

SUGARCANE VARIETIES OF THE BOMBAY PRESIDENCY, INDIA.

In taking up the task of the improvement of any crop, it is highly desirable, if not absolutely necessary, that a careful survey be made of the varieties of that crop that are being grown within the area where the work is to be done. With this object the writer began the collection of materials for such a survey of the varieties of sugarcane that are found growing within the Presidency of Bombay, India. Both district and agricultural officers of the tracts where cane is known to be grown were asked to send samples of the local canes to the Sugarcane Experimental Station at Manjri, Poona. A hasty preliminary study was made of these and they were classified into thick and thin canes and also by colour. They were then planted in small plots in order to secure material for more detailed study. Several of the varieties did not make normal growth under the conditions existing at this station so that the study of these had to be supplemented by field observations in the localities from which they came.

Associated with the work in this line, were the trials made of a few varieties of canes obtained from other parts of India and also from other cane growing countries in order to find if any of these would prove more useful under the conditions of the presidency than the local varieties. This work has already yielded useful results. A few of these varieties that gave promising results in the preliminary trials were given out to cultivators and are being grown by them. In such cases where the varieties show signs of being permanently established they have been included in the list of Bombay canes.

This work has been delayed by various causes till at the moment of leaving the country it was thought that the results as far as available, even though incomplete, should be put into a form that would be useful to future workers. It was not finished at the time of sailing and was taken to America for completion.

All over the sugarcane growing world the classification of cane varieties is in a somewhat chaotic condition. In this respect India is not different from other countries. Variety names for different sugarcanes appear in quite early literature, the earliest of which is perhaps that of F. Batuta in the

fourteenth century. Noel Deerr in his latest edition of "The Sugarcane" gives a fairly complete bibliography of the literature of references to cane varieties. However, he has not attempted to fully straighten out the tangle of synonyms that are met with in these references. Barber and Venkatraman in India, Jeswiet in Java and Fawcett in Argentina have all made studies with a view of reducing the confusion in nomenclature found everywhere and of establishing some standards of description by means of which the varieties can be identified. Carelessness in the use of the names of the varieties and their synonyms is to blame for some of the confusion. In other cases the trouble has arisen from mixing the varieties in the field. It may happen that a field supposed to be planted with a given variety may have as a mixture perhaps ten per cent. of another kind. If sets are taken from this mixture for a fresh planting, it may chance that the second variety may increase its proportion until finally it predominates but is still known by the name of the first variety. Cases like this I have seen several times in India. Another source of confusion is the giving of names to introduced varieties of the places from which they have been imported. At Manjri the well known cane, Cavanagierie, was found growing under the name of Red Mauritius. Since there are several red canes grown in Mauritius it leads to confusion to speak of any one of them as Red Mauritius. Especially is this the case since more than one of these has been brought to India. Another cane found at Manjri station under the name of J33, was pronounced by Dr. Barber as wrongly labelled, though he was unable to identify it. As it gave promise of being useful in certain tracts of the presidency and was available for a limited distribution it was given the farm name of Manjav. It now appears to be B376. In the lots of cane received from sugarcane experiment stations in India three distinct canes were labelled Ashy Mauritius. These instances clearly indicate that all workers in cane should take the greatest care in getting the correct names and keeping the varieties correctly labelled.

In taxonomic work with sugarcane, one is largely restricted to the use of vegetative characters as many varieties do not flower. The indefiniteness and carelessness in the use of descriptive terms by some of the early writers on the subject had made it no easy task to identify correctly the varieties to which they refer.

The scheme of description used in this paper is not original but is an adaptation of that used by Dr. Barber. Detailed measurements except in a few cases have not been possible on any considerable scale. Sugarcane varies so greatly in size, owing to the effect of climate, soil and method of cultivation, that the value of such measurements is not very great for purposes of identification. The relative terms that are used herein will, it is hoped, be all that is necessary in this connection.

Colour of canes like their size is subject to wide variations due to various causes. This character is also lessened in value owing to the vagueness of the terms usually employed in describing it. Several shades of green and yellow occur in the same stool among those varieties spoken of as white, green or yellow and the dark coloured varieties vary from a light claret to a dark red almost black. In spite of this there are characteristic shades of each variety that are of great use to the practical observer in distinguishing them.

The eye bud is a character that has been proposed as useful for identification. Considerable caution is necessary in its use, owing to the variation that it undergoes in the stages of its development. Only dormant buds are of use for taxonomic purposes such as are usually found at the lower nodes or in the very upper nodes. For terms used in this paper in bud description see Fig. 1 (page 27).

The shape of the internodes, the characters found about the node and those at the throat of the leaves have been found to be of the most help in cane description. The inflorescence has not been considered in this paper except to note the freedom and extent to which the varieties vary.

The Scheme adopted for description is given below:—

I. The Whole Cane.

A. Habit of growth:

1. erect; 2. spreading; 3. inclining; 4. reclining.

B. Height:

1. tall, eight feet and over; 2. medium, six to eight feet; 3. short, under six feet.

C. Thickness:

1. thick, over one inch in average diameter;
2. medium, from three-fourths to one inch in diameter;
3. thin, under three-fourths of an inch in diameter.

D. Colour:

in general terms 1. green, yellow or white;
2. striped or variegated; 3. red, purple or black.

E. Flowering habits:

whether it arrows or not and age at arrowing.

F. Tillering habits:

extent.

G. Number of months required for ripening.

H. Characteristic markings.

II. The Several Parts.

A. Stem or cane:

(a) General manner of growth: 1. straight;
2. zigzag.

(b) Number of joints or internodes: (approximately.)

(c) Length of stripped cane: (approximately.)

(d) Node or joint.

1. Rings:

*
growth ring, distinctness, width and colour.

**
root ring, number and arrangement of dots.

leaf scar, prominence, thickness and amount of recurvature beneath the bud.

wax ring, amount of constriction, thickness of wax and colour beneath.

2. Eye bud:

*
size and ratio of dimensions.

**
base, shape.

basal tuft, size, covering and continuity.

apical part, shape.

apico-basal angle, position and size.

flanges, width and covering.

scale border, position and outline.

method of bursting.

(e) Internode:

1. Shape:

*
in section, cylindrical or flattened.

**
sides, parallel, bulging or constricting.

2. Size:

*
girth, average, in inches.

**
length, average.

3. Colour:

in detail.

4. Markings:

*
waxy.

**
corky or "ivory."

dried patches of epidermis.

black incrustations.

5. Channel:

presence, extent and size.

B. Foliage:

(a) As a whole:

1. Amount; 2. style of growth; 3. colour in general terms; 4. drying and dropping habits.

(b) Blade of the leaf (lamina):

* width
** length } (both in inches).

marginal spicules.

apex, amount of tapering.

(c) Leaf sheath:

*length and ratio to the blade.

**

colour.

texture.

covering.

(d) Throat:

*ligular band, its fullness, border, colour, and interruption at the midrib.

**

Extension of sheath beyond the blade.

Auricles, shape and size.

Indentations at the margin of the throat.

Hairs.

Ligule.

C. Inflorescence: occurs or not, age at which arrowing takes place.

III. Composition of the cane: fibre, sacrose, reducing sugar, and purity of juice.

IV. Outturn of cane and yield of *gur* or crude sugar.

V. Distribution and special notes as to its adaptation to Bombay conditions.

VI. Synonyms and history.

The canes found in Bombay Presidency belong to two distinct classes, the thick canes and the thin canes. These are readily distinguished from each other by several well marked characters. First and perhaps most conspicuous is the great difference in size especially in girth. Few thin canes will reach a diameter of three-fourths of an inch while the majority of the canes of the thick types will be considerably over that figure. The thin canes grow in dense stools of thirty to a hundred shoots. The thick canes tiller much less freely varying from five or six to fifteen or twenty. The leaves of the thin canes are much narrower and shorter than those of the thick type and they are thinner in texture. The

leaf sheaths of thin canes cling tightly to the canes which makes trashing very difficult. The thin canes contain much more fibre and less juice. The high fibre content makes crushing more difficult, especially if it is done with bullock mills. The yield of sugar is also less. The thin canes, however, do not require as much water or manure and they are less easily damaged by pigs or jackals. Dr. Barber has made a careful study of the thin canes****. Only two of the classes made by him have been found in this Presidency, *Saretha* and *Sanabile*. The former represented by the Kalkyas and the latter by *Sanabile*, *Kadya* and *Wansi*.

The thick canes of the Presidency may also be easily separated into two groups, which may be designated as the hard and soft canes. The hard canes are fairly generally distributed in the Presidency though most often found as mixtures with the soft canes which seem to be later introductions in most tracts. There are several characters for separating the hard from the soft, other than hardness, which are well marked. The hard canes have a distinct zigzag manner of growth whereas the soft canes are practically straight. The leaves are thicker, wider and of a lighter colour with a bluish tint. The internodes of the cane are flattened and usually show patches of dry epidermis. The eye buds, both of the lower joints and of the upper nodes, tend to sprout if the cane is kept beyond ten or eleven months. These canes very rarely flower. While not having as high a fibre content as the thin canes they have much more of it than do the thick canes. This type of cane is found in three colours. The green kinds are known as *Bass*, the variegated as *Bangadya* and the red as *Tambadya*. The last two names vary according to the local vernacular as they mean banded and red respectively. These are short season canes and seem very hardy. They do better in the lighter types of soil and do not require as much manure or water as the next group. Some of the thin canes are probably superior to them in outturn and in richness of juice.

