succeeding two years. On the West Coast of India, the critical rains are those which are received during January to April. Annual variations in the yields of nuts are much more for the uncultivated plot than for the cultivated plot. The vagaries of seasons have less effect on the trees in a cultivated garden, than on those in a plot left uncultivated.

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MULTIPLE SEEDEDNESS IN SORGHUM AND CONSEQUENT REPERCUSSIONS

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The occurrence of double seeds in cereals is frequently reported. The presence of double seedeed varieties in sorghum is on record. In a previous article (G. N. R. Ayyangar and M. A. S. Ayyar, 1929)[1] the stray occurrence of double seeds in a variety of sorghum (*S. Roxb* var *hians.*) has been reported and the possibility of accentuating this double grained condition by continued selection over a period of years indicated. Such selection work was done but resulted in no appreciable increase in doubleness. The range of occurrence proved to be of about the same degree of fluctuation.

While this selection work was in progress further fresh material was obtained from various sources and led to a detailed and careful examination of this doubleness. The material represents varieties from Madras, Central Provinces, and Bihar in India and Nigeria, Rhodesia and Tanganyika in Africa. The incidence of doubleness varied according to the variety. This variation was from head to head in the variety and in the incidence within the earhead. In six varieties (mostly *S. Durra*) all the earheads produced double grains. In the others the incidence was from 1 to 70 per cent of the population. This wide range of material from the various parts of the world representing varying degrees of manifestation of doubleness afforded very good material for the study of this character.

In M. S. 2556, a variety from Nigeria, an analysis of a typical earhead showed that out of the 490 spikelets, 89 were single seeded, 387 double seeded and 14 triple seeded. The double seeded were 79 per cent and the triple seeded 2·8 per cent of the total number of spikelets. In A. S. 3618, a pure line selected from a Bihar variety, the incidence of triple seeded spikelets in an earhead was as much as 36 per cent. This accentuation in tripleness resulted in the production in the same earhead of 81 four-seeded, 14 five-seeded and 3 six-seeded spikelets representing 7·7, 1·3 and 0·3 per cent respectively of the total number of spikelets. This occurrence of 4, 5, and 6 seeded condition in the same spikelet (Fig. 1) is the first on record in sorghum. The incidence of six seeded-ness is 0·3 per cent, a considerable excess over the 0·23 per cent incidence of tripleness recorded by Karper (1931)[2].

This tendency to multiply the seeds finds its commonest expression in doubling. The North Indian name, *Dho-Dhanya*—Two Grains—is connotative of this frequent occurrence. Before the details of this doubling are gone into, the structure of a grain-bearing sorghum spikelet may be given. The two outer glumes of the spikelet are leathery. The two inner glumes are hyaline. The inner-most glume (hyaline) has a palea and between these two are the floral parts producing the seed. It is this fourth grain-bearing glume that bears an awn. The inner glumes, as has already been mentioned, are hyaline and any protection to the growing grain is afforded by the outer leathery glumes that are behind these hyaline ones. When the fourth glume bears a grain between it and its thin palea, the grain develops with the embryo towards the side of its glume, the development of the endosperm being towards the palea and therefore towards the third hyaline glume and the first leathery one behind it.

This free development of the endosperm towards one side leaves the grain asymmetrical with reference to the embryo. Another effect of this glumal equipment is the flat disposition of the growing endosperm which the resistance of the leathery glumes impose on it.

The first type of doubling and the commonest is when the third glume which is hyaline bears a grain in its axil subtended by a new palea which it develops to enclose this second grain. As in the case of the first grain the embryo is towards its glume and the endospermal development towards its palea, with the inevitable result that in this common type of doubling, the two embryos are away from each other, one each towards the outer leathery glumes. This opposite disposition of the embryos is therefore much more simple of explanation than in terms of "inversion" (Karper)[2].

