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FLOODING TOLERANCE OF PANICUM COLORATUM

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SUMMARY

Five *Panicum coloratum* cultivars and one of *Panicum maximum* were flooded in pots. Flooding damage was assessed by visually rating the induced chlorosis, counting live tillers per pot and measuring percentage dry weight of the plants. Superior flooding tolerance was shown by the cultivar Kabulabula C.P.I. 14375 and variety *makarikariense* cvs Bambatsi, Burnett and Pollock. The results are compared with field information.

I. INTRODUCTION

Bryant (1966) reported that *Panicum coloratum* is widely distributed throughout southern and eastern Africa, and within this wide climatic area two habitat factors are repeated with remarkable consistency—its preference for clay loam and clay soils either freely drained or seasonally flooded. The agronomic features, description, and possible uses of the species in Australia have been outlined by Wilson (1963), Bryant (1959, 1966 and 1967), Lloyd and Scateni (1968), Anderson (1970*a*, 1970*b*), and Lloyd (1971).

Anderson (1970*a*), working in flooded areas of Area III of the Brigalow Development Scheme in Central Queensland, reported that *Panicum coloratum* cv. Kabulabula and *Panicum coloratum* var. *makarikariense* cv. Bambatsi, the only cultivars of the species tested, were the most flood tolerant of a range of grasses. Limited testing has also shown *Panicum maximum* cv. Sabi to have some flood tolerance. However, three cultivars, Bambatsi, Burnett and Pollock, described by the Australian Registrar of Herbage Plant Cultivars (1967) and Lloyd and Scateni (1968), have been selected for Australian conditions, and of these Pollock has been stated to be most suited for waterlogged conditions. This paper reports the flooding tolerance of a range of *Panicum coloratum* cultivars as assessed in small pots.

II. MATERIALS AND METHODS

The experiment was conducted in 8½ in. polyester pots in an open-sided glasshouse at the Mackay Experimental Centre of the Queensland Department of Primary Industries. The soil was the same as that described by Anderson (1972), an alluvial grey-brown clay of medium to heavy texture. It was crushed and sieved of root debris prior to potting and 1,200 g were placed in the same volume of each pot.

Treatments, arranged in a randomized block design with three replicates, were: 6 grasses (*Panicum coloratum* var. *makarikariense* cvs. Bambatsi, Burnett and Pollock, *P. coloratum* cv. Kabulabula C.P.I. 14375 and C.P.I. 16796, and *Panicum maximum* cv. Sabi) by 5 flood durations (0, 10, 20, 30 and 40 days).

An excess of seed was sown in each pot on December 19, 1968, and later thinned to five plants per pot. These were allowed to grow for 9 months and then cut to 1½-2 in. height on August 14, 1969, and fertilized with sulphate of ammonia equivalent to 60 lb N/ac. Flooding, by submerging the pots in plastic bags containing water, commenced on September 10, 1969. The bags were held upright by attachment to an overhead trellis. The water was maintained at a height of 18 in. above the soil level. The plants were harvested to 1½-2 in. on October 27, 1969 (7 days after the removal of the longest flood duration).

Prior to flooding, the plant heights and number of tillers were recorded. When the flood was removed from each pot the visual effect of flooding was rated on a 0 (dead) to 10 (no effect) scale for each plant. At harvest the number of live plants and tillers per pot, and the oven-dry weight (drying to constant weight at 70°C in a forced air draught oven), were determined.

III. RESULTS

At the commencement of flooding there was little difference in the maximum height of each species—Burnett and Pollock 18 in. to Kabulabula C.P.I. 14375 21 in. (Table 1). Initial flooding caused all leaves to be covered by water regardless of whether they had the potential height to have their tips exposed to the air. After 20 days the tips of a few leaves of Bambatsi, Burnett, Pollock and Kabulabula C.P.I. 14375 were above the water surface, while all leaves of Kabulabula C.P.I. 16796 and Sabi remained submerged. The situation remained the same after 40 days' flooding except that more leaves of Kabulabula C.P.I. 14375 were exposed to a greater height above the water surface (Table 1).