The most productive and richest juice is found in the thick soft canes and where the soil, water and manure are suitable no other cane can compete with them. They are thought to be more susceptible to disease than the other kinds, so that when cane diseases prevail the hardier sorts might be safer.

****Memoirs of the Department of Agriculture in India: Studies in Indian Sugarcanes.

It has been found possible to divide these canes into two groups, basing these divisions principally upon the characters at the throat of the leaf where the leaf sheath joins the blade. In the first of these classes the margins of the sheath project upward beyond the margin of the blade forming large auricles which are often hooked at the end. The ligula band is very wide in front and almost continuous at the back. The leaves of these canes especially their sheaths are thickly clothed with stiff spicules. The internodes have a tendency to be strongly swollen in the middle. The canes of the second group of thick soft canes have no auricle are much less thickly covered with spicules, have a narrower ligular band and have nearly parallel sides to the internodes without bulging.

In the first of these groups are included two canes that are not very closely related,—the Waxy Reds, and the *Pundhias*. They resemble each other not only in the throat characters already given but also in both being very rich in sugar content. The canes, however, do not look very much alike. The Waxy Reds form a distinct sub-group. They are found in Sind and in some other parts of the Presidency. The canes are of a deep wine colour but so covered with wax as to make it difficult to see their exact colour until the wax has been removed. No reliable data is available as to the yield of these canes. They are juicy and the juice is very rich. There seem to be possibilities in these canes. A cane very like this has been sent from several places as Ashy Mauritius which, however, is quite distinct from any of these canes. Another cane found growing at Manjri under the name of Red Sports has a similar waxy covering but it does not seem to be related to this sub-group.

The other canes of the first group of the soft canes are all more or less closely related to *Pundhia* only varying in colour and they are probably mere bud variations of that variety. The principal one of which is known as *Kabyria* a variegated or striped cane found growing in the Deccan. It is a heavy yielder. A red cane much resembling *Pundhia* has been found around Manjri as a mixture with *Pundhia* of which it may be a variant.

In many respects *Pundhia* is one of the best canes in India. It grows rapidly, tillers freely and yields heavily

a twelve months crop and frequently seven tons of stripped cane although on the average it cannot be depended upon to go much above twenty-five or thirty tons per acre. It is rich in sugar with a very pure juice if fully ripe.

The second group of soft canes is less uniform than any of the other groups. Most of its members are apparently recent introductions into India. *Khajuria* is not one of the recent arrivals and least resembles the others put in this group. *Cavanagerie* is found up and down the Bombay coast (Konkan) and frequently inland. Whether this has all occurred since the importation of Red Mauritius (*Cavanagerie*) by Mr. Mollison cannot be definitely said but it seems to have been here longer. This variety has two characteristics which make it very easy of recognition. Its light red canes are generally striped with narrow stripes of dark green and the leaf sheaths are striped with white.

The remaining varieties can hardly be said to be Bombay canes. Descriptions are given in case they may be met with.

A synoptic table is given which it is hoped will help any one to distinguish the varieties. In the descriptions that follow the table there may be some repetition of what has already been given. This is to make the descriptions as complete as possible. Separate descriptions are not given of the colour variations.

**Key for Determining the Varieties Mentioned and Described
in the following Pages.**

DESCRIPTION OF VARIETIES.

	Page.
A. Thin varieties—including those of less than three-fourths of an inch in diameter—	
B. With Channels	... KALKYA ... 13
BB. Without channels	... SANABILE ... } 13
	WANSI, Syn. ... }
	KADYA, Syn. ... }
AA. Thick varieties—including those over three-fourths of an inch in diameter—	
B. Canes strongly zigzag with thick light green leaves—	
C. Colour, green	... BASS ... 14
CC. Colour, variegated red and green...	BANGADYA, Colour varied ... 15
CCC. Colour, some shade of red	... TAMBADYA, Colour varied ... 15
BB. Canes not strongly zigzag —	
C. With distinct auricles at the throat—	
D. Colour, variegated red and green	... KADYRIA ... 19
DD. Colour, red—	
E. Covered with dense wax	... WAXY REDS .. 15
EE Wax cover inconspicuous...	MANJRI RED ... 17 & 19
DDD. Colour, green, white or yellow—	
E With large auricles on both margins	... PUNDHIA ... 18
EE. With small auricles on the outer margin only	... SAHIBI ... 19
EEE. With auricles on the inner margin only—	
F. Auricles, very short	... MANJAV ... 20
FF. Auricles, long	... MALABARI ... 21
CC. Without auricles—	
D. Colour, variegated red and green.	STRIPED MAURITIUS ... 22
DD. Colour, red	... RED MAURITIUS of Mysore ... 22

DDD. Colour, green —			
E. Bud, long—			
F. Cane, tall	... ARROWING		
	PUNDHIA	...	23
FF. Cane, short	... KHAJURIA	...	24
EE. Bud truncate	... MAURISHI, Surat.		25
DDDD. Colour, light red striped with dark green	... CAVANAGERIE	...	25

Page.

KALKYA.

A short, erect, thin, hard, white or green cane, tillers profusely, ripens in ten to twelve months.

Stripped canes are from three to five feet long, slightly zigzag; number of internodes, from twenty to twenty-five; the nodes are larger in diameter than the internodes, growth ring distinctly depressed with raised borders of darker colour than the rest of the joint; root ring wide, root dots few and large arranged in two ranks; wax ring depressed, separated from the internode by a narrow green line; eye bud longer than wide, base sharply curved, basal patches of curly hair, almost continuous; apico-basal angle about half the distance of the base to the apex; apex acute; flanges prominent and continuous. Internode round in section; from an inch and a quarter to an inch and three quarters in circumference; from three to five inches in length, colour greenish white with considerable wax, frequently with black fungous incrustations sometimes with purple lines, no corky (or ivory) markings; channel (or groove) present, wide for the size of the cane.

Foliage abundant, persistent even after turning brown; blade very narrow one half to three-fourths of an inch; twenty to thirty inches long; sheath eight to ten inches long with spines. Throat characters, sheath margins extending slightly beyond those of the blade, auricles very small and sometimes wanting indentation a sharp curve.

KHADYA.

(*Syn.* Sanabile, Wansi, Bettakabbu.)

Medium or short, thin, hard, white cane, erect in habit; tillers very profusely; ripens in eleven months. Stripped cane three to five feet long, straight or with a slight zigzag; number of internodes variable, from twenty to thirty. The nodes are usually of greater diameter than the internodes, wide, elevated, darker in colour than the rest of the cane; root ring wide, root dots few, large, in two ranks, wax ring wide, not depressed, lower border indistinct, wax extends down the internode; eye-bud large for the cane, nearly oblong with the longest dimension along the cane, base broadly rounded, basal tufts indistinct, apico-basal angle three-fourths of the distance from the base to the apex, apical part of the

bud nearly semi-circular, mucronate, broad, interrupted at the top by a wide space, bearing a few short bristles on the flanges, longer ones in the space between the flanges at the top. Internode very variable in size, from one and a half inches to three inches or even larger, the length is also very variable from three to five or six inches (for detailed measurement see Barber), colour distinctly lighter than the thick varieties, white or pale yellow straw, sometimes light green covered with considerable amount of wax, corky markings (ivory) usually present, considerable black incrustation on the wax. Rarely there is a purplish tinge. Channel or groove not present.

Foliage, abundant, erect, dark green; blade narrow, under three-fourths of an inch, twenty to thirty inches long, or one-third the length of the blade. Throat characters, sheath margins project beyond those of the blade and the outer one bears a very tiny auricle; indentation shallow, especially in the inner one.

I regret not having been able to make as careful a study of the thin canes as was earlier expected.

BASS.

A short to medium, thick, hard, greenish yellow cane, of erect habit. Does not flower in the Deccan; tillers well, requires ten to twelve months to ripen.