The endosperms of both the grains are flattish and the flatness of disposition is in a plane parallel to the glumes. This abnormal development in an otherwise abortive glume leads to the natural result of

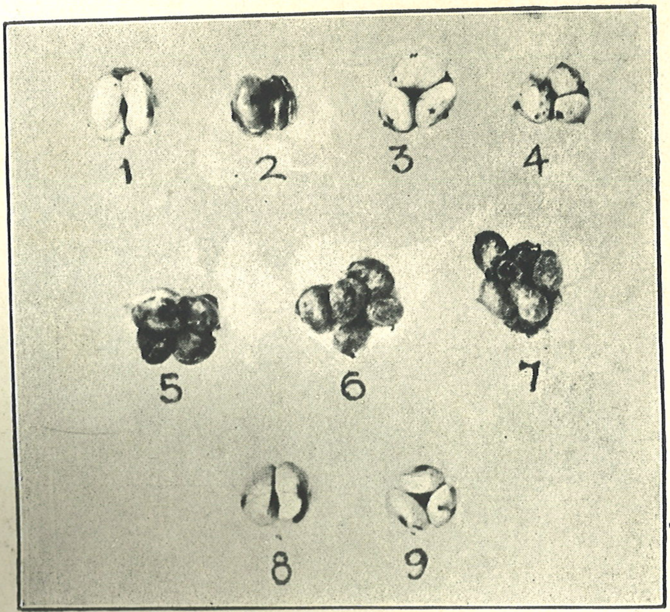
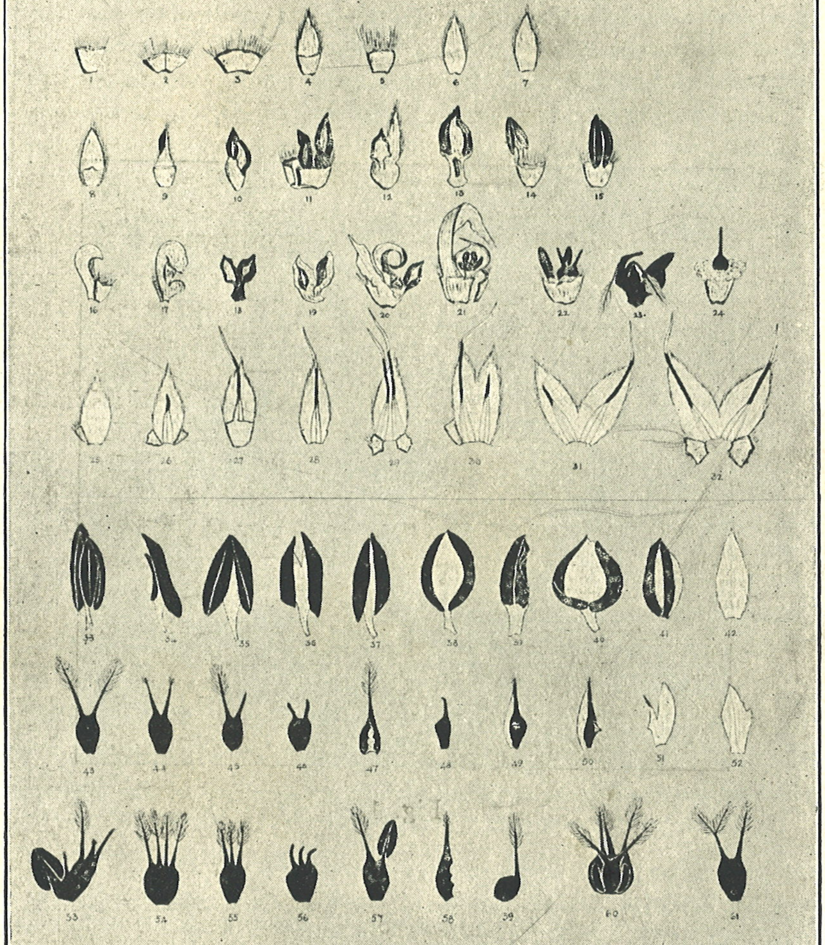


Fig. 1.



one of the pair—the new one—being a bit smaller (Fig. I, 2) than the other—the usual one. The two leathery glumes are a protection to the flowers and the growing grain. The two inner glumes could alone bear grains in their axils—so much so that this type of fertility and the double seeds that result therefrom can be double and no more. The "primordia of a third flower" (Karper)[2] have not been met with. From tripling to six-seeded-ness having been met with, the causes for the phenomena are otherwise than this basic fertility of these inner glumes.

