

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

DIVISION OF PLANT INDUSTRY BULLETIN NO. 797

**NATURALIZED FODDER SORGHUMS IN
QUEENSLAND, AND THEIR ROLE IN
SHATTERING IN GRAIN SORGHUM**

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SUMMARY

In an attempt to understand the nature of shattering off-types of *Sorghum bicolor* in grain sorghum crops in Queensland, the taxonomy of the related naturalized fodder sorghums is outlined, and the possible role of these species in the evolution of shattering off-types is discussed. The species concerned are *S. halepense*, *S. almum*, *S. verticilliflorum*, *S. sudanense*, *S. miliaceum* and *S. brevicarinatum*.

I. INTRODUCTION

One of the most common requests received at the Botany Branch, Brisbane is for the identification of specimens of the three sorghum species *Sorghum verticilliflorum* (wild sorghum), *S. halepense* (Johnson grass), and *S. almum* (Columbus grass). Recently however (since the 1976-77 season) the need to understand the relationship between these and closely related sorghum species has grown because of their involvement in the appearance of shattering off-types in grain sorghum crops in Queensland (see figure 4), and more recently (1977-78 season) in New South Wales (J. Strang and T. Dale personal communication). The genetically controlled characteristic of seed shedding can be found in any *Sorghum* species (Swarbrick 1977), including those of section *Sorghum* (formerly incorrectly called section *Eu-Sorghum*), which includes all species discussed in this paper. Three other species less commonly collected but likely to be confused with the three common species, are *Sorghum sudanense* (Sudan grass), *S. brevicarinatum* and *S. miliaceum*.

Section *Sorghum* is divided taxonomically into subsection *Halepensia*, characterized by the possession of elongated rhizomes and a somatic chromosome number of 40 (rarely 20), and subsection *Arundinacea*, in which the plants are tufted and have a somatic chromosome number of 20 (Snowden 1955; Doggett 1970). *Sorghum halepense*, *S. almum* and *S. miliaceum* belong to subsection *Halepensia*, and *S. verticilliflorum*, *S. sudanense*, *S. brevicarinatum* and cultivated grain sorghum (*S. bicolor*) belong to subsection *Arundinacea*. The spikelets and inflorescence of both sub-sections are extremely similar in their morphology and the only reliable morphological character separating these two groups is the presence or absence of an elongated rhizome; for this reason it is essential the whole plant including all and not only some of the underground portions, be used for identification.

II. KEY

The following key applies to grain sorghum and wild fodder sorghums naturalised in Queensland:

1. Panicle axis tough and much thicker than the branches; grains large, usually exposed at maturity, with the glumes gaping 1. *S. bicolor*
(grain sorghum)
1. Panicle axis fragile, slightly thicker than the branches; grains small, enclosed by the glumes at maturity.
 2. Plant with an elongated rhizome, sometimes with prop roots.
 3. Sessile spikelet $4.5-5.0 \times 1.8-2.0$ (-2.3) mm, becoming yellowish though reddish to purple and occasionally black and shiny in exposed parts at maturity; lower-most panicle branches 2-4-nate; some rhizome internodes with a tendency to be long and thin.
 4. Leaf blades 0.5-2.0 cm wide; culms 0.5-1.8 m tall, up to 5 mm thick.
 2. *S. halepense*
(Johnson grass)
 4. Leaf blades 2-4 cm wide; culms 2-3 m tall, up to 1 cm thick.
 3. *S. miliaceum*
 3. Sessile spikelet $5.0-6.5 \times 2.0-5.0$ mm, becoming black and shiny at maturity; lowermost panicle branches (3-) 4-9-nate; culms up to 3.5 m tall; rhizome internodes with a tendency to be short and thick 4. *S. alnum*
(Columbus grass)
 2. Plant tufted, often with prop roots, without rhizomes.
 5. Sessile spikelet 4.5-5.5 mm long 5. *S. brevicarinatum*
 5. Sessile spikelets (5.5-) 6.0-7.5 mm long.
 6. Perennial, loosely tufted, sometimes annual; raceme disarticulating readily at maturity with the sessile spikelets breaking clean from the apex of the rhachis internode; pedicelled spikelet falling free from the pedicel 6. *S. verticilliflorum*
(wild sorghum)
 6. Annual, raceme not disarticulating readily at maturity but finally breaking up with the upper portion of the rhachis internode attached to the sessile spikelet; pedicelled spikelet persisting on the pedicel 7. *S. sudanense*

The morphological differences between all these species, as seen from the key and figures, are extremely small and often it is difficult to accurately identify plants. The ease with which the species cross, results in hybrids and hybrid swarms between species. It could be that the intermediate plants are those most often sent in for identification.

III. ENUMERATION OF SPECIES

Sorghum bicolor (L.) Moench.

Grain sorghum, cultivated sorghum, sorghum (figures 1, 2A, 3H, 4, 13, 14, and 15).

Much morphological variation is covered by this binomial. Plants vary from forms to 3 m tall with very open heads to very short commercial cultivars only 0.5 m tall with tightly clustered heads. Snowden (1936) recognized 31 species within this taxon but it has since been shown that variability is continuous between them with as many intermediate forms as there are species. For this reason, and for the fact that all Snowden's species readily cross-breed, it is considered more meaningful to treat all grain sorghums under the one binomial. Although introgression from the fodder sorghums does occur, grain sorghums have been found always to differ morphologically from fodder sorghums by the possession of a much thicker panicle axis and by the development of large grains which become exposed at maturity.

