

TABLE III

Density of every internode of Co. 331 (one entire cane from the top to bottom).

Date of planting 22-2-39

Date of observation 18-5-40

Co. 331 arrowed			Co. 331 unarrowed		
Inter- node No.	Density	Pith as observed	Inter- node No.	Density	Pith as observed
1	0.688	Completely pithy	1	0.981	$\frac{1}{2}$ diameter pith
2	0.769	Full of pith	2	0.981	" do. "
3	0.810	Nearly full of pith	3	0.950	" do. "
4	0.825	More than $\frac{3}{4}$ diameter pithy	4	0.966	$\frac{3}{4}$ diameter pith
5	0.902	$\frac{3}{4}$ diameter pithy	5	0.940	Nearly $\frac{1}{2}$ diameter pith
6	0.935	$\frac{1}{2}$ " do. "	6	0.886	$\frac{3}{4}$ diameter pith
7	0.961	do. "	7	0.884	do.
8	0.959	do.	8	0.846	Nearly $\frac{1}{2}$ diameter pith
9	1.018	Small central core	9	0.890	Slightly more than $\frac{1}{2}$ diameter
10	1.034	do.	10	0.968	$\frac{3}{4}$ diameter pith
11	1.035	do.	11	0.966	$\frac{1}{2}$ " do. "
12	1.027	do.	12	0.970	" do. "
13	1.026	do.	13	1.028	$\frac{1}{2}$ " do. "
14	1.047	do.	14	1.024	Small central core
16			15	1.009	$\frac{1}{2}$ diameter pithy
17			16	1.008	Small central core
18			17	1.020	do.
19			18	1.014	do.
20			19	1.026	do.
			20	1.053	Very small central core

### Rotation and Mixed Crops with Sorghum.

By G. N. RANGASWAMY AYYANGAR F. N. I., I. A. S.,

*Millet Specialist and Geneticist,*

and

M. A. SANKARA AYYAR, B. A., B. Sc. Ag.

*Assistant, Millets Breeding Station,*

*Agricultural Research Institute, Coimbatore.*

**Introduction.** Sorghum is the chief cereal crop grown under rain-fed conditions in the Madras Presidency. It is grown on an area of more than  $4\frac{1}{2}$  million acres. It is usually grown in rotation with the commercial crops—cotton, groundnut (*Arachis hypogea*, L.), tobacco or chillies (*Capsicum* spp.). A pulse crop like red gram (*Cajanus cajan*, (L) Millsp.) or Bengal gram (*Cicer arietinum*, L.) is grown in rotation with it in some parts of the presidency. These as well as other pulses are often grown mixed with sorghum, thereby saving land, labour and cultivation expenses, and obtaining a variety of produce. The crops grown mixed with sorghum and in rotation with it depend upon the nature of the soil and season, and the local conditions and demand. Irrigated sorghum is usually grown as a pure crop.

Information on rotation and crops mixed with sorghum was obtained from different parts of the presidency, and the data gathered is summarised in this paper. Considering the soil and seasonal conditions and agricultural practices the presidency can be roughly divided into eight regions, the agricultural practices in each of which being more or less similar for the region. In the districts of Chingleput, Tanjore, Malabar, S. Canara and Nilgiris the area of sorghum is negligible, and hence the practices in these districts are not recorded here.

**Agricultural practices.** In the three northern districts of Vizagapatam and East and West Godavari sorghum is a minor crop, except on the uplands bordering the Eastern ghats. The total area of sorghum in the three districts is about 240,000 acres. There are two seasons in which sorghum is grown: *punasa* (June to September) and *pyru* (September to January). In the *punasa* season, *Konda Jonna* or *Tella Jonna* (*Talaivirichan cholam* type) and in the *pyru* season *Patcha Jonna* (yellow grain) is grown. The *Patcho Jonna* is also grown in the high level lands bordering the Godavari river and its deltaic branches, subject to flooding during the South West Monsoon. These lands are known as *lankas* and are very fertile. In these the chief crop is tobacco, sorghum being grown only occasionally. In parts of the Vizagapatam district sorghum seedlings are transplanted in rain-fed lands. The seedlings are dropped in plough furrows, the succeeding furrow covering up the previous one and thus planting up the seedlings dropped.