The canes instead of being straight are zigzagged from node to node at an angle sometimes as high as twenty degrees; three and a half to four and a half feet long when stripped for milling, from thirty to thirty-five internodes. The cane is constricted at the nodes; growth ring, usually depressed with raised border of the same colour as the adjoining internode; leaf scar, thick, prominent, strongly recurved beneath the bud, slightly so all around the node; root ring narrow, root dots prominent, arranged in two ranks; wax rings moderately constricted, with thick wax layer; eye buds small, narrow, width only one-third of length, base narrowly semi-circular, basal tufts wide, prominent, continuous, covered with wax and coarse setae, apico-basal angles one-fourth the length of the bud from the base, apex moderately acute, reaching beyond the growth line, flanges wide, lighter coloured than surrounding parts, have a tendency to be raised up from the cane, bear long bristles toward their apical

part, scale border at one side of the medium line, bursting apical. The internodes are strongly flattened, bulge considerably except immediately over the bud, four to four and a half inches in circumference, three and a half to four inches or even a little more in length, colour characteristic, the green is deeper than in *Pundhia* and the yellow is more of a buff (these shade from one to the other); frequently cloudy patches of green occur on a yellowish buff back-ground. Basal internodes are occasionally smoky or olive green or even of a purplish tinge. Ivory or corky markings are rare in this variety, and there is very little wax outside of the wax ring. Large patches of dried epidermis are characteristic of this cane and all its class, and black incrustations are occasionally present. The channel is pronounced especially in the upper internodes, it varies from an arrow line to a groove one-fourth of an inch wide.

There is a large bunch of green leaves for each stem of a characteristic bluish green colour. They grow very erect, persist quite late, few of the sheaths ever dropping. The blade is very wide, two and one half to three inches, but not as long as in other classes, forty to forty-five inches. The apex is not drawn out into as fine a point as in other canes. In texture the leaves are much thicker than in other classes and they are not split by the wind as much as is often the case with other varieties. The margins of the leaves bear very long and slender spicules sometimes in pairs. The sheath is from ten to twelve inches long being one-third to one-fourth the length of the blade, lighter in colour, thin and flexible, thickly clothed with stiff hairs. The ligular band, wide in front (12 *m.m.*) and of nearly constant width till near the midrib where it is interrupted by a narrow space. Its colour is yellowish, and the margins of the sheath extend beyond the blade by only a short distance (3 or 4 *m.m.*); no auricles; indentations shallow, the outer being only a slight notch, the inner slightly deeper; both bear soft long hairs, this hairy region extending for nearly half an inch up the blade. The ligule is narrow with a wavy margin, of nearly uniform width till near the margins. *Bangadya* and *Tambadya* are colour variations.

WAXY RED.

(There are sub-varieties with vernacular names.)

A tall, thick, soft, erect cane, of a dark red or wine colour but so covered with dense wax as to have the appearance

of being blue in colour; arrows regularly, tillers moderately; requires ten to twelve months to ripen. This variety is easily distinguished by its heavy wax layer.

The stripped canes are straight, five to seven feet long. Each contains twenty to twenty-five internodes. The nodes are of nearly the same diameter as the internodes; growth ring a depression with raised borders of a deep green colour; leaf scar narrow, usually with pieces of the sheath remaining attached, a little recurved beneath the bud; root ring straw colour; root dots rather faint, arranged in three ranks; wax ring not strongly constricted, very densely covered with wax which merges into the general wax covering of the cane; eye bud, large, length and width nearly equal, base broadly semi-circular, basal cushions broad, continuous, and clothed with short straight hairs, apico-basal angle situated above the middle line between the base and the apex, flanges broad at the angles and narrowing at the apex beyond which they project like a verandah over which the apex is raised, sides of the apex broadly curved point of apex blunt. Internodes nearly cylindrical, four and one half inches in circumference; from four to four and a half inches long, color under the wax light brownish purple, darker in places, seen through the dense coating of wax appears as a gray blue, aside from this dense wax there are no other markings except rarely a slight dark discolouration of the wax. Channel usually present on all internodes but more prominent on the upper ones.

Foliage abundant, light green, drooping in graceful curves; leaves die off early and drop, leaving the sheath which later also drops, leaving twelve to fifteen green leaves with five or six dead leaf sheaths. Blade one and three quarters to two and one quarter inches wide, thirty to fifty inches long, apex slender and threadlike, marginal spicules very slender much more so than any variety observed near the throat these merge into hairs. Sheath ten to sixteen inches long, about one-third that of the blade, not lighter than the blade in colour, texture thick and leathery, hairs at the back sparse and short. Ligular band very wide in front (12 m.m.), a little narrower at the midrib, where it is interrupted by only a narrow space at the midrib, upper border, curved and very wavy, lower straight, colour brown, overlaid with wax, whole band wrinkled.

Sheath margins extend considerable distance beyond the blade, bear tooth-like auricle at each margin about half inch

long, indentation one-third the arc of a small circle, the whole throat covered with numerous long hairs sometimes buff in colour. Ligule narrow.

MANJRI RED.

A tall, erect, thick, soft red cane, arrowing regularly, tillering freely, requiring about twelve months to ripen.

Stripped canes are straight, six feet and over long, composed of about twenty internodes. The nodes are about the same diameter as the internodes; growth ring narrow and elevated above the surface of the node; leaf scar thick, strongly recurved, especially under the eye bud; root ring wide, root dots large and numerous, irregularly arranged; wax ring wide, very slightly depressed, lower border indefinite in outline, wax not very thick; bud base, nearly horizontal with extreme ends slightly curved up, basal cushion, not continuous, bears a few silver white hairs, apico-basal angle at about one half the height of the bud, sides of the apex broadly curved, apex mucronate, flanges broad of darker colour than the rest of the bud. Internodes are circular in section and with parallel sides, circumference from three and three quarters to four and a quarter inches, length five to seven inches, colour varies from a deep wine red to a brownish red. The wax extends from the wax ring only about one-fourth way down the internode. Channel distinct especially in the upper internodes.

Foliage, abundant, slightly darker than that of *Pundhia* gracefully drooping over, leaves dry and drop early except the top tuft. Blade two inches in width, fifty to sixty inches in length, marginal spines long, hairlike, bent down, closely pressed to the margin. Ligular band wide, its borders in regular curves, not continuous at the midrib. In tender leaves the band appears to be delicate blood red when seen from behind the ligule otherwise it is green in colour with some wax; sheath twelve to fourteen inches long, from one-fifth to one-fourth the length of the blade. Margins wider than the sheath outer without auricle inner with a blunt auricle one-fourth of an inch long. Outer indentation wide in curve, bearing long buff coloured hairs outer indentation, a deeper curve. Ligule border curved and much wider at the back.

PUNDHIA.

(Syns. Pounda, Pandia, Rasdali.)

A tall, spreading, thick, soft, green cane. Rarely arrows in Bombay Deccan, but more freely at Mysore; tillers abundantly; requires twelve to fourteen months to fully ripen; ratoons well.

Stripped canes are straight, four to six feet long, composed of from twenty to twenty-five internodes. The nodes are of less diameter than the internodes; growth ring narrow, not much raised above the surface of the cane, of the same general colour as the rest of the region; leaf scar thin and only slightly recurved; root ring, medium in width, root dots in four ranks; wax ring medium width (about ten millimeters) deeply constricted, densely covered with white wax, underneath which the colour is deep green; eye buds moderate in size and somewhat variable in character, base broadly semi-circular, with a narrow basal tuft, nearly continuous, the apex broadly acute, often mucronate, the apico-basal angle is nearly half way between the base and the apex flanges prominent, from a half to a whole millimeter in width, glabrous, the scale margin, straight and medial; bursting sub-apical. The internodes are nearly circular in outline, strongly bulged, except above the bud, on the average about five inches around at the largest place, length from four and a half to five and a half inches, in colour there is considerable variation from light green and light yellow to the deeper shades of green. The more exposed the cane is the darker the green, the upper part of the internode is usually light green, lower and opposite to the bud the colour is straw yellow, in exposed canes faint purple streaks may occur, a tinge of rose in exposed and stripped canes may be seen. Nearly every internode is marked with sinuous fine lines of cork like appearance, the ivory markings of Barber. The whole node is coated with a thin layer of wax which till rubbed off gives the canes a bluish cast; a black fungous growth is frequently found on this wax giving the cane a dark appearance. The channel is often indistinct though at other times a well marked shallow channel can be seen in the upper internodes.

The foliage is moderate in quantity, of a light green colour; the leaves curve over and begin to die off; after seven or eight months they dry up and drop off, sheath and all, so that

only ten or fewer green leaves will be left at the top. The blade is about two inches wide at the widest part and sixty inches long, it tapers very gradually to a fine threadlike apex. The leaves are thin and bear a great many stiff spicules which at the margins stand out like teeth of a saw; sheath about one-fourth the length of the blade, of a lighter green, thin and flexible, densely coated with stiff spicules or hair. The ligular band is wide in front (10 m.m.), narrowing to less than half at the midrib, only very slightly interrupted, its upper border is irregularly curved, colour coffee brown in front which becomes paler at the back. Both margins of the sheath project beyond those of the blade and are formed into long auricles very characteristic of the variety. The auricles are often as much as three inches long and are frequently bent back or hooked. The inner auricle is usually shorter. The throat in front is deeply indented by a semi-circular indentation bearing numerous long hairs. The ligule is five millimeters wide at the back and tapers very gradually, its margin, entire without hairs. *Kabyria* and *Manjri Red* are colour variations.

SAHIBI.