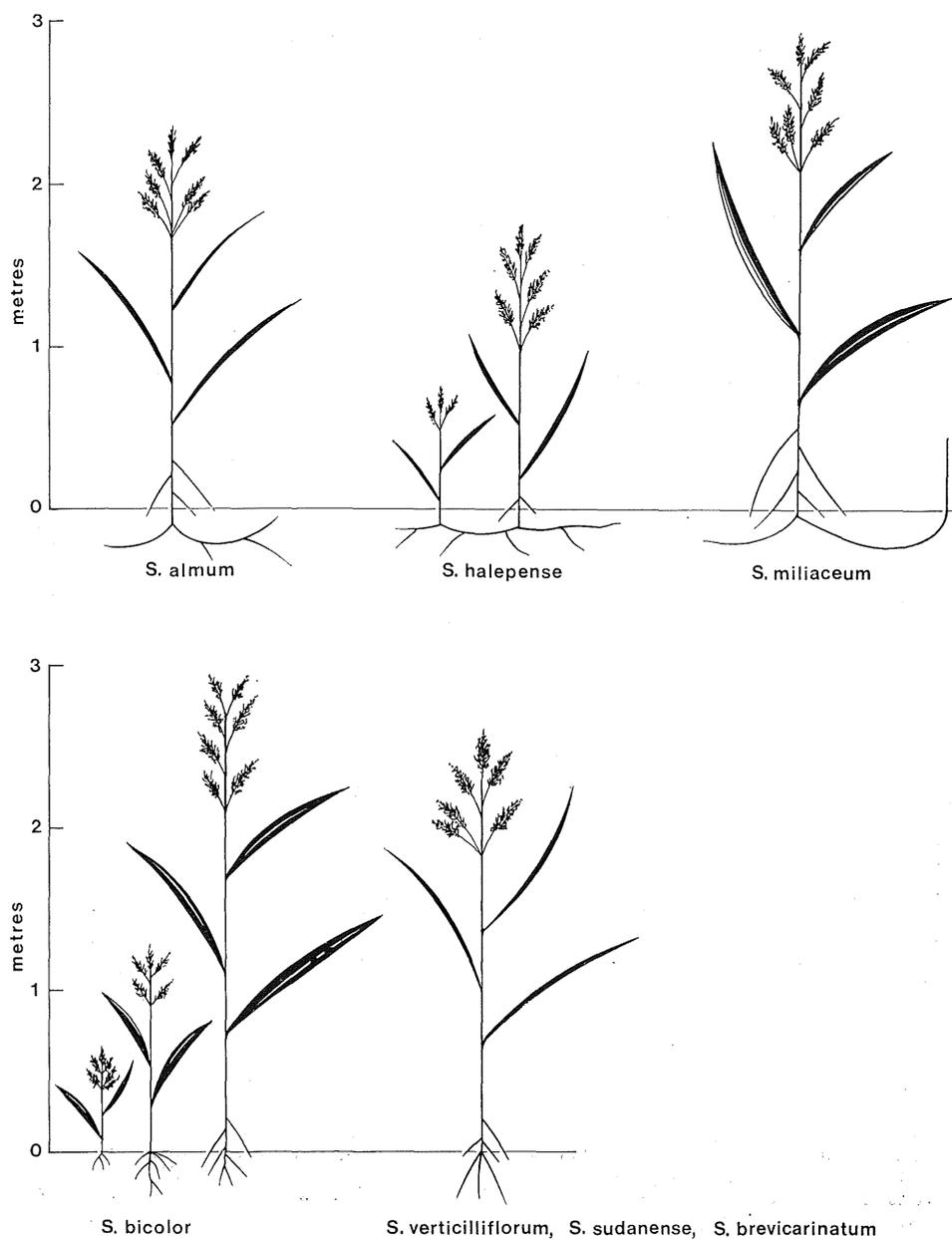


Figure 1. Habit ideograms of fodder and grain sorghums.