No regular rotation is practised near the hills. Sorghum and other millets mixed with pulses, oil seeds and sometimes rice also, are grown according to the time and nature of rains. Lands under cultivation for two or three years are often left fallow for five or six years before they are cultivated again. This is common in the Agency tracts. In places where cultivation is more advanced, short duration millets like *tenai* (*Setaria italica*, Beauv.), *samai* (*Panicum miliare*, Lamk.) or *cumbu* (*Pennisetum typhoides*, Stapf and Hubbard) mixed with gingelly (*Sesamum orientale*, L.) and pulses or groundnut are grown in the *punasa* season and *Patcha Jonna* in the *pyru* season.

In the areas lower down, especially in the *lankas* of the East Godavari district, tobacco and chillies are grown in rotation with sorghum. In some places cotton or *ragi* (*Eleusine corocana*, Gaertn.) is rotated with sorghum in black soil areas. In this area sorghum is usually grown as a mixed crop. The crops usually mixed with it are pulses—red gram, lablab, (*Dolichos lablab*, L.), cowpea (*Vigna unguiculata*, (L.) Walp.), green gram (*Phaseolus aureus*, Roxb.), black gram (*Phaseolus mungo*, L.), horsegram (*Dolichos biflorus*, L.), and *tegapesara* (*Phaseolus* Sp.), oil seeds—gingelly, and fibres—sunnhemp (*Crotalaria juncea*, L.) and *gogu* (*Hibiscus cannabinus*, L.); shorter duration cereals—rice, *tenai*, *samai* and *varagu* (*Paspalum scrobiculatum*, L.) are also mixed with *Konda jonna*. Sorghum is grown as a pure crop also, but in very limited areas.

In the Anaparthi and Guntur districts the area of sorghum is about 635,000 acres. In this region it is grown mostly for fodder in the *punasa* season and for grain in the *pyru* season. The common variety is *Patcha jonna* (yellow grain), of different types of varying duration. *Konda jonna* (*Talaivirichan cholam* type) is rare. Sorghum figures in the same land only once in 3 or 4 years. The other crops grown in rotation with it are tobacco, chillies, cotton, groundnut and *cumbu*. Two crops are usually grown in the same year, both being short in duration. Sorghum or *cumbu* mixed with pulses and oilseeds are the chief crops in the *punasa* season and tobacco, chillies, variga (*Panicum miliaceum*, L.), *pyru jonna* (sorghum), coriander (*Coriandrum sativum*, L.) and horse gram in the *pyru* season. Cotton and red gram are sown in the *punasa* season mixed with short duration cereals (*cumbu* or *tenai*) which are harvested in about three months leaving the cotton or red gram in the field for the *pyru* season crop. Various crops are grown mixed with sorghum. Some of them are *pillipesara* (*Phaseolus trilobus*, Ait.), *tegapesara* and *kollanganjeru* (*Ipomea hispida*, R. & S.) to improve fodder, red gram, green gram, cowpea, sunhemp, *gogu*, gingelly, and also a variety of cucumber—*Nakadosakaya* (*Cucumis Melo* L. var. *utilissimc*). Only some of these and they too only in small quantities (about  $\frac{1}{8}$  or  $\frac{1}{16}$ ) of each are mixed with sorghum, which doubtless occupies more than three fourths of the land. Sorghum is sometimes grown as a mixture with *tenai* or *cumbu* in the *punasa* season and with *variga* in the *pyru* season in parts of the Guntur district. In these mixtures sorghum occupies a fourth or less of the area. Sorghum is sometimes grown in field borders for fodder purposes. In some black soil areas in the Guntur district sorghum is often grown as a pure crop.