A second type of doubleness is the one that results in usually two and occasionally three seeds within a lemma. (Fig. I, 1, 8). The seeds resulting therefrom fall under the group of connate, and Siamese twin group. This doubling occurs within a lemma and involves no excess floral envelopes. There are two embryos. The endosperm developes in support of each of these two. This double development is not easy towards the leathery glumes. The two halves of connate grain therefore grow out and fill the V-shaped interstices formed by the glumes forced apart. This type of doubling and the free development of endospermal growth on two sides instead of one, leaves the double grain, taken as a unit, symmetrical with reference to the two embryos and the two endosperms, each half being as usual, asymmetrical by itself. Such a disposition of the embıyo and its endosperm in doubleness will automatically leave the embryos adjacent to each other. The very nature of this doubling is such that no marked inequalities can exist between the two halves. An accentuation of this type of doubling can lead to triplets in the same lemma (Fig. I, 3 & 9). When triplets occur, their embryos are likewise at the centre and near each other.

The above two types of doubling may occur either alone or together in one and the same spikelet. When they occur together it is the normal grain in the fourth glume that turns connate, leaving the newly activated third glume usually single. This leads to triplets, (Fig. I, 4). Occasionally the grain in the third glume may also turn connate. This results in quadruple seeds (Fig. I, 5). Other degrees of intensity in manifolding, representing a combination of these dual lines of doubling result in the extreme cases of six and five grains (Fig. I, 6 & 7).

This prolificness is also reflected in the pedicelled spikelets which are occasionally antheriferous. An examination of a number of spikelets in *Dho-Dhanya* showed that even in these pedicelled spikelets the third glume bore anthers, only these tended to be a bit smallish in size. The pollen in these anthers was normal. There were two lodicules and a palea. In most cases there were only two anthers, the third one proliferating.

This proliferation in grains led to a close examination of the incidental floral accompaniments. Several abnormalities have been met with and most of these have been connected with the newly activated flower in the third glume. The normal equipment per flower are the usual single ovary, three stamens, two lodicules and two stigmas. The intense proliferation, firstly by the activation of the third glume into fertility and secondly by each of these centres of fertility proliferating into connateness sometimes of a triple degree, created conditions so chronically different to the usual, that the normal ratio between the number of grains and the attendant floral accompaniments got seriously upset. This led to metamorphoses of types tending to throw intense light on the fundamental trimerousness of the grass flower. Three lodicules and 3 to 5 stigmas have been met with. Six stamens in entirety did not occur. This trimery is and could never be met with in perfection but all the rudimentary stages indicative of this have been experienced. Most of the aspects are naturally abnormal. The stages by which the metamorphosis of floral parts have occurred are in Fig. II.

A series by which the ciliate, fleshy lodicule turns into a parchment-like ciliate lemma is pictured in Fig. II, 1–7. The stages through which a lodicule gets metamorphosed into a stamen are presented in sketches 8–15. A lodicule turning through various incipient stages into an additional flower is pictured in sketches 16–24. The lodicule turning into a lemma with an awn, (the sole vestige of a glume that could be fertile) is portrayed in 25–32. The transitions between an anther and a lemma are figured in 33–42. Similarly, between an ovary and a lemma in 43–52. The abnormalities in stigmatic doubling are given in 53–61.

These multifloral tendencies leading to an elaboration of the floral parts in a unifloral type are of intense evolutionary interest. They amply bear out the hexamerous condition of the Grass Flower and lend weight to Saunders' (1925)[3] interpretation thereof.

This double seeded-ness having been met with in a constancy of manifestation, crosses have been made with single seeded varieties. The first generation plants were double seeded and further generations are keenly looked forward to.

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