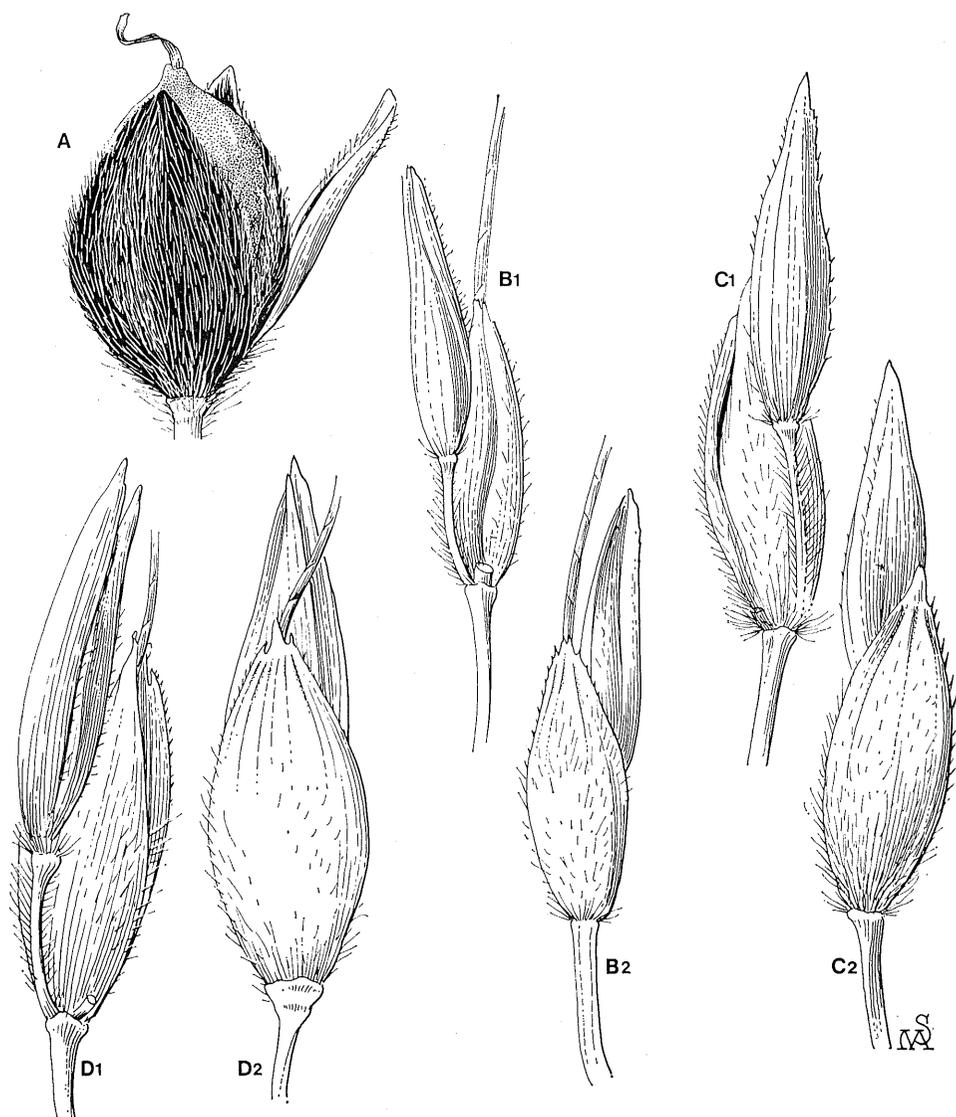


Figure 2. Spikelet pairs of A. *S. bicolor*, shattering off-type at mature stage (Finlay and Barnes 4); B. *S. halepense* (Walsh 76-1); C. *S. miliaceum* (Finlay 2-1962); D. *S. alnum* (Everist 5/1965); all x 8. Spikelet pairs are shown in back view (1) and front view (2). A is shown in front view.

Sorghum halepense (L.) Pers.

Johnson grass (figure 1, 2B, 5, and 6).

This troublesome weed with its system of aggressive rhizomes is naturally distributed from the Mediterranean to Pakistan and India. It was introduced to the United States by 1830 although the exact date of its first introduction is not certain (McWhorter 1971). A Colonel Johnson is reported to have taken it into cultivation early as a fodder grass. It was widely grown in the southern United States and became a troublesome weed. It was probably introduced first to Australia in the 1860's or 1870's, as it is mentioned in *Flora Australiensis* (Bentham 1877), but there were further introductions after this. It occurs in Queensland in coastal and sub-coastal localities from Wallangarra to Mossman. There is only one record in the Brisbane herbarium from inland Queensland and that is from Cloncurry where the species was recorded as a garden weed. Emphasis in the past has been placed on its long creeping rhizome as a character to distinguish it from *S. almum* which has been described as having shorter rhizomes which soon ascend. However, this characteristic has not been found to be consistently developed in herbarium material, where there are specimens of *S. almum* with extensive elongated rhizomes. There is however, a tendency for some rhizomes of *S. halepense* to have longer and thinner internodes than those of *S. almum*. More reliable differences are the smaller spikelets and shorter stature of *S. halepense*. It differs from *S. verticilliflorum* by its smaller spikelets and height, and also by its possession of rhizomes.

Sorghum miliaceum (Roxb.) Snowden

(Figures 1, 2C, 7 and 8.)

This is a very robust species allied to *S. halepense* and in its native habitat is a grass of rain-forest clearings in northern and eastern India. Some authors have treated it as a variety of *S. halepense* (e.g., Magoon *et al.* 1967). It has been collected in Australia only in areas around the Burdekin delta and on the Darling Downs and its method and date of introduction are unknown. It has the narrow spikelets, elongated rhizomes and long thin rhizome internodes of Johnson grass but it is much taller with prop roots usually developed and has much wider leaf blades than that species.

Sorghum almum Parodi

Columbus grass (Figures 1, 2D, 9 and 10).