In the four districts of Kurnool, Cuddapah, Bellary and Anantapur (the ced-d districts, as they are commonly called), about 1,779,000 acres of sorghum are grown annually. In this region sorghum is the crop of major importance. It is the chief food and fodder crop of the area. It is usually grown in rotation with cotton—pure or mixed with *tenai*, or groundnut, the choice of the rotation crop depending upon rainfall and market conditions. Thus sorghum is grown in the same land in alternate years in most of the area, and in some places once in three years. In parts of the Bellary district where *Mungari jonna* (early season sorghum) is grown, no regular rotation is practised.

In the Kurnool and Cuddapah districts the common variety is *Patcha jonna* (yellow grain) and in the Bellary and Anantapur districts, it is *Tella jonna* (white grain). In portions of the Kurnool district sorghum is grown as a pure crop, while in the rest of the district and in the other districts sorghum is grown mixed with various pulses such as red gram, cowpea, green gram, lablab and Bengal gram, oilseeds such as gingelly, safflower (*Carthamus tinctorius*, L.) and castor (*Ricinus communis*, L.), and also sometimes with *tenai*, *cumbu*, indigo and sunhemp. In all cases sorghum is usually the major crop. Sorghum is occasionally found as a

mixture in *tenci* or *cumbu* in the *punasa* season, or *variga* in the *pyru* season, in parts of the Kurnool district. In these mixtures sorghum forms a very small portion and is used either as fodder or for inducing the production of big earheads for good seed. Sorghum is sometimes grown mixed with cotton also, either of them dominating in area.

In the Nellore district (sorghum, about 428,000 acres) the practices differ from the neighbouring districts. No regular rotation is adopted in the major portion of the district. Groundnut, horsegram or *pillipesara* are sometimes grown in rotation with sorghum. Most of the pulses—green gram, black gram, red gram, *pillipesara* and horse gram are grown mixed with sorghum. In the *pyru* season sorghum and *variga* are grown mixed, wherein the latter is the main crop and sorghum is a minor mixture, about one-eighth.

In the three central districts of Chittoor, North Arcot and South Arcot, the area under sorghum is only about 190,000 acres. Most of the sorghum grown is for fodder only, especially in South Arcot and in portions of Chittoor and North Arcot. There is no regular rotation. The area of sorghum depends upon the rainfall and the demand for fodder. It is rarely grown mixed. When mixed, the other crop groundnut, red gram, *cumbu* or *ragi* is the major one, sorghum being a minor mixture in it.

In the Salem and Trichinopoly districts, area about 470,000 acres, sorghum is a minor crop, occupying less than one-sixth of the net area cropped annually. No regular rotation is followed. The major crop of the area is either *cumbu* or *ragi*. Often sorghum is a mixture in these crops, occupying only a minor place. The other important crops grown in rotation with these cereals in some parts of these districts are groundnut and cotton. When sorghum is grown as a major crop, pulses such as lablab, cowpea, red gram, green gram and dew gram (*Phaseolus aconitifolius*, Jacq.) and castor or gingelly are grown mixed with it. *Irungu cholam* is grown for fodder and *Sen cholam* (red grain) or *Vellai cholam* (white grain) for grain.

In the Coimbatore district sorghum is the major cereal crop in rain-fed lands. It is grown in area of about 467,000 acres. In parts of the district where only one crop could be grown annually, cotton and sorghum usually alternate. In the South-eastern parts of the district, where sometimes favourable rains are received in the summer season, a short duration sorghum is followed by a short duration pulse, such as Bengal gram or horse gram, in the same year. In these parts groundnut is an important crop in dry lands in the early season (April to August); and this is followed by sorghum mostly for fodder, in the second season (September to January). Thus sorghum is grown in two seasons in this area. The crops grown mixed with it are one or more of the pulses—red gram, green gram, cowpea, lablab and dew gram, and in parts of the district castor and gingelly also. These mixtures occupy only a minor area. The long duration crops



in the mixture—red gram, lablab and castor continue in the field after the harvest of the rest. When lablab is one of the mixtures, odd stalks of sorghum with lablab twining on them are left when sorghum is cut, as lablab matures later. What is thus lost in straw is more than gained by the produce of the pulse twining on it.