A medium tall, spreading, thick, soft, green or yellow cane, which does not arrow, tillers freely, and ripens in from eleven to twelve months.

The stripped canes are slightly zigzagged, about five feet in length, internodes about twenty-five. The nodes are of about the same diameter as the internodes; growth ring narrow depressed with raised borders; leaf scar prominent, strongly recurved beneath the bud; root ring narrow, root dots very irregular in arrangement; wax ring, wide, not much depressed, colour beneath the wax much darker than the rest of the region, wax thick but not spreading below the ring to the internode as in *Pundhia*; eye bud, long, narrow, base straight except at the sides which curve up, basal tufts dense and continuous, apico-basal angle one-fourth the length of the bud from the base, apex sharply acute, flanges covered with long hairs, scale border out of the medial line, straight, bursting apical. Internode sides nearly parallel except a slight bulging just above the node opposite the leaf scar, circumference four to four and a half inches, length three to eight inches, colour yellowish green somewhat clouded, when exposed to sun it turns to a bright yellow or

orange which is characteristic of the variety, neither corky (ivory) marks, black incrustations or wax are present except slight black discolouration near the node.

The foliage is moderate in quantity, light green in colour, erect in habit of growth, the ends of the leaves curving down. The leaves dry up early and the blades drop, the sheath remaining quite late, in this respect it is midway between *Bass* and *Pundhia*. Blade two inches wide, fifty to fifty-five inches long, firm and thick in texture; marginal spicules often three pointed and stouter than in *Pundhia*; apex much less slender than in *Pundhia*; sheath only overlapping at the bottom, length ten or eleven inches or one-fifth that of the blade of the same colour as the blade thin and flexible, sparsely hairy, with some wax. Throat characters, ligular band wide, in front tapering rapidly towards the midrib, interrupted about two-thirds of the distance from the margins to the midrib thus making a wider interruption than is seen in most varieties, colour light brown coated with wax; sheath margins beyond those of the leaf outer one bearing a tiny auricle inner one none; indentations deep curved.

MANJAV.
(*Syns.* B. 376.)

A medium tall, partially spreading, thick, soft, green, cane; arrows regularly; tillers moderately; ripens in eleven months.

The stripped canes are straight, from four to six feet long, composed of from twenty to twenty-five internodes. The nodes are constricted, growth ring distinct and of lighter colour, leaf scar slightly recurved, prominent, root ring wide, dots arranged in three or four rows, wax ring depressed covered with medium thick layer of wax, under which the green is deeper in colour; eye buds, slightly longer than broad, base, nearly semi-circular, basal tufts, thick, narrow, continuous, reaching up to the apico-basal angles, which are about one half the distance from the base to the apex, apex widely acute, flanges wide hairy, but arises from a waxy cushion, scale margin is wavy, bursting sub-apical. The internode circular in section, four and a half to five and a half inches in circumference, five to six inches long, colour green of different shade changing to white or yellow, faint narrow purple stripes occur, sometimes faint purple clouding the

wax covering gives a bluish cast to the green, a black fungous growth is common; channel is present.

Foliage is moderate in amount, partially spreading, light green in colour, of a darker shade than *Pundhia*, drying and dropping early. The blade is one and three quarters inches wide, forty-five to fifty inches long, apex moderately thin, marginal teeth thick at the base not as fine as in some varieties. The sheath of the leaf about twelve inches long or about one-fourth the length of the blade, lighter in colour than the blade thin and flexible in texture covered with spicules or hairs. Throat characters, ligular band very wide in front (15 m.m.) and rapidly narrowing towards the midrib with a narrow interruption; upper border irregular, lower a regular curve colour light brown; margins of the sheath project beyond those of the blade; inner margin bears a small straight auricle, outer margin without any; indentation deep; ligule wide at the back (4 to 5 m.m.) tapering slowly towards the front, margin entire.

MALABARI.

A tall, semi-erect, thick, soft light green or white cane, does not arrow, tillers well, ripens in nine to eleven months.

The stripped canes are straight, five to six feet long, of fifteen to twenty internodes. The nodes are less in diameter than the internodes; growth ring wide, raised; root ring narrow, root dots in two ranks, upper row faint; wax ring slightly depressed, wax layer, light, lower border indistinct; eye bud, one and a half times longer than wide, base straight with sides sloping abruptly up, basal tufts prominent, continuous, clothed with long waxy hairs, apico-basal angle and the flanges not distinct owing to the long hairs from the basal tuft which extend to the apex, apex acute. Internodes flattened slightly, bulging considerably in circumference four to five inches, in length about five inches, colour a light green varying between ivory white and light yellow in exposed portions; channel prominent.

Foliage abundant, spreading, light green, though darker than *Pundhia*, leaves dry and drop early. Blade one and a half to two inches wide, fifty to sixty inches long, apex long and fine; sheath twenty to thirty inches long, margins of the sheath die and turn brown early; sheath covered with dense wax and numerous stiff spines at the back, thick and brittle in texture; throat characters, ligular band, lower border

nearly straight, upper border broadly curved, wide interruption at the midrib, colour dark green; margins of the sheath do not project beyond those of the blade, long auricle on the inner margin, indentations deep covered with long hair; ligule lower margin bent down at the back.

STRIPED MAURITIUS.

(*Syn.* Bamboo cane.)

A tall, erect, medium thick, soft striped, red and green cane; arrows regularly; tillers moderately; ripens in from ten to twelve months.

Stripped canes are straight, five or six feet long, composed of about twenty internodes; nodes are not much less in diameter than the internodes, growth ring very narrow, raised; leaf scar strongly recurved under the bud; root ring narrow of a straw colour, dots faint, sparse, arranged in two or three ranks; wax ring narrow, not depressed below the surface of the cane, green in colour, covered with a very thin layer of wax; eye bud, not longer than broad, base broadly rounded, basal tufts of short hairs, apico-basal angle about half the distance from the base to the apex, flanges wide and prominent, apex almost a right angle bears a tuft of brown hairs. Internodes circular in section with nearly parallel sides, three and one half to four inches in circumference, five to seven inches in length, bright wine red and green striped, stripes of variable width, no other markings. Channel slight except in extreme upper nodes.

The foliage moderate in amount, light green, semi-erect, falling over at the tips; leaves dry and fall early both sheath and blade, width of blade two inches, length fifty inches; sheath eight to ten inches long or about one-fifth or one-sixth the length of the blade, thin, flexible, nearly glabrous, the ligular band moderate width with regularly curved borders light brown with some wax. Margins not extending much beyond that of the leaf, auricles not present, outer indentation shallow, inner deeper both curved and covered with light yellow hair. Ligule wide, margins parallel for some distance.

RED MAURITIUS.

(*Syn.* Purple Mauritius.)

A tall, spreading, thick, soft, purple or dark red cane; does not arrow in Bombay Deccan; tillers moderately; ripens in ten to twelve months.

Stripped canes straight or curved, five to six feet long, of twenty-five to thirty internodes; node not smaller in diameter than the internode; growth ring very narrow, raised, yellow or green; leaf scar narrow and not recurved under the bud; root ring straw yellow, or green, dots few and large in two or three ranks; root ring furrowed from the veins of the leaf sheaths; wax rings not depressed, narrow, (five millimeters) colour under the bud lighter than that of the internode; eye bud width and length nearly equal, base nearly horizontal with sides curved up, basal tuft not continuous but reduced to two lateral tufts of short curly hairs, apico-basal angle one-third the distance of the height from the base, flanges of uniform width, narrow, apex acute, reaching to the growth ring. Internodes circular or slightly flattened in section with nearly parallel sides, four inches in circumference, three and a half to four inches in length, colour dull purple shading to a dull brownish green or an olive green in the upper internodes sometimes with faint signs of striping; channel very faint or absent.

Foliage abundant, light green, droops over in a curve, dries late and is persistent to an advanced stage of maturity. The blade is one and a half to two inches in width, fifty inches long, marginal spines often in pairs from a single base which is wider than usual; sheath ten to twelve inches long about one-fifth the length of the blade, thick and inflexible in texture, thickly clothed at the back with hair, lighter in colour than the blade. Throat characters, ligular band one-fourth inch wide, continuous across the midrib, borders regularly curved, wrinkled; margins of the sheath and blade are nearly continuous with only very slight indentation, no auricles; the throat bears large, soft, buff hairs which continue up the leaf. Ligule very narrow.

ARROWED PUNDHIA.

(The name was given to this because it was found as a mixture in the *Pundhia* fields. It, however, differs in several characters from that variety. *Syn.* White Mauritius and Mysore.)

A tall, erect, thick, soft, green cane, arrowing regularly, which tillers freely, ripens in about twelve months.