This species was described in Argentina in 1943 from cultivated material and is postulated to have arisen from a cross between *S. halepense* and a member of the section *Arundinacea*, the latter being either a grass fodder sorghum (Parodi 1943) or a cultivated grain sorghum (Endrizzi 1957). It has broader spikelets than those of *S. halepense* and is taller. It has been reported to differ from *S. halepense* by having shorter rhizomes which are not horizontally developed (Everist 1974). However, as mentioned under *S. halepense*, this difference is not consistently developed and there are many intermediate stages of rhizome development between the two species with some rhizome internodes tending to be shorter and thicker than in *S. halepense*. It has an inflorescence very similar to that of *S. verticilliflorum*, although the sessile spikelets are slightly smaller. It has been introduced to Australia many times by C.S.I.R.O. since 1946 (Griffith Davies and Edye 1959) and is widely grown for fodder in Queensland in areas of 500-900 mm rainfall. Naturalized occurrences are sub-coastal in south-eastern Queensland but are more coastal in the north of the State.

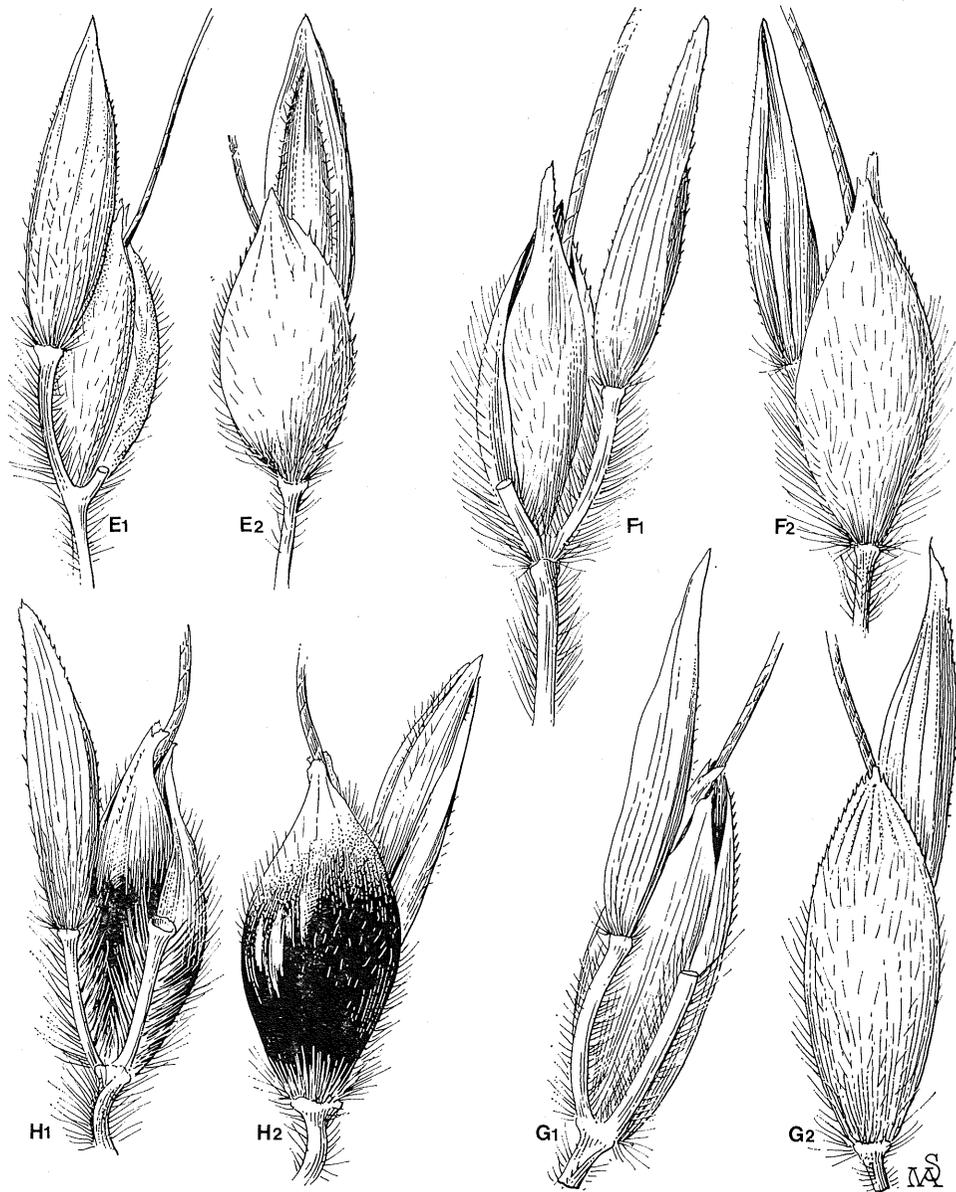


Figure 3. Spikelet pairs of *E. S. brevicarinatum* (Schmid 50); *F. S. verticilliflorum* (Hubbard 2378); *G. S. sudanense* (White 9736); *H. S. bicolor*, younger stage than *A.* (Henzell 16). All x 8. Spikelet pairs are shown in back view (1) and front view (2).