In the Madura, Ramnad and Tinnevely districts, sorghum is grown mainly for fodder purposes, the area under the crop being about 402,000 acres. The variety grown for fodder under rain-fed conditions is *Irungucholam*. In this variety the grains are small and almost completely enclosed within the glumes. It is grown in rotation with cotton and *cumbu*, and in some places with groundnut or *varagu*. Some of the following pulses—red gram, green gram, lablab, cowpea and dew gram, and groundnut, castor or gingelly are grown as mixtures with sorghum.

From the above it will be seen that sorghum is not often grown as a pure crop; it is usually mixed with a wide variety of crops. Most of the pulses and sometimes oil seeds and fibre crops are grown mixed with it. It is sometimes grown mixed with other cereals and rarely with indigo.

**Objects and advantages of mixtures.** Many are the objects and advantages reported for mixing the various crops with sorghum. These are summarised below. The average holding of a ryot is small. He is not in a position to grow different crops separately. To overcome this difficulty he resorts to mixed cropping. By growing a mixed crop of cereals, pulses and oil seeds, the most common mixture, he is able to obtain most of his food products from the limited land he owns. There is a saving not only in land but in labour also, as in most cases the seeds of different crops are mixed together and sown. By this, sowing and cultivation expenses are minimised. In some places a long and a short duration crop are mixed, such as sorghum and *tenai*, or red gram and sorghum, to get the maximum outturn from the land. The short duration crop is harvested first, and the other continues in the field and yields almost as much as a normal pure crop in favourable seasons. When the season is unfavourable, the short duration crop at least yields some produce, thus preventing total loss of outturn from the land due to vicissitudes of weather. Also when crops of different durations are mixed the limited labour of the poor cultivator is utilised to the best advantage as different crops come to harvest at different times.

Pulses of three kinds are usually mixed with sorghum. Pulses such as Bengal gram and red gram are mixed for grain. Those, such as cowpea and lablab are mixed with the object of obtaining grain as well as improving the quality of fodder, while others like dew gram, *pillipesara* and *legapesara* are mixed mainly for improving the quality of fodder. A mixed crop of pulses and cereals is believed to be a good combination to maintain soil fertility, especially when the same crops have to be grown year after year without any proper rotation for want of sufficient land. By this system it is considered possible to maintain the supply of combined Nitrogen in a

way that would not be possible on small holdings if crops are not mixed. It has been reported that cereals grown in association with pulses get enriched in protein content. This is a fruitful line of investigation, especially under Indian conditions, where the toning up of quality of food crops has to be achieved without much extra labour or cost. It is also reported that the mixtures of pulses which are generally small in proportion do not normally reduce the yield of sorghum. Usually about as much yield as from a pure crop of sorghum is obtained from a mixed crop also in favourable years, the produce from the pulse crop thus forming an extra income. It is not economic to grow some of the crops like green gram and cucumber as pure crops; they are therefore always grown as mixtures. Damages due to insects are reported to be minimised by mixed cropping. Sunnhemp when grown mixed with sorghum is reported to be less damaged by insects than when grown as a pure crop.

In some places sorghum is a minor mixture in other cereals such as *tenai*, *cumbu* or *variga*. It is reported that stray plants of sorghum in the field act as a check on cattle being allowed to trespass and graze on the young crop, as sorghum plants in the young stage are poisonous to cattle. Such plants are usually cut for fodder before they mature. Small mixtures of sorghum in long duration crops such as *varagu* or cotton are utilised to obtain good seed, as plants in such crops will be vigorous and produce big, well-filled earheads with bold grains.