The stripped canes are straight, about six feet long, of eighteen or twenty internodes. Nodes of nearly the same

diameter as the internodes; growth ring raised, narrow, of about the same colour as the region; leaf scar prominent, strongly recurved under the bud, and is oblique to the length of the cane; root ring, dots very numerous and arranged in three or four ranks irregularly; wax ring narrow, not depressed below the surface of the region, wax covering thin; eye bud small to medium, slightly longer than wide, base broadly curved, basal tufts small nearly continuous, apico-basal angles about one-third of the distance from the base to the apex, flanges narrow, separated by a darker coloured line from the bud, glabrous, scale margin straight and medial, sides above the angles run nearly straight to the apex which is obtuse, bursting apical. The internodes circular in outline, with nearly parallel sides, three to four inches in circumference, five to six inches in length, green and yellow, becoming deep green where exposed, very little wax, no corky (ivory) markings, black incrustations found on the upper internodes; channel faint on the lower internodes broader on the upper ones.

Foliage moderate in amount, darker green than *Pundhia* but not so dark as some varieties, erect with ends curving over, leaves drop early; blades one and three-fourths inches wide, fifty-five inches long, apex very thin; sheath twelve to fourteen inches long or about one-fourth the length of the blade, of lighter green than the blade, thin and pliable, nearly glabrous with a coating of wax. Throat characters—ligular band wide in front (10 m.m.), narrow at the midrib, discontinuous by a wide space, light brown in front and yellow at the back, covered with wax; margins of the sheath do not extend beyond those of the blade with which they are continuous, the indentation reduced to a slight curve, both margins bear long brown silky hairs, the hairiness continuing up the blades for an inch; auricles absent; ligule narrow (3 m.m.), margin entire.

KHAJURIA.

A short, erect, thick, soft, dark green cane; rarely arrows; does not tiller freely; matures in from ten to twelve months. Easily recognized by its short fat internodes and narrow leaves.

Stripped canes short, three and a half to four and a half feet long, of twenty to twenty-five internodes, of a characteristic shade of dark green. The node of considerably less diameter

than the internode; growth ring raised, lower margin sharply delineated from the root ring, upper margin merges into the internode; leaf scar not conspicuous; root ring dots small but distinct in three ranks spirally placed; wax ring slightly depressed, lower margin indistinct colour under the wax same as that of the internode; eye bud small, elongate, width two-thirds of the length, base nearly semi-circular, basal tufts not distinct, discontinuous, apico-basal angle one-third of the distance from the base to the apex, sides of apical part run straight to the apex, flanges prominent, widest at the apico-basal angle, about one millimeter wide, apex acute, scale border straight; bursts at the tip. The internodes are nearly circular in section, strongly bulged, three and a half inches in circumference, short, two to three and a half inches long, colour green much like *Pundhia*, lower part of the internode often shading to a light straw colour, the internodes can be distinguished from those of *Pundhia* by the almost entire absence of wax or corky (ivory) markings, sometimes faint subcutaneous black streak may be found. Channel narrow and shallow extending the entire length of the internode.

Foliage less than in most varieties, bright green, rather upright, leaves drop late and sheaths persist till nearly maturity; blades narrow from one inch and a quarter to two inches and a quarter in width, thirty-five to forty inches long, apex not as fine as *Pundhia*; marginal spicules long, slender, depressed. Sheath nine to ten inches long, or one-fourth to one-fifth the length of the blade moderately thin and flexible margins do not meet in front on the upper third of the internode, at the back are found a few short spiny hairs. Ligular band narrow, borders regularly curved, not wrinkled, discontinuous, dark brown overlaid with wax; sheath only very slightly extending beyond margin of the blade; auricles not present, indentation very small especially the inner, the whole throat densely covered with hairs in front. Ligule very narrow.

MAURISHI.

(This variety was only observed just before leaving India and the description is incomplete.)

A tall, thick, soft, cane, green in colour.

Node; growth ring, plain; root ring, dots in three ranks; wax ring not constricted; eye bud wider than long, base curved broadly, basal tufts extending to the margins of the

truncate apex, apico-basal angle about three-fourths of the distance from the base to the apex, apex truncate the bud is divided into three parts by two longitudinal furrows.

Foliage, sheath covered with wax and a few short hairs, throat characters, ligular band nearly continuous, both margins curved and oblique to the blade, indentations shallow, no auricle ligule curves down at the back.

CAVANAGERIE.

(*Syn.* wrongly called Red Mauritius in the Deccan.)

A very tall, thick, soft, slightly spreading, light red cane with dark green stripes that are characteristic of the variety; does not arrow; tillers abundantly; requires fourteen to sixteen months to fully ripen though *gur* can be made from cane twelve months old.

Stripped canes are straight, from six to seven feet long, containing about thirty internodes each. The nodes are of nearly the same diameter as the internodes; growth ring—narrow, raised; leaf—scar, narrow, inconspicuous; root ring—wide (8 *m.m.*), dots numerous in four ranks; wax ring—narrow, with thin layer of wax; eye bud—wider than long, raised above the surface about one-fifth of the width, base very broadly curved, basal cushion narrow, with sparse hairs, apico-basal angle more than half the distance from the base to the apex, flanges narrow, apex nearly a right angle, bursting sub-apical. Internodes circular in outline and with sides parallel or slightly bulging, circumference four and a half to five inches, length five and a half to six and a half inches, colour a bright wine, sometimes darker upon which are dark olive green stripes.

Foliage abundant, dark green slightly drooping, drops early. Blade two and a half to two and three-fourths inches wide, length fifty-five to sixty inches, marginal spines at greater intervals than in most varieties, long and very slender. Sheath fifteen to eighteen inches long or about one-fifth of the length of the blade, thick and stiff in texture, clothed with stiff spines at the back, colour green and white variegated which is characteristic of the variety. Ligular band wide at front, with regularly curved borders, discontinuous at the midrib by a broad space, colour dark green, covered with wax; sheath margins not extending greatly beyond those of the blade; auricles not present; indentations shallow; ligule narrow.

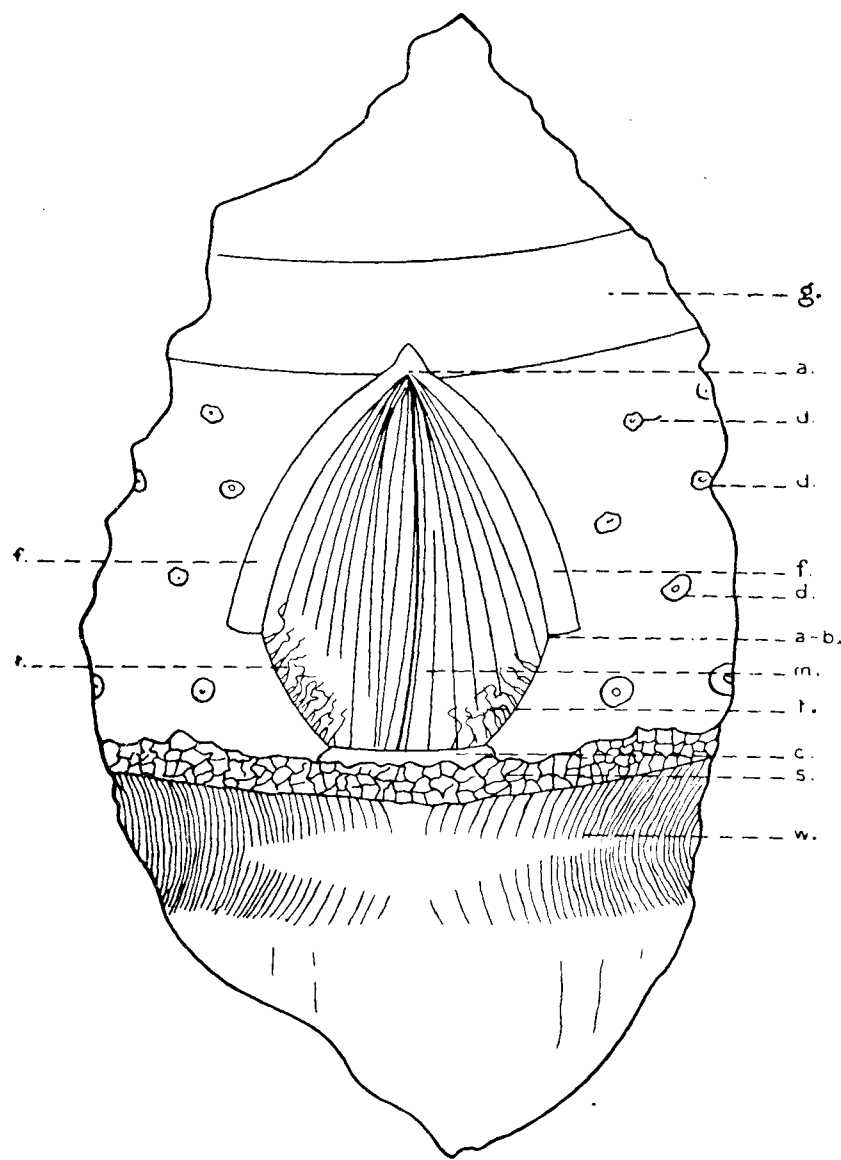


Fig. 1

Diagram of Eye-bud—Explanation.—(g) growth layer; (a) apex; (d, d, d) root dots; (f, f) flanges; (a-b) apico-basal angle; (m) scale margin; (t, t) basal tufts; (c) cushion; (s) leaf scar.

