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# STUDIES IN *PASPALUM SCROBICULATUM*, L. THE KODO MILLET

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The Kodo millet, *Varagu* (Tamil) and *Arika* (Telugu), occupies an area of well over a million acres in the Madras Presidency. The grain of this millet is easily preserved and proves a good famine reserve. It is a poor man's food. The crop is very drought-resistant. Only well-matured grains should be husked and used as food. Husks and immature grains are poisonous. This millet is considered safer for use as the grains get old. Both as food and fodder the crop is poor. While the crop is ripening it is considered dangerous to graze animals on it. This millet is grown mostly rain-fed, though in small areas under irrigation also. Trichinopoly and South Arcot districts have over 170,000 acres each; Kurnool, Nellore and Ramnad have each over 90,000 acres. The Nilgiris, Malabar and South Kanara are the only districts in which this crop is not grown. About 21,000 acres are raised under irrigation. Of these Coimbatore, Ramnad, Madura and Kurnool have about 13 thousand acres. This millet yields on an average 800 lb. of grain per acre with a range of 400 to 1200 lb. according to the tract. The yield of straw is about 1000 to 2000 lb. per acre. The straw is used as a manure in alkaline lands. This millet has been under study at the Millets Breeding Station and the following summarise the knowledge so far gained.

**Seedlings.** The seeds of this millet have a thick husk which is about 40 per cent. of the seed by weight. It is, therefore, slow in germination. On the fifth day after sowing are seen the first signs of sprouting. A single long leaf is visible and no stem is in evidence. All leaf-sheaths and under-surfaces of leaves are densely hairy. The mesocotyl is smooth with no rootlets and dries up soon. It is capable of elongation adjusting to varying depths of sowing. It is unpigmented though the adult plant develops purple pigment. When the seedlings are a fortnight old, the first secondary root makes its appearance. Secondary roots are also unpigmented.

**Adult Plants.** These are usually erect, and occasionally spreading or prostrate in habit and are 1 to 2½ feet in height. They differ in their leafiness. In a good leafy plant the leaves are broad and numerous and give it a dense, bushy appearance. Less leafy plants have narrow leaves giving them an all-stem and little-leaf look. The nodes are swollen or not according to varieties. The first node is hairy and the other nodes are glabrous. In a few varieties villous upper

nodes are met with. The internodes are solid. The length of internodes increases gradually from bottom to top in any tiller. The internodes, in most cases, are fully ensheathed. The number of tillers in varieties varies from 5 to 18. The early tillers set well. The later ones are more sterile. Nodes touching the ground strike root. They ascend from a prostrate and rooting many-noded base; simple or sparingly branched, usually five-noded. The leaf blades are linear to lanceolate-linear; equally wide or slightly constricted at base; glabrous; margins scabrid; smooth on either surface, broad or narrow; erect, arched or bent. The arched condition is associated with the broad leaf which droops and gives the plant its characteristic appearance. Narrow-leaved plants have very few bent leaves. The leaf is usually of a dark green colour. A few varieties have light green leaves. The midrib of the leaf is white or dull green in colour. The ligule is membraneous, colourless, broad or narrow. The junction of the leaf blade and sheath is usually covered with a felt of long hairs. Rarely such hairs are short. The leaf tip remains green in most varieties but in some it dries up to brown even before the heads ripen. The size of leaf varies with the varieties and a considerable range in their length has been noted resulting in differential habits.

**Purple Pigmentation.** This manifests in seedlings as a purple wash. With the growth of the seedling and the elongation of the leaf-blade, leaves begin to bend and from the bend to the tip there is a wash of purple. At a further stage of growth when the basal nodes show out, their nodal bands take on the pigmentation. With increased growth, such bits of internode as the intense ensheathing leaves bare, begin to have a wash of purple more of self colour and less of lines. Leaf junctions, axils and leaf margins are purple coloured. In some the tips of glumes develop purple. The stigmas show grades of purple ranging from dark to very faint purple. In the anthers purple rings and dots are developed on a yellow background. Anthers without any easily noticeable purple pigment occur occasionally. The stigmas and anthers dry to a brown colour of grades which parallel the depth of purple in them. After the flowering is over, the panicle branches get liberated from the sheaths and the peduncles also get coloured purple. The optimum manifestation of the purple pigment is from the flowering to the milky stage of the grain, after which there is a falling off. Advancing age, however, loosens out the internodes from the clasp of the sheaths and these together with prominent nodal bands retain the purple pigment as long as they continue to be sappy. Looked at *en masse* this field crop has a characteristic violet look. Though all the varieties are purple pigmented, the depth of colour varies. In some the colour is so much reduced that only a very careful examination reveals the pigment in odd parts.