**Results of experiments.** By mixing two crops which feed at different depths in the soil both can thrive well without interfering with each other. Root studies at the Dry Farming Research Station, Bellary, have shown 'Setaria-groundnut' and 'Setaria-horsegram' mixtures are ecologically sound combinations. Spreading pulses such as *pillepesara*, *tegapesara*, dew gram and groundnut reduce soil erosion. Experiments on soil erosion studies at the Dry Farming Station, Bellary have shown that *pillipesara*, groundnut (spreading type), horsegram and mixture of groundnut and horsegram with *tenai* are comparatively more efficient in preventing soil erosion.

In the trials of 'sorghum-pulse' mixtures conducted at the Cotton Breeding Station, Coimbatore, the following conclusions have been recorded:—"On all the three soils (irrigated red, rain-fed red and rain-fed black) the mixing of pulse both with irrigated and rain-fed types of *cholam* does not benefit either the *cholam* or the succeeding cotton. Such a step is found on the other hand to lower the straw weights. It is interesting to note, however, that the after effects of growing leguminous crops on cotton are not alike. Cluster beans have been found most beneficial in the case of irrigated *cholam*, while lablab and cowpea seem to do good to rain-fed *cholam*. Soy beans, green gram and cowpea do more harm than good when they precede cambodia cotton in summer. *Pillipepara* likewise depresses the yield of *Karunganni* cotton that follows it. The above observations bring into doubt the present practice of mixing cowpea with irrigated fodder *cholam* raised in summer. Cluster beans would appear to have

more points in its favour than cowpea. The most suitable proportion for mixing a pulse with *cholam*, when one is needed, is three of *cholam* and one of pulse in the case of irrigated red soils, and one of *cholam* to three of pulse or both in equal proportions in the case of rain-fed soils." The above results are with regard to Coimbatore soils.

Rotation experiments at the Agricultural Research Station, Nandyal (Kurnool Dt.), have shown that a three year rotation: Sorghum—cotton—pulse (groundnut or Bengal gram), is more profitable than a two year rotation of sorghum—cotton (without a pulse) both with regard to yield of sorghum as well as nett produce for three years. Similar experiments at a few other stations have not led to any conclusive results.

**Conclusion.** It is obvious that more work is to be done in different parts of the presidency to decide the suitable mixtures and rotations for different soils and different seasons. This important question of mixtures and rotation requires a thorough *agro-economic* examination. The question of cereal—pulse mixture in dry lands thus presents a comprehensive set of problems in farming practices, economics, soil physics and nutrition, and demands more systematic attention than it has commanded so far. It is hoped that before long this subject will receive the attention it deserves.

## Stone Dragging Competition for Cattle in Kurnool District.

By K. RAGHAVACHARYA, L. Ag.

*Assistant Director of Agriculture, Cuddapah.*

**Introduction.** The Ceded District ryot is noted for his skill in the use of his cattle for a variety of agricultural operations. The soils of the tract are generally poor, the rainfall low and ill-distributed and the holdings extensive. The climate is also adverse and the ryot is naturally averse to much of human labour. While ploughing, carting, and mhothing where there are deep wells, are all the operations that cattle are set to do in other districts, the work cattle of the Ceded Districts are put to a much wider use. The work cattle draw heavy ploughs in teams of four to six pairs, while the ryots of the Tamil or Circars country think that such work can only be done by elephants. In this tract crushing big clods raised by the use of these ploughs is done by cattle power while in other districts to break much smaller clods raised by the wooden ploughs, manual labour is engaged. Where the stubbles of cotton and sorghum are dug out by manual labour elsewhere, the Ceded District ryot removes them over wide areas by a pleasure drive standing over a blade harrow worked by his cattle.

He drill-sows his seeds economically using lower seed rates and obtains a meticulous uniformity in stand and an admirable straightness of rows which are sometimes several furlongs long. This is achieved with the