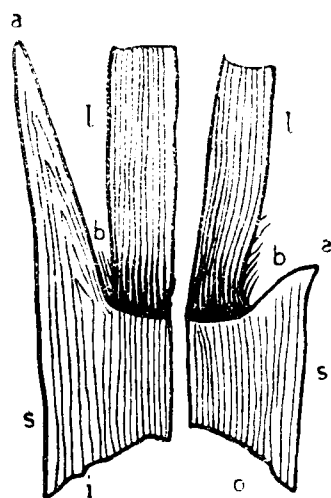


Fig. 2

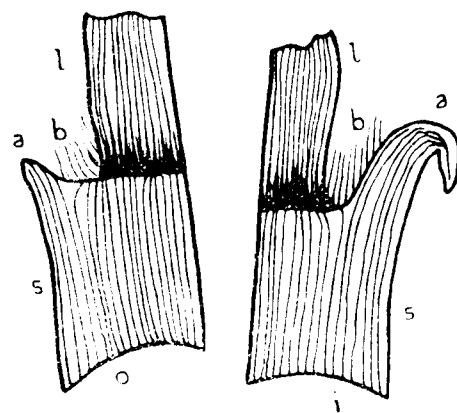


Fig. 3

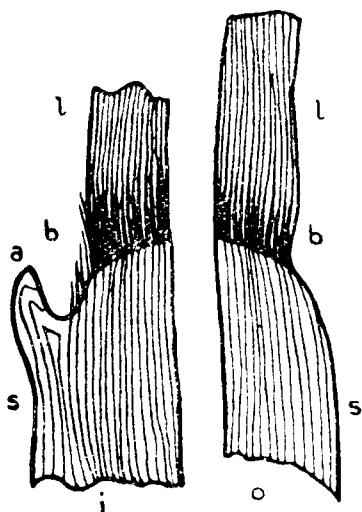


Fig. 4

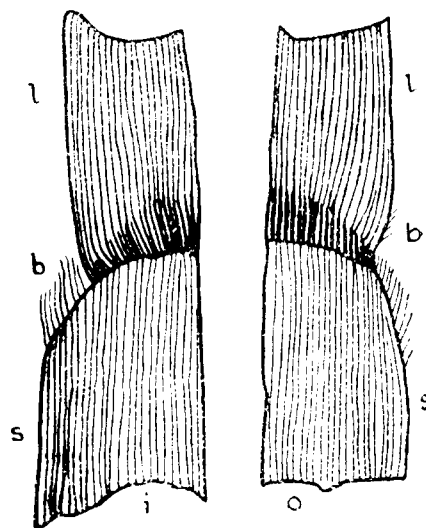


Fig. 5

Characters at the Junction of the Lamina and the leaf—Explanation.—Fig. 2—long auricle inner margin, short one on outer, usual Pundhia type; Fig. 3—similar to figure 2 except that long auricle is hooked, a very frequent condition; Fig. 4—small auricle only on the inner margin, found in Manjav; Fig. 5—margins without any auricle, Cavanagerie. Details:—(letters on all figures refer to the same parts) (i) inner margin, (o) outer margin, (a) auricle, (b) angle, (l) lamina, (s) sheath, (b) ligula band.

RIDGE CULTIVATION IN LOWER GUJARAT.

Gujarat* consists essentially of a flat plain lying almost at sea level, stretching between the sea and various mountain ranges, from a hundred miles north of Bombay, northward to the fringe of the Rajputana desert. In the south of this region, generally known as Lower Gujarat, the general aspect, especially of the portion where cotton and jowar (*Andropogon sorghum*) are chiefly grown, is that of a flat plain formed by the alluvium deposited in the basins of the Tapti, Nerbudda and some other rivers. Of this area, Surat may perhaps be regarded as the most typical centre. The soil in it, being derived from the region of the Deccan trap, has all the characteristics of the black cotton soil or *regur* of Western India, varying in depth and stiffness, however, from place to place.

This black soil possesses in this region, in a pre-eminent degree, the power of expansion and contraction on wetting and drying respectively, which is the most obvious character of black cotton soil. As a result, in the hot weather, it is traversed by deep and wide cracks which disappear with the first advent of the rains. The cracking of the soil is considered by the people to be a great advantage as it leads to the surface soil being mixed with the subsoil either during the process of cultivation or during the first rains. The flow of the water into the cracks, carrying with it a large amount of surface soil, leads, on the one hand, to a capacity on the part of the soil to absorb when perfectly dry, a very large amount of rain (even up to seven to eight inches) in one continuous fall without surface wash or erosion, and (when cultivation is on the flat) to the conversion of a field into a series of basins (especially if the previous crop is a deep rooted one) which need to be levelled up before any further operation is undertaken. Though the soil at the first monsoon rain is capable of absorbing an enormous amount of water, once the cracks are filled up and the soil saturated, the water drains away so slowly, that the land remains very full of water for a long time and it can only absorb further water with difficulty.

* The general description of the soil conditions prevailing in South and Lower Gujarat has been very largely summarised and adapted from M. L. Patel's recent Memoir, "Studies in Gujarat Cottons", Part II (Memoirs, Department of Agriculture, India, Bot. Ser. Vol. XII, No. 5 of 1924).

If the rain remains continuous and heavy, erosion takes place, water stagnates on the surface, and all the signs of temporary water-logging are seen.

In this area the rainfall is also of a character which tends to emphasise the characteristics of the soil which have just been described. The rainfall is usually forty inches or over per annum, but this is concentrated in five months, the rest of the year being entirely dry. The actual average rainfall for forty-four years at Surat and at Jalalpur (Navsari), two typical centres, is as follows:—

Month.	Surat. Inches.	Jalalpur (Navsari) Inches.
January	...	...
February	...	...
March	...	...
April	...	...
May	...	...
June	8.48	9.33
July	16.69	21.27
August	7.76	9.45
September	6.11	8.07
October	1.65	1.86
November	...	...
December	...	...
Total	40.72	49.98

Though this rain is exceedingly variable, its general character is such as to give, in by far the largest proportions of cases, a very large rainfall in July, which makes it almost certain that at this time of the year any crop on the ground will be subjected, when cultivation is on the flat, to a partial water-logging during part of that month and possibly also in June and August, which may include partial flooding, at intervals, for days together.

In spite of these facts, the ordinary cultivation of this area consists of a rotation of *jowar* (*Andropogon sorghum*) and cotton, grown on the flat, and sown as soon after the commencement of the rains in June as the soil conditions allow. The ordinary procedure is that the preparatory tillage for the crop to be grown begins about the end of April by the harrowing of the fields to remove the stubbles of the previous crop. If manure is used in the rotation it is usually applied in May or June, previous to the cotton crop, but consists exclusively of cattle manure. Artificial manures have