**Panicle—Emergence.** The panicle arises usually from the fourth node. The first sign of the growing panicle is a slight bulge in the

leaf-sheaths. The swelling increases gradually and the panicle is seen through the sheath slit. It takes about a week for it to emerge. When fully emerged it is enclosed by three overlapping leaf sheaths, which inroll one inside another at the tops. The flag and the leaf below it, likewise inroll at the top and, in most cases, do not separate even when the panicle is in full flower. In the inrolled region mentioned above the ends of the inflorescence remain stuck up. The upper end thus fixed, the floral branches, as they elongate, bend outwards at the centre. The enclosing leaf-sheaths are forced apart by the rapid growth and consequent arching of the panicle until thereby the tips are also forced out. This is the general rule but in a variety imported from Sierra Leone, the peduncles clear out of the leaf-sheaths, elongate and hold the panicles aloft and away from the leaf-sheaths.

**Panicle—Arrangement.** Excepting the lower three nodes, the other two bear panicles. From each of the two upper nodes three separate peduncles arise. Of these the central one aborts and the two lateral grow. The abortive one bears a sessile panicle. This panicle may contain one or two branches bearing rudimentary spikelets. Of the two free growing peduncles one grows quickly and shows out earlier than the other. The earlier is always bigger and has more spikelets and less of sterility. In the later peduncle the spikelets at the tips of the branches are usually sterile. Each of these peduncles gives rise to three branches one of which aborts, the other two showing a likewise differential growth and development. These branches repeat this trimerous process untill small spikelet-bearing branches of differential size arise and produce flowers. In this ultimate trimerousness some of the abortives get converted into long stalked single flowers. The weaker flower-bearing branches are mostly unbranched, whereas the stronger ones branch out and bear a larger number of flowers. The largest number of spikelets in a branch may be as many as 100.

**Panicle—Branches.** Each branch has a broad, flat rachis with a series of depressions corresponding to the situation of the spikelets. On the side on which the spikelets are situated, a central ridge runs along the entire length. On either side of the ridge the spikelets are arranged alternately in two series on short pedicels. In some varieties instead of the usual two-seriate condition, a branching of the pedicel gives rise to a non-seriateness, the spikelets being irregularly arranged. At the base of the branch it is two-seriate; in the middle the non-seriate condition prevails; and towards the tip the two-seriateness continues. The non-seriate condition is found in some cases along the entire length of the branch. Other variants to the simple branching of the pedicel and the production of two flowers are the following:— (1) the pedicel instead of forking into two, branches into three, each bearing a spikelet. (2) It may bear more than four flowers at different

levels. (3) Small branches arise at different levels on the ridge of the branch and these bear a fairly large number of flowers. In addition to the crowding induced by the branching of the pedicel, the double seededness of such non-seriate heads is the most important factor in the crowding and small size of the grain in the earheads that are not two-seriate. The disturbance of two-seriateness brings about a dense packing of spikelets on the flat rachis and contributes to the reduction in the size of the spikelets. Consequently the spikelets in these are ⅓ to ½ the size of those in the two-seriate panicles. It may be observed that the non-seriate varieties are early, lighter pigmented with grains of a lighter brown husk.

**Spikelet—Single Seeded.** The description of this spikelet has been elaborated from Hooker's Flora of British India in which a description of the variety with double seeded spikelets is not found. Spikelets orbicular, mostly decidedly plano-convex, falling entire from the short rudimentary pedicels and abaxial on the dilated rachis of spike-like racemes.