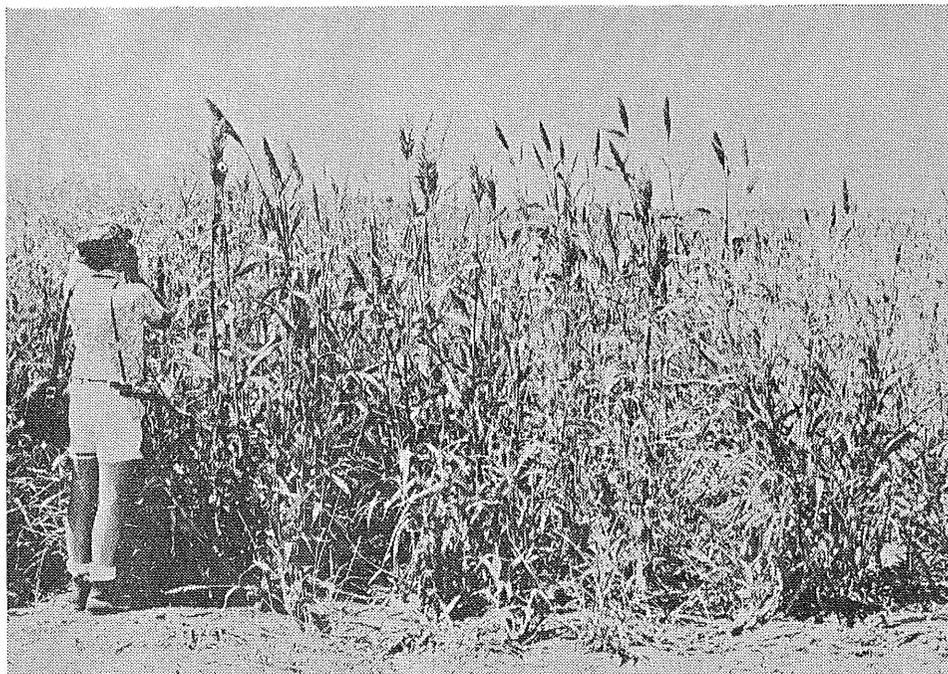


Figure 4. Shattering off-type of *S. bicolor* growing in a field of grain sorghum (Photo by Mr T. Dale, New South Wales Department of Agriculture).

***Sorghum brevicarinatum* Snowden**

(Figures 1 and 3E).

Like *S. verticilliflorum* and *S. sudanense* this is a tufted grass without rhizomes but differs from these species by its shorter spikelets. The few Queensland records of this species come from Mt. Isa and the Darling Downs. The history of its introduction to Australia is unknown.

***Sorghum verticilliflorum* (Steudel) Stapf**

Wild sorghum (Figures 1, 3F, 11 and 12).

Although called wild sorghum in Australia it is not native here and comes originally from the savannah areas of tropical Africa and sub-tropical southern Africa. Its exact date of introduction to Queensland is not known but in 1937 it was recorded to have been here for many years (White 1937). It is a vigorous loosely tufted perennial, sometimes annual, and usually has distinctive prop roots; it differs from *S. almum* and *S. halepense* by its larger spikelets and by the lack of a rhizome.

It is less favoured for forage purposes than the closely related Sudan grass due to its fragile racemes which shed their spikelets readily at maturity. It occurs in Queensland in coastal and sub-coastal localities from the New South Wales border to north of Cairns and in scattered inland localities.

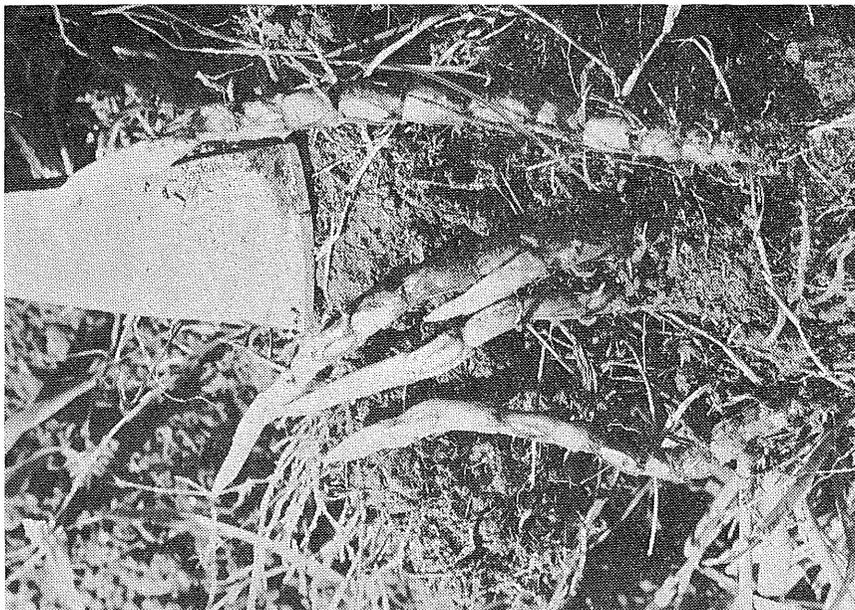


Figure 6. Rhizomes of *S. halepense*.