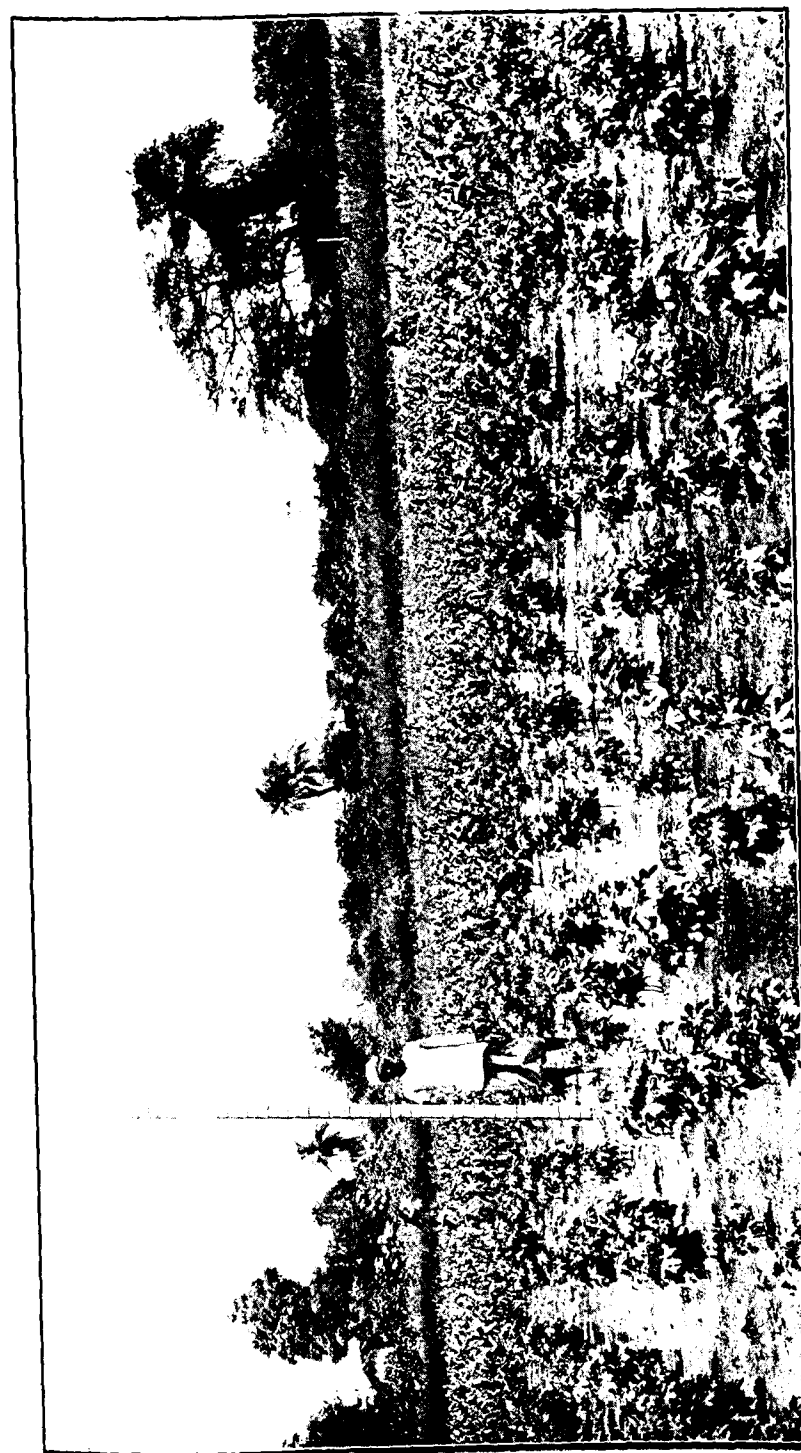


PLATE 1.—Showing Oversaturation and Stagnation of Black Soil after good Rains from 17th to 20th September 1922, of nearly 6" of Rain.

never been used, hitherto, on any large scale. When the rain comes, the fall is usually heavy and is followed by a break, during which the land is ploughed, harrowed, and sown with great speed, for if further rain comes, the land can neither be worked nor sown until it is again partially dry.

After sowing, the crops may fail owing to excessive rain or owing (more exceptionally) to drought, and in this case sowing has to be repeated. If there is no actual failure and the usual heavy rain takes place in July, there ensues a period during which both *jowar* and cotton become yellow, look miserable, and have every appearance of lack of root aeration or water-logging (Plate 1).

The usual remedy for this state of affairs would normally be considered to be either under-drainage or ridge cultivation. But under-drainage with tiles is impossible in the conditions of real black cotton soil which dries completely out during part of the year, as the cracking of the soil (as has often been found) tears the tiles apart, and they rapidly cease to form a drain. Open drains are of little value, as, owing to the slimy and treacherous character of the soil, they are very difficult to keep open. Further, owing to its very great retentive powers for water, drainage from such a partly water-logged soil is very slow, and hence the number of open drains required is impossibly large.

On the other hand, ridge cultivation using small ridges such as can be turned up by a country wooden plough is not feasible, for, again owing to the slimy and treacherous character of the soil, these small ridges tend to disappear during a spell of heavy rain in July, and the use of such small ridges has again and again been proved to be of small value.

As a result of these facts, cultivation on the flat without drains has remained universal in the black soils of Lower Gujarat, though it has always been recognised that the less slimy and retentive soils give much better and more reliable returns than the others, and though in considerable areas (Olpad, &c.,) the partial water-logging above referred to has been so long continued that cultivation has been so risky as to make the land hardly capable of being cultivated.

Moreover, the considerations referred to would seem to be almost the dominant factor in the yield, and modifications of cultivation or of manuring or of rotation, which do not deal with this question of partial water-logging, seem very ineffective in producing any increases in yield of the main crops of

the area. The experience on the Surat Government Farm* from the year 1902 to 1920 was that no method was effective in materially increasing the yield of these crops, provided flat cultivation was retained. During the early years of that farm, the effect of deeper and more perfect cultivation was fully studied, and no appreciable advantage was found. In several other series of experiments the introduction of a leguminous crop (tavyer (*Cajanus indicus*), groundnut, &c.) was studied, again without material effect on the yield of the main crops. Then attention was concentrated on the judicious use of cattle manure or of artificial manures, but with most disappointing results, for the manures did not by any means always produce increases in yield, and, when they did, the application was rarely profitable. In one case only when a very large amount (85 cart-loads per acre) of crude night soil or a corresponding large amount of cattle manure was applied, was a large increase of yield constantly obtained, the increase being maintained for a number of years, owing largely, it is probable, to an alteration in the physical texture of the soil.

First Experiments on Ridge Cultivation.

Under these circumstances, it was decided to try and see whether the use of much larger and higher ridges was possible, and whether under these conditions manuring could by some means or other be made effective. A preliminary comparison was made in 1920-21 between the crops raised on the ordinary flat cultivation of the Government Farm without manure, and the crops raised on ridges either ten or fourteen inches high made with a large ridging plough, the seed being dibbled on the top of the ridges in one row as soon as the weather allowed. The ridged plots were manured, in 1920-21 only, with 50 cart-loads of cattle manure per acre before ploughing or ridging, and in addition the following applications were made per acre after ridging, in the furrow between the ridges:—

(1) In June at planting—

2,000 lb. cotton seed hulls.

300 lb. slaked lime.

300 lb. wood ashes.

* The figures of the results referred to will be found in the Annual Reports of the Surat Farm from 1902 to date.

(2) In September—

400 lb. cotton seed meal.

1,000 lb. ground rock phosphate.

The application of these manures in the ridged plots reduced the value of any comparison which can be made between the ridged and flat plots, but as many previous experiments had shown little result from these quantities of manure when applied without ridging, and as the experiment was only preliminary, the results may be given.

Cotton.—Ridges made in 1920-21, 14 inches high. Ridges six feet apart. Variety of cotton used, *Broach Deshi Strain—1 A Long Boll*.

Treatment.	Spacing.	Yield (by plots) of seed cotton per acre.	Average yield of seed cotton per acre.
1920-21.		lb.	lb.
(1) Flat plot, no manure.	Dibbled 2 ft. by 2 ft.	(a) 484 (b) 479	481
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	(a) 645 (b) 627	636
(3) Ridged, single line of plants on each ridge.	Dibbled plants 1½ ft. apart.	(a) 795 (b) 832	814
(4) Ridged, single line of plants on each ridge.	Dibbled plants 3 ft. apart.	(a) 857 (b) 887	872
1921-22.			
(1) Flat plot, no manure.	Dibbled 2 ft. by 2 ft.	(a) 425 (b) 410	417
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	(a) 450 (b) 426	438
(3) Ridged, single line of plants on each ridge.	Dibbled plants 1½ ft. apart.	(a) 538 (b) 515	526
(4) Ridged, single line of plants on each ridge.	Dibbled plants 3 ft. apart.	(a) 454 (b) 537	495

The effect of the ridging and treatment which accompanies is remarkable. (Plates 2, 3). While it has been difficult in the past with the ordinary type of cotton grown and without irrigation to get more than 600 lb. of seed cotton per acre, the year has jumped in the first year after ridging to between 800 and 900 lb. per acre. Without any further treatment the crop in the following year is also much higher than on the flat. Taking the best of the flat plots (spaced three feet by three feet) as the basis, we have the following results in summary:—

Treatment.		Average yield of cotton per acre.	Percentage increase in yield.
<i>1920-21.</i>			
(1) Flat plot	...	636	...
(2) Ridged, close planting	...	814	28
(3) Ridged, wide planting	...	872	37
<i>1921-22.</i>			
(1) Flat plot	...	438	...
(2) Ridged, close planting	...	525	20
(3) Ridged, wide planting	...	495	13

This result was in part due to better growth of the plants, but also partly to the larger number of gaps in the flat plots. These gaps represent the normal loss due to failure in the semi water-logged soil. The actual percentage of gaps in the three plots named above (obtained by counting in a few rows taken at random) was as follows:

	1920-21, Percentage of gaps.	1921-22, Percentage of gaps.
	Per cent.	Per cent.
(1) Flat plot	... 19	14
(2) Ridged, close planting	... 10½	6
(3) Ridged, wide planting	... 5½	2½



PLATE 2.—Showing Profuse Drainage and Storing of Water in the Furrow after nearly 6" of Rain from 17th to 20th September 1922.

