar or Strain	Plant weight (grammes)	Survival Percentage	Significant Differences (5% levels)
Setaria sphacelata	C.P.I. 32728	1.9	91	
Setaria sphacelata	C.P.I. 32930	2.8	64	
Setaria sphacelata	C.P.I. 33453	1.4	41	
Panicum coloratum	Pollock	0.4	31	
Panicum coloratum	Burnett	0.4	14	
Panicum coloratum	Bambatsi	0.3	13	
Setaria sphacelata	Kazungula	1.0	10	
Panicum coloratum	C.P.I. 16796 (kabulabula)	2.3	0	
Panicum maximum var. *trichoglume*	Petrie (Green Panic)	3.0	0	
	Sowing (4)			
Panicum coloratum	Burnett	0.4	70	
Panicum coloratum	Bambatsi	0.5	36	
Panicum maximum var. *trichoglume*	Petrie (Green Panic)	5.3	12	
Panicum coloratum	C.P.I. 16796 (kabulabula)	5.0	7	

The plant weight figures listed in Tables 3, 4 and 5a have been calculated from the autumn yield per unit area divided by the autumn density count. As sowings (1), (2) and (4) were cut at 1½ inches above ground level, the plant weight figures listed in Tables 3 and 4 were only an indication of plant weight and not an absolute measure, i.e. runners of siratro (*Phaseolus atropurpureus*) were largely below the sampling level. The plant weights listed for sowing (4) (Table 5b) were based on the yield per quadrat divided by the number of plants sampled in the quadrat.

DISCUSSION

It is impossible to prove that the measured death of the sown species was due solely to frosting. However rainfall between the autumn and spring counts in both years was such that moisture stress was not a likely cause of plant death.

Although the summer species were not growing vigorously in the September-October of both years, no plants were seen that had survived the winter period and died following commencement of spring growth. There was no death of seedlings due to dry autumn conditions after the initial quadrat counts and prior to the onset of frosting, except for very scattered seedlings of *Paspalum plicatulum* cv Rodds Bay sown in 1967. The high measured winter mortality of some reportedly drought resistant species (i.e. *Dolichos axillaris*), contrasted with the much lower mortality of some drought susceptible species (i.e. *Desmodium uncinatum*), further suggests that soil moisture stress did not cause death.

Of the commercial or near commercial grass cultivars, the frost resistant setaria introductions, rhodes grass and makarikari panics had the highest survival percentages (Table 4 and 5). No mortality was noted among scattered invading plants of *Paspalum dilatatum* or transplanted kikuyu (*Pennisetum clandestinum*). Single plots of *Eragrostis curvula* and Katambora rhodes grass sown in 1967 (sowing 2) had high survival percentages of 79% and 61%. The most frost susceptible cultivars, in terms of mortality, were green panic (*Panicum maximum* var. *trichoglume*) and *Panicum coloratum* (kabulabula).

The interpretation of the survival percentages from sowing (4) is complicated by the possibility of death due to competition from winter weeds and to heavy grazing pressure. However the ranking of the cultivars in terms of survival is still the same as for the Beauaraba site. The survival of very scattered *Panicum coloratum* (kabulabula) in sowing (4) appeared to be due to surface stone protecting the butts of grass tussocks.

The survival percentage ranking of the species included in both sowings (2) and (3) was similar, although sowing (2) was grazed prior to and during winter and sowing (3) was not. Consequently the poor survival of green panic and *Panicum coloratum* (kabulabula) in sowings (2) and (4), as compared with makarikari panic, cannot be attributed to differential effects of defoliation on the more rapidly growing green panic and *Panicum coloratum* (kabulabula).

Plant size and defoliation prior to winter can affect survival of a frost susceptible species. The data on *Panicum coloratum* (kabulabula) survival in Table 6 suggest that, within the given ranges of plant weights, the survival percentage increased as plant weight increased. However isolated eighteen months old plants of green panic, Nandi Setaria, and *Panicum coloratum* (kabulabula) have apparently been killed out by frosting even during their second winter under conditions of close grazing prior to or during this winter.

TABLE 6

Autumn plant weight and winter survival percentage of Panicum coloratum *(kabulabula strain) in four sowings.*

Sowing Date	Strain	Plant weight (grammes)	Survival Percentage
January 1967 (sowing 1)	C.P.I. 14375	10.8	35
January 1968 (sowing 4)	C.P.I. 16796	5.0	7
February 1967 (sowing 2)	C.P.I. 16796, 14375	0.9	0
February 1968 (sowing 3)	C.P.I. 16796	2.3	0

In both years almost all plants regrew to some extent after the first frost killed off top growth. Some species, notably *Panicum coloratum* (kabulabula), grew again after successive frostings into June and July but there was a reduced number of plants shooting again after each successive frosting. There was no consistent relationship between the tendency of species to show this successive regrowth and the survival of species through the first winter.

The weight of individual plants and their winter survival was not related when comparing species. For example, in sowing (2) there was good winter survival of both rhodes grass, with relatively large plants, and makarikari panic with smaller plants. In the same sowing there was poor survival of both green panic, with relatively large plants, and *Paspalum plicatulum* with small plants.

There was no consistent relationship between the reported resistance of species to frost injury, as noted at other sites with assumed less severe winters, and the mortality of these species during the first winter in the Downs environment. Siratro, commonly accepted to be one of the most sensitive of tropical legumes to frost injury, had the highest survival percentage of all tropical legumes while *Teramnus uncinatus* and *Dolichos axillaris*, noted as relatively frost resistant in the northern Wallum (Evans, 1967) had survival percentages of nil and 7%. *Panicum coloratum* (kabulabula), noted as frost resistant by Evans, was almost eliminated in both the 1967 and 1968 grass sowings. *Paspalum guenoarum*, noted as relatively resistant to frost injury at Eskdale by 't Mannetje (1967), and also to the first frosts of the 1967 Downs sowing, had only a 22% survival at the end of winter. On the other hand makarikari panic, which is commonly noted as resistant to frost injury (Bryant, 1967), had, with rhodes grass, the least mortality of all the present commercial summer grasses in the 1967 and 1968 sowings.

The most frost resistant grasses, in terms of carrying green leaves through or into severe frosts were, in order of resistance, *Chloris distichophylla*, invading plants of *Paspalum dilatatum*, frost resistant *Setaria sphacelata* introductions C.P.I. 32728, 32930 and 33453, kikuyu (*Pennisetum clandestinum*), makarikari panic *Panicum coloratum* var. *makarikariense*) rhodes grass (*Chloris gayana*) and *Paspalum guenoarum*. However, the observed winter growth of all these species was negligible and only *Chloris distichophylla* remained green when the terrestrial minimum fell below 20°F. All these grasses noted as frost resistant, with the exception of *Paspalum guenoarum*, also had high measured survival percentages (Tables 4 and 5) or, in the case of kikuyu and *Paspalum dilatatum*, had no observed death due to frosting.

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