TABLE 1

MAXIMUM HEIGHT OF PLANTS PRIOR TO FLOODING AND NUMBER OF LEAVES AND THEIR HEIGHT ABOVE THE WATER SURFACE AFTER 20 AND 40 DAYS' FLOODING

Cultivar	Maximum Height* Prior to Flooding (in.)	Number of Leaves and Height Out of Water		
		Flood Duration (days)		
		20	40	
			Number	Height (in.)
Kabulabula C.P.I. 14375 ..	21	Some tips exposed ..	19	10
Bambatsi	20	Some tips exposed ..	4	6
Burnett	18	Some tips exposed ..	4	3
Pollock	18	Some tips exposed ..	4	7
Sabi	18·5	All covered	0	0
Kabulabula C.P.I. 16796 ..	19·5	All covered	0	0

* At flooding day 0 all leaves remained below the surface of the water.

After 10 days' flooding, only Kabulabula C.P.I. 16796 and Sabi showed any visual effects from the water. These effects increased as the flood duration lengthened. At 40 days' flooding all plants of these two species were dead. After 30 days' flooding the plants were still alive but all of Kabulabula 16796 and half of Sabi died subsequent to the removal of excess water. A description of the flood effect and a visual rating of this effect are given in Tables 2 and 3, respectively.

TABLE 2

VISUAL EFFECTS OF FLOODING

Cultivar	Flood Duration (days)			
	10	20	30	40
Kabulabula 14375	No visual effect	Stem nodes turning a red/purple colour; obvious growth made	Stem nodes a distinct red/purple colour; extensive root growth on soil surface	Stem nodes a distinct red/purple; a few seed-heads; profuse surface roots; obvious growth; new tillers growing
Bambatsi	No visual effect	A few basal leaves dead; otherwise no effect other than some apparent slight wilting	Chlorosis and death of a few basal leaves; otherwise no effect	A few basal leaves dead and rotted; plants mildly chlorotic
Burnett	No visual effect	Similar to Bambatsi	Similar to Bambatsi	Similar to Bambatsi; also a few roots on soil surface
Pollock	No visual effect	Similar to Bambatsi and Burnett	Similar to Bambatsi and Burnett	Similar to Burnett
Sabi	Basal leaves dying; tip of these leaves dead	More basal leaves dead; no tiller deaths; plants becoming chlorotic	A large number of leaves dead, the rest chlorotic; some tiller deaths	All plants obviously dead, decaying; decomposing mulch; strong red stain at base of stems
Kabulabula 16796	Similar to Sabi	Similar to Sabi	Most leaves dead or nearly so; basal portion of tillers and leaf sheaths only portion green	Similar to Sabi

TABLE 3

EFFECT OF FLOODING ON THE VISUAL APPEARANCE OF PLANTS AS RATED ON A 0 (DEAD) TO 10 (NO EFFECT) SCALE

Cultivar	Flood Duration (days)			
	10	20	30	40
Kabulabula 14375	9·84	8·67	9·00	8·33
Bambatsi	10·00	9·00	9·33	8·00
Burnett	10·00	9·00	9·00	8·00
Pollock	10·00	9·00	9·00	8·00
Sabi	7·67	6·33	4·67	0
Kabulabula 16796	7·67	6·00	2·67	0

S.E. 0·54 L.S.D. 5% = 1·55; 1% = 2·06

Prior to flooding, a count of the number of tillers per pot emphasized two groups of plants—the Kabulabula types and Sabi—had similar tiller numbers but these were greater than those of the Makarikari types, which had similar tiller numbers. After flooding, the tiller numbers (mean of all flood treatments) had shown an increase except for Kabulabula C.P.I. 16796 and Sabi (Table 4), which had decreased.

TABLE 4

NUMBER OF LIVE TILLERS PER POT (MEAN OF ALL TREATMENTS) PRIOR TO, AND AFTER, FLOODING

Cultivar	Number of Tillers/Pot	
	Prior to Flooding	After Flooding
Kabulabula 16796 ..	53·53	33·53
Kabulabula 14375 ..	52·55	77·66
Sabi	52·00	34·47
Burnett	41·87	55·53
Pollock	41·27	58·27
Bambatsi	41·07	54·40
S.E.	2·49	3·75
L.S.D. 5%	7·02	10·61
1%	9·30	14·12

Extended flooding had little effect on the tiller numbers except for a reduction and/or death at the 30 and 40-day flood durations for Sabi and Kabulabula 16796. This trend also was apparent in the oven-dry weight of the material harvested after flooding. There was a slight reduction in weight at the 30 and 40-day flood durations for the other four cultivars, but Kabulabula 14375 produced more dry matter than the other five cultivars in the control and at all flood durations. The above data have been excluded because they add little to the information on the effect of flooding already tabulated. Instead (Table 5) the percentage dry weight is presented. It will be noted that the percentage dry weight increases as plants become affected by flooding.