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| Glume I. | o (suppressed.) |
| Glume II. | More or less equal to the spikelet; convex; membranous; light green; deciduous; glabrous; 5-6 nerved. |
| Glume III. | Similar to Glume II, but less convex and more flat; light green; thin; glabrous; deciduous; 2-5 nerved; along the inner margins are seen shallow transverse pits whence the specific name "*scrobiculatum.*" |
| Glume IV. | Horny; pale green; later develops a light or dark brown colour; glabrous; 5 transparent nerves; margin firm; obtuse; emucronate; persistent. |
| Palea. | Tightly embraced by the narrowly involute margins of Glume IV; similar in substance to Glume IV; 2 transparent nerves; the palea with flaps widened into a broad auricle below the middle; persistent. |
| Stamens. | Three; filaments short, 1 m. m. long, anthers-3, 2-3 m m. long; 2-loculed; locules open by longitudinal lateral sutures |
| Ovary. | Oval; translucent; stigmas-2, styles distinct and laterally exserted near the tip of the floret; styles feathery from one-third the length from the apex. |
| Lodicules. | Two; flesby; serrated tips; broadly cuneate. |
| Grain. | Tightly enclosed by the slightly hardened glume and palea; rotundate—elliptic; very convex in front, flat on the back; pale; scutellum up to half the length of the grain. |

**Spikelet—Double Seeded.** In the double-seeded spikelet, between Glume II and palea of Glume IV an extra flower is interpolated. It is enclosed in an extra glume and palea. This extra flower develops seed, each spikelet thus having two seeds. Abortive conditions of this double seededness freely occur interspersed with this double fertility and arise as follows. An extra flower is developed between Glume II and palea of Glume IV. It is a perfect flower and has only an extra palea. It does not set seed.

**Opening of the Flower.** The opening of the first flower is generally, on the second day after the emergence of the panicle. This

flowering begins between 2-30 and 3-0 a. m. on each day and continues till sunrise. Youngman and Roy (1923) note that these flowers open between 7-30 and 8-0 a. m. at Nagpur. Flowers do not commence to open from any definite region. They usually start from the middle of the floral branch and gradually spread to either ends. Instances in which flowers begin to open at either end are met with occasionally.

**Anthesis of a Flower** (*anthers extruded*). Detailed observations on the anthesis in a normal average flower are recorded below showing the trend of sequence.

| | | |
|---|---|---|
| 2-30 | a. m. | Glumes begin to open. |
| 2-40 | „ | Anthers visible through opening. |
| 3-15 | „ | Anthers emerge. |
| 3-30 | „ | Anthers completely out. |
| 3-35 | „ | Anthers dehisce. |
| 3-45 | „ | Glumes close completely. |

The stigmas may or may not come out of the glumes. When the glumes begin to gape the anthers crowd at the orifice and are undehisced. They are mostly non-emergent. Their filaments are 1 mm. in length. In stray cases anthers emerge, their filaments being 6 mm. long. These filaments remain turgid for a long time, often till 8-9 a. m. The anthers may emerge simultaneously or one by one or two at a time followed by the third. This stray emergence accounts for the paucity of evidences of flowering in this unobtrusive millet. When the anthers remain inside the flower, their dehiscence takes place long after the opening of the glumes. Dehiscence starts as a slit at one end and gradually spreads or it begins in the middle and proceeds to the ends. The stigmatic feathers dry in the evening. The anthers remain fresh and do not wither till next morning. The lodicules are fleshy and do not shrink immediately after the anthesis of flowers but remain fleshy for 6—8 hours after the opening of the glumes and then dry up—a probable device preventing the closing glumes from jamming the anthers.

**Progress of Flowering.** The following table connotes the daily anthesis energy of the 15 per cent of flowers opening during the flowering period, emerging and non-emerging anthers included.

| Day of Flowering. | 2-3 a. m. | 3-4 a. m. | 4-5 a. m. | 5-6 a. m. | Total. |
|---|---|---|---|---|---|
| First Day | 14 | 1 | 1 | – | 16 |
| Second Day | 2 | 10 | – | 1 | 13 |
| Third Day | 7 | 11 | – | – | 18 |
| Total. | 23 | 22 | 1 | 1 | 47 |

*N. B.* 15 per cent of the flowers in the head opened. The remaining 85 per cent were cleistogamous.

It will be seen that all the flowers in the head do not open. The percentage of open flowers in the varieties varies from nil to 50 per cent., the most frequent being 10 to 15 per cent. This millet is

therefore highly cleistogamous which explains the complete absence of natural crossing in it. Any artificial manipulation of the spikelet irretrievably damages it and many attempts at emasculation and artificial pollination proved futile.