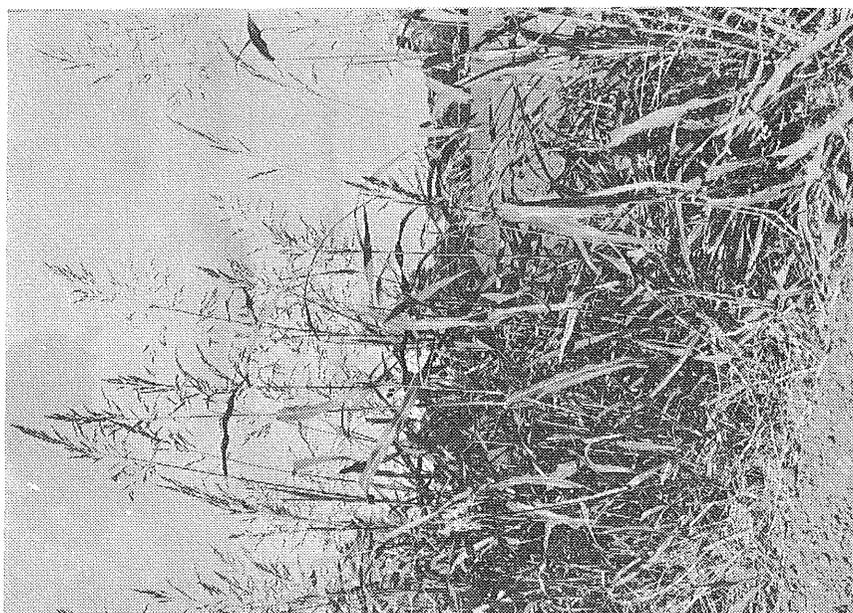


Figure 5. Plants of *S. halepense* with flowering culms ranging in height from 0.5 to 1.8 m.



Figure 7. Plants of *S. miliaceum*, with flowering culms to 3 m.

Sorghum sudanense (Piper) Stapf

Sudan grass (Figures 1 and 3).

This annual forage grass was introduced to Australia in 1913 (Breakwell 1915) from the United States where it was introduced from the Sudan in 1909. It is morphologically very similar to wild sorghum, differing from it in its uniformly annual habit, its ability to produce more tillers and its persistent racemes. Further, when the sessile spikelets fall at maturity, they do so with a rachis fragment remaining attached to their base as opposed to the spikelets breaking off cleanly from the rachis apex (see figures 3F and 3G). Sudan grass has become naturalized in both coastal and inland areas of Queensland, probably as escapes from cultivation, but how long the populations persist in the naturalized condition is not known.



Figure 8. Rhizomes of *S. millaceum*.

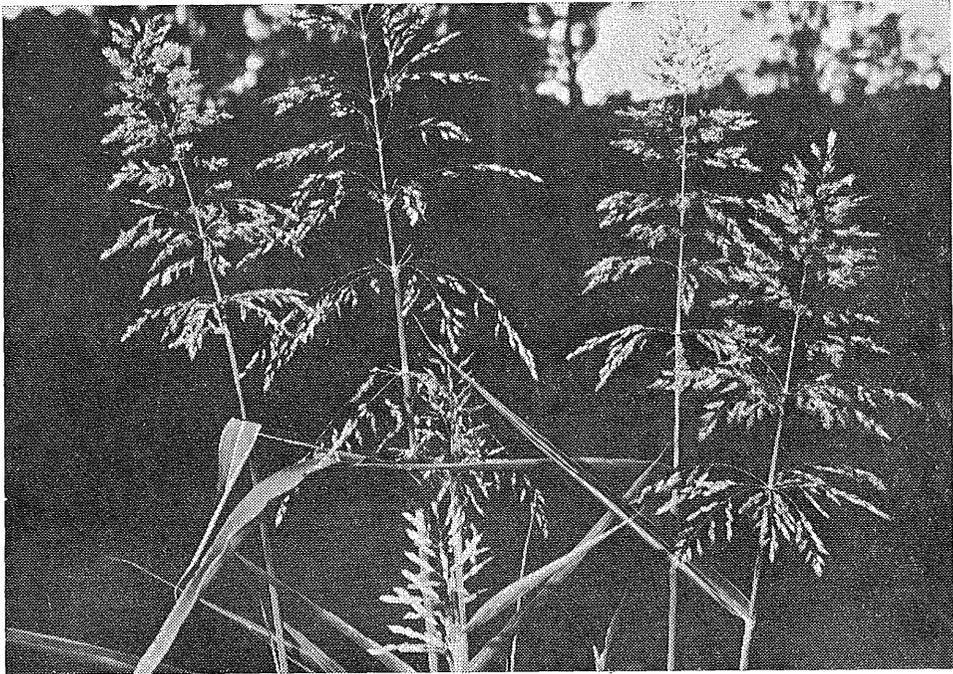


Figure 9. Flowering heads of *S. alnum*.