TABLE 5

EFFECT OF FLOODING ON THE PERCENTAGE DRY WEIGHT OF PLANTS

Cultivar	Flood Duration (days)				
	0	10	20	30	40
Kabulabula 14375 ..	28·05	29·30	32·87	31·23	24·13
Bambatsi	23·73	24·28	20·04	19·06	18·92
Burnett	23·59	22·20	20·90	19·68	17·27
Pollock	21·81	21·36	24·43	21·53	16·58
Sabi	28·35	28·12	30·18	57·42	73·37
Kabulabula 16796 ..	27·49	29·29	30·59	82·59	70·03

S.E. 3·22 L.S.D. 5% = 9·13; 1% = 12·15

IV. DISCUSSION

The use of yellowing and death of leaves as criteria for assessing flooding injury is supported by Kramer (1951) and Heinrichs (1970). Kramer also noted that the chlorosis superficially resembled nitrogen deficiency, but it developed much too soon after flooding to be caused by nitrogen deficiency. He suggested that the yellowing and death of lower leaves might be caused by desiccation, or by toxic substances escaping from dying roots or being produced in the soil which are carried up in the transpiration stream.

The positive relationship of greater flooding tolerance and the ability to produce adventitious roots, as noted in this experiment, has also been recorded by Satoris and Belcher (1949) and Kramer (1951). Kramer also suggested that those plants which produced adventitious roots most rapidly suffered the least injury. The results for Kabulabula 14375 indicate that this may apply.

The use of percentage dry weight as a quantitative means of assessing the effect of flooding is justified by its good correlation with the visual ratings. The increase in dry weight percentage with increasing damage by flooding results from the desiccation of plant cells due to cell breakdown, decay and death. The apparent anomaly (although not statistically significant) of decreasing dry weight percentage with increasing flood duration, in the grasses with most flood tolerance, could be due to a number of factors. Most important is the poorer recovery, for dry weight determination, of the basal leaves due to complete decomposition and rotting. Another reason is the production of new tiller growth.

The lesser flooding tolerance shown by Sabi and Kabulabula C.P.I. 16796 may have been accentuated under the conditions of this experiment. These two species were the only ones in which the anaerobic conditions of complete submersion caused early cessation of growth and they subsequently remained covered with water for the whole experiment (Table 1). Evidence of oxygen supply from aerial parts to roots has been given by Cannon (1925), Cannon and Free (1925), Van Raalte (1940) and Aimi (1960). Also, Davis and Martin (1949) and Beard and Martin (1970) have noted that grass plants survive several weeks in water provided that at least the tips of the leaves are above the surface.

While there can be no direct application to the field, the relative performance of species in this experiment is likely to be the same. In another experiment which was flooded in the field in February 1968, the area was flooded up to a depth of 10 ft for 6 days. Of the range of grasses present, only Bambatsi, Kabulabula C.P.I. 14375 and Sabi showed any significant survival (Anderson 1970*a*). This area was again naturally flooded in February 1971 (not published), up to a depth of 16 ft for 14 days. On the second occasion Bambatsi and Kabulabula again survived but under the more severe conditions Sabi was killed. These results confirm that Bambatsi and Kabulabula C.P.I. 14375 possess greater flooding tolerance than Sabi.

Although the Australian Registrar of Herbage Plant Cultivars (1967) says Pollock has the capacity to make active growth under waterlogged conditions while Bambatsi is not as well suited, and Lloyd and Scateni (1968) rate Pollock as the best grass for waterlogged conditions, this experiment indicates there is no difference between the two cultivars. For practical purposes, the commercially available *Panicum coloratum* cultivars Bambatsi, Burnett and Pollock can be regarded as having equal flooding tolerance and their selection for "flooded" country should be based on such factors as seed price, establishment ability, growth rhythm, production and frost tolerance rather than on their flooding tolerance.

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