**Grain.** The grain matures in 30—35 days after flowering. It is tightly enclosed by the hardened fourth glume and its palea. The husk is coloured shades of brown. In the two seriate varieties, the grain is bigger and nearly twice the size of those in the non-seriate ones. In the variety imported from Sierra Leone (referred to above), though the head is two-seriate, the grain is small. The degree of emergence of the heads has no effect on the setting of the seed, both having about the same degree of sterility. In this millet seed-setting is dependent on the season. In the year 1928, the drought affected the seed-setting in some varieties to such an extent that not even a few grains per plant could be obtained. Under favourable conditions good yields can be expected.

**False Polyembryony.** In the year 1931, in the course of a number of seed germinations for albinism in this millet, two instances of two seedlings arising from a single seed were noticed. The seedling had a single root and two plumules each with its own coleoptile. At the surface of the seed, the two were separate. Paraffin sections of the seed showed that the plumules had independent vascular bundles. Lower down, the cortical portions of the two shoots were found to unite, the bundles running separate. In a few sections lower down, the vascular bundles were closer and approached each other until finally they became enclosed in a single endodermis. Sections still lower down showed the root strand run into this single bundle. From this examination of the course of the vascular bundles and also of the cortical region, it will be seen that what appears to be independent at the top is, in reality, the result of the branching of a single seedling. At a very early stage in the development, the mesocotyl has branched into two, resulting in the double seedling—a case of false polyembryony. Cases of pseudo-polyembryony have been recorded by other workers. Only those pertaining to the Gramineae are noticed. In maize, Kiesselbach (1926) noted seedlings with (1) two plumules each with its own coleoptile and two primary roots enclosed in a single coleorhiza, (2) a single plumule with two primary roots in a single coleorhiza. In the case reported here, there are two plumules each with its own coleoptile but with a single radicle.

**Paspalum Sanguinale, Lamk.** Several species of Paspalum, especially *P. dilatatum* are grown in America, Australia and South Africa as pasture grass. A wild ally of Paspalum known as *Chicco* (*P. sanguinale*, Lamk) is grown in the Vizagapatam District. This was grown at the Millets Breeding Station for a number of years and the following notes are appended.

The seed which is very small takes 7 days to germinate, two days later than for *Varagu*. Unlike *P. scrobiculatum*, the seedlings are green and have no purple pigment anywhere in the plant. Before flowering the plants are spreading and almost prostrate. The panicle-bearing tillers become erect at flowering. Unlike *Varagu* the internodes are hollow and much exposed. At ripening stage they have a golden yellow colour. The nodes are glabrous and not swollen. The flag is the broadest leaf in the plant. The upper surface of leaves is rough and the lower is smooth. The leaves are arched and not bent. The plants have five to six heads with long well emerged straight peduncles. Occasionally their fullness leads to goose-necking. The panicle has a general resemblance to that of a well grown *Chloris barbata*. It consists of a number of fingers (or branches) arranged in irregular whorls along a short axis. An average earhead may have about 40 fingers. The bulk of these arise from the two bottom whorls, the rest of them being distributed to those above, mostly in twos and threes. Each finger may have about 100 flowers. The spikelets are arranged alternately in clusters of one to three. The spikelets are very small, the length in each being four to five times the width. The glumes are prominently ribbed and dry to a straw colour. The structure of the spikelet is like any other Paspalum. The flowers of this wild ally open from 1—30 a. m. and the anthesis continues up to 7 a. m. The greatest anthesis energy is within the first hour after opening. It takes four to five days for a panicle to complete its flowering.

This wild Paspalum scores over *P. Scrobiculatum* in a number of points, viz., more herbage, free earheads, greater drought resistance, larger number of seeds per head and absence of sterility. A cross with this wild ally is indicated as a potential source of improving the Kodo millet, if the difficulties in the manipulation of this close and delicate cleistogamous flower could be overcome.

### References.

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## HILL VILLAGES OF TIRUPATTUR TALUK.

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**Introduction.** A portion of the Eastern Ghats is situated in Tirupattur Taluk, N. Arcot district in two separate blocks viz. the Yelegiris and the Javadhi hills. The entire length of the mountain range is 45 miles in the taluk. The Yelegiri has a range of 13 miles and is situated a mile and a half from Jalarpet Railway Station, while the Javadhis with a range of 32 miles run continuously from north to