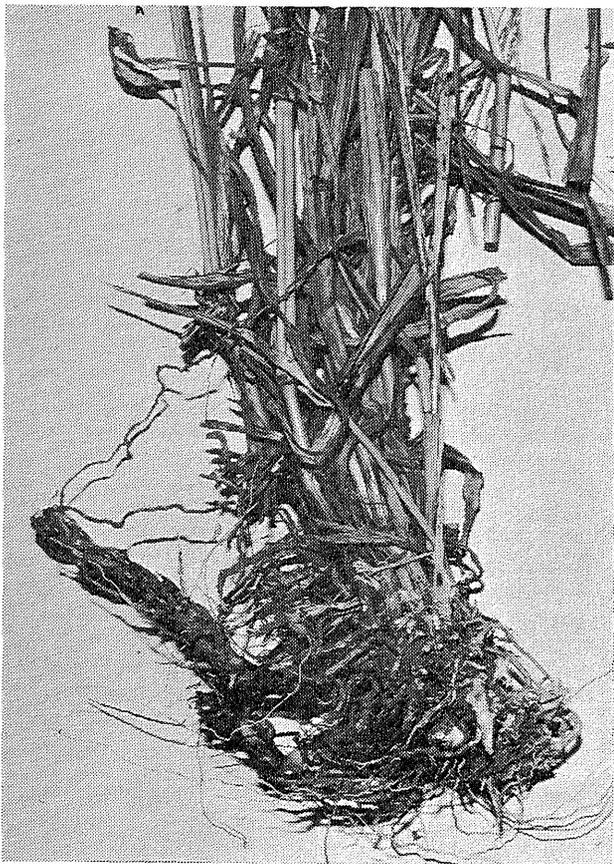


Figure 10. Base of S. alnum showing rhizomes.



Figure 11. Plants of S. verticilliflorum with flowering culms to 2.3 m.

IV. ORIGIN OF SHATTERING TYPES

Consideration of the possible origin of shattering off-types in grain sorghums in Australia must include cyto-taxonomic aspects of the section *Sorghum*. Native Australian sorghums belong to other sections (Garber 1950, where sections are treated as subgenera) and are not likely to cross with cultivated sorghums. Subsection *Arundinacea*, which contains both non-rhizomatous wild fodder sorghums and cultivated grain sorghums, has only diploid species and all members cross readily with each other. For this reason some authors (Harlan & De Wet 1972) have used one binomial, *S. bicolor*, to cover all forms of this complex, but it has been pointed out (Purseglove 1972) that hybrids between cultivated and wild sorghums rarely persist in nature due to their reduced fertility. An alternative suggestion (Purseglove 1972) is a grouping of all wild members of subsection *Arundinacea* under the binomial *S. arundinaceum* with taxa that are usually treated as species being given varietal rank. Subsection *Halepensis*, containing the rhizomatous wild fodder sorghums has tetraploid species in most cases and members likewise cross readily with fellow members. An extreme case for lumping has been taken in the classification of De Wet and Huckabay (1967) where both subsections are put together under *S. bicolor*. The rhizomatous forms are called *S. bicolor* subsp. *halepense* and non-rhizomatous fodder forms *S. bicolor* subsp. *bicolor*, which are further divided into four varieties and one of these (var. *bicolor*) is divided into four races. However, the classification of De Wet (1978) re-establishes *S. halepense* as a distinct species and divides *S. bicolor* into three subspecies one of which represents the cultivated grain sorghums, with separate races, and the other two represent fodder sorghums. Although these classifications may better reflect the relationship of the entities, separate binomials are kept for the different taxa in this paper purely for practical reasons of communication in that these taxa are known in Queensland by these names.

Members of the subsection *Halepensis* show little tendency to hybridize with the cultivated grain sorghums (Snowden 1955) primarily due to the difference in chromosome numbers. For this reason shattering strains of *S. alnum*, *S. halepense* and *S. miliaceum* are an unlikely source of "shattering genes" in recently discovered shattering off-types of grain sorghum. This therefore leaves diploid *S. verticilliflorum* as a likely donor. However, crosses between members of the two subsections have been made (Celarier 1958; Endrizzi 1957; Hadley 1958; Pritchard 1965; R. G. Henzell personal communication) so the shattering *Halepensis* members cannot be ruled out as a source of genes causing shattering. Introgression between the two subsections probably occurs, and it has been mentioned (Doggett 1970) that "there is steady intercrossing between the diploid *Arundinacea* and *S. halepense*, though at a low level." *S. sudanense* can probably be dismissed from consideration as a donor of genes causing shattering in that it is not a shedder or the type that breaks cleanly at the base of the sessile spikelet.

Shattering off-types collected from crops to date have large grains loosely enclosed by the glumes (see figure 2A) and possess inflorescence types ranging from fairly open to the semi-clustered types approaching that of forms of cultivated *S. bicolor* (see figure 13). If *S. verticilliflorum* is responsible for the shattering character the shattering forms could be represented nomenclaturally by the hybrid formula $S. bicolor \times S. verticilliflorum$. However, the leaf-blades of the off-types are as wide as those of cultivated sorghum, whereas *S. verticilliflorum* has narrower leaf blades. My recent survey of the Burdekin delta region revealed several colonies of tall open-headed wide-leaved *S. bicolor* with prop roots up to the third node growing on the headlands of sugar cane plots (see figures 14 and 15). Most

of these "wild-type" strains of *S. bicolor*, are strong shatterers, and are more likely to be a putative parent of the shattering off-types of cultivated sorghum found in the Burdekin delta region than is *S. verticilliflorum*. However until the source of "shattering genes" is definitely established it is probably preferable to refer to the shattering forms as the shattering off-type of *S. bicolor*.

A state-wide survey of all grassy sorghums is presently being undertaken by the Agriculture Branch of the Queensland Department of Primary Industries (W. H. Hazard, personal communication). Included in the data being collected is whether the plant has shattering or non-shattering spikelets and a rhizomatous or non-rhizomatous habit. The aim is to establish which species could be involved in the evolution of the shattering off-types and where they occur. Dormancy tests of all collections are also being undertaken by the Standards Branch of the Department of Primary Industries (R. L. Harty, personal communication).

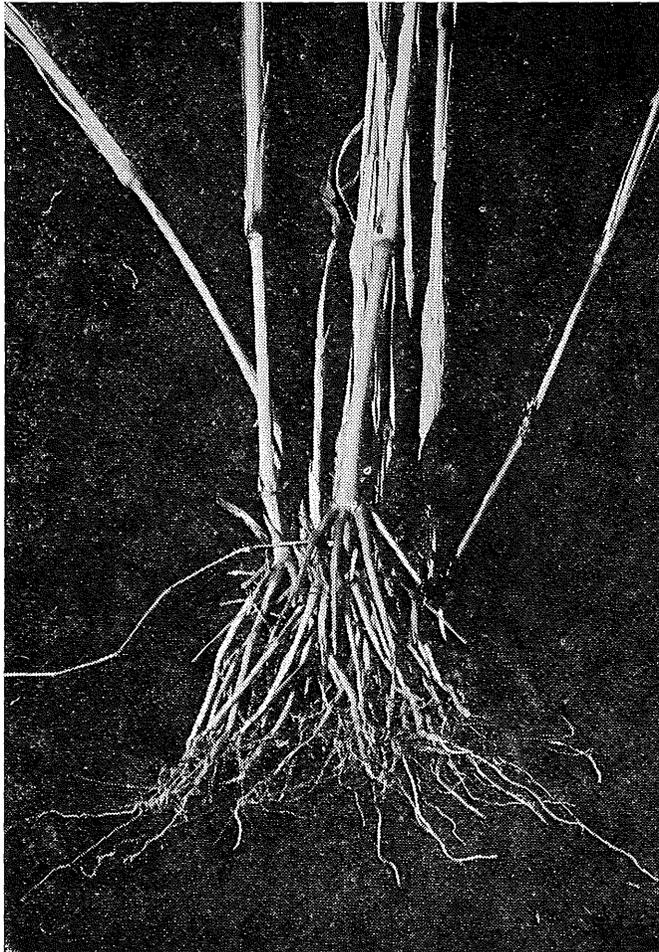


Figure 12. Base of *S. verticilliflorum* showing prop roots.



Figure 13. Range of inflorescence types of shattering off-type S. bicolor found in grain sorghum (Photo by Mr T. Dale, New South Wales Department of Agriculture).

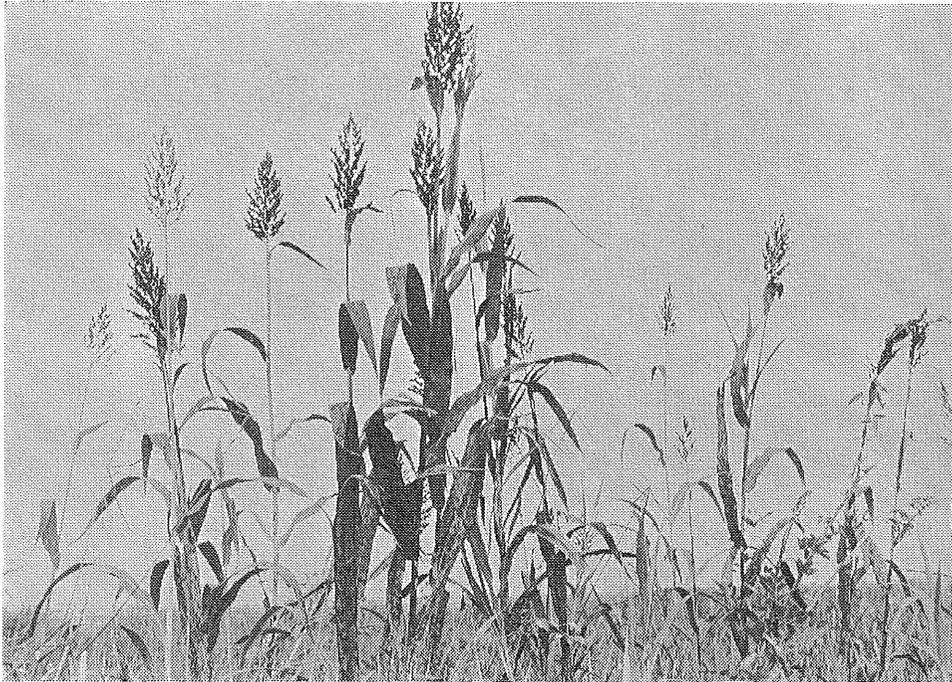


Figure 14. Plants of robust S. bicolor from the Burdekin delta region.



Figure 15. Base of robust S. bicolor showing well-developed prop roots.

V. ACKNOWLEDGEMENTS

I would like to acknowledge the help of officers of the Agriculture Branch, Queensland Department of Primary Industries for making available much sorghum material during the off-type sorghum survey of 1977-78. I also thank Mr. Moray Finlay, Department of Primary Industries, Ayr for showing me the areas of shattering sorghums in the Burdekin delta region.

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