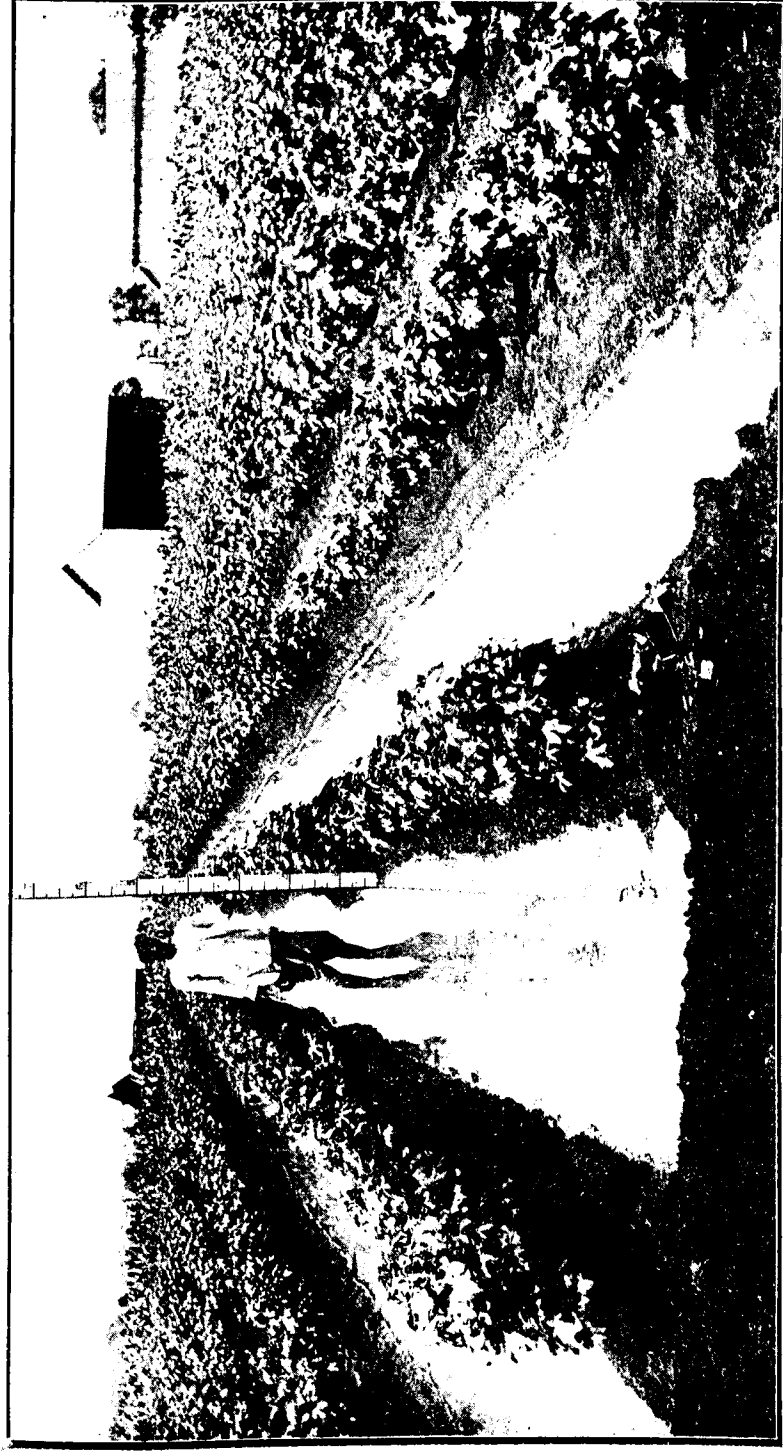


PLATE 3.—Showing Profuse Drainage and Storing of Water in the Furrow after nearly 6" of Rain from
17th to 20th September 1922.

Jowar.—Ridges made in 1920-21, ten inches high. Ridges four feet apart. Ridges made in 1921-22, 14 inches high. Ridges six feet apart. Variety of *jowar* used *Perio*.

Treatment.	Spacing.	Yield by plots per acre.		Average yield per acre.	
		Grain.	Straw, &c.	Grain.	Straw, &c.
		lb.	lb.	lb.	lb.
<i>1920-21.</i>					
(1) Flat plot, no manure.	Drilled, 2 ft. rows, 1 ft. apart in row.	{ a 820 b 870 }	{ 3,130 2,830 }	845	2,990
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	{ a 1,145 b 1,190 }	{ 3,807 4,677 }	1,167	4,240
(3) Ridged single line of plants per ridge.	Dibbled 1 ft. apart (one plant per dibble).	{ a 1,150 b 1,165 }	{ 3,100 3,150 }	1,157	3,125
(4) Ridged, single line of plants per ridge.	Dibbled 1 ft. apart (5 plants per dibble).	{ a 1,130 b 1,050 }	{ 3,320 3,185 }	1,090	3,250
<i>1921-22.</i>					
(1) Flat plot, no manure.	Drilled, 2 ft. rows, 1 ft. apart in rows.	{ a 945 b 900 }	{ 1,600 1,465 }	922	1,532
(2) Flat plot, no manure (Plate 4).	Drilled, 3 ft. rows, 1 ft. apart in rows.	{ a 945 b 960 }	{ 1,630 1,770 }	952	1,700
(3) Ridged, double lines of plants on ridges.	Drilled, 9 inches apart in rows 2 feet apart.	{ a 1,340 b 1,475 }	{ 3,280 3,385 }	1,407	3,332
(4) Ridged, double line of plants on ridges (Plate 5).	Drilled, 18 inches apart in rows 2 feet apart.	{ a 1,635 b 1,517 }	{ 3,865 3,600 }	1,576	3,732

In the case of *jowar* little or no effect is visible in 1920-21 even with the heavy manuring given to the ridged plots; on the other hand the effect in 1921-22 even without any further manuring is remarkable. *Jowar* is a relatively shallow crop, and would naturally suffer badly from the partial water-logging in a wet year. Now 1921-22 was such a wet year in July, though there was no heavy rain in June, while 1920-21 gave at no time such a heavy and continuous downpour. The actual rainfall per fortnight in the two years was as follows:—

		Rainfall.	
		1920.	1921.
		Inches.	Inches.
June—1st fortnight	...	7.14	0.41
2nd fortnight	...	0.62	0.40
July—1st fortnight	...	6.20	2.29
2nd fortnight	...	4.31	25.18
August—1st fortnight	...	3.12	5.02
2nd fortnight	...	1.39	2.94

Further Experiments on Ridging.

The results just quoted give a clear indication that we have discovered one of the chief causes of the limitation of yield and the lack of effectiveness of manures at Surat and in the black cotton soil of Gujarat generally. An experiment was, however, laid out under more rigid conditions by which—

(1) the general effect of ridging on the cotton and *jowar* plants and on their yield could be determined;

(2) the effect of manures on such ridged crops, and the best way of applying it;

(3) the best manner of applying interculture during the growth of the crop.

In this case all ridges, made during the hot weather before the crops were sown, were constructed 14 inches high and five feet apart between the centres of the ridges. The ridges themselves had a flat top 18 inches wide, and the

furrows were wide enough to allow the passage of a plough at the bottom for deep interculture purposes.

All planting, both on the flat and on the ridged plots, was done with the same spacing. Cotton was dibbled in at five feet between the rows, and two feet between the plants in the rows. *Jowar* was drilled in two adjacent rows, 18 inches apart on the ridges, and at a corresponding distance on the flat.

The experiment was in two sections. The first was to determine the effect of ridging without manure whether accompanied by shallow or deep inter-tillage between the ridges, as soon as the condition of the soil allowed this to be done, the second was to ascertain the effect of manure in ridged plots and the best method of applying it.

1ST EXPERIMENT.

Ridging without Manure.

Cotton (Broach Deshi, Strain 1027 A. L. F.).

Treatment.	1922-23, Seed cotton yield per acre.	1923-24, Seed cotton yield per acre.	Average, Seed cotton yield per acre.	Increased yield over flat plot.
	lb.	lb.	lb.	Per cent.
(1) Flat with usual inter-tillage.	534	471	502	0
(2) Ridged, with shallow inter-tillage.	616	542	579	15
(3) Ridged with deep inter-tillage.	660	575	617	23

Jowar (Perio).

Treatment.	1922-23, Yield per acre.		1923-24, Yield per acre.		Yield per acre Average.		Increased yield over flat.	
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.
(1) Flat with usual inter-tillage.	880	1,635	777	1,632	828	1,633	...	...
(2) Ridged with shallow inter-tillage.	933	1,846	896	1,547	914	1,696	11	7
(3) Ridged with deep inter-tillage.	1,055	2,167	983	1,422	1,019	1,794	23	10

When account is taken of the fact that 1922 was a wet year and that 1923 was a very dry year, the success of ridging is considerable even when unaccompanied by manuring, but to get the full advantage of it, inter-tillage must be done deeply in the furrows between the ridges. If this is carried out an increase of yield of seed cotton and of *jowar* grain amounting to 23 per cent. may be expected, with a ten per cent. increase in the *yield* of *jowar* fodder (including chaff).

This is accompanied by a greater development of the plants both above and below ground. So far as the roots are concerned two typical cotton plants grown on the flat and on the ridged land with deep inter-tillage were completely excavated in 1922, and the roots gave the following measurements:—

	Roots on Flat Plot.	Roots on Ridged Plot.	Increase.
	Inches.	Inches.	Per cent.
(1) Total length of main root branches.	272	686	152
(2) Vertical depth of main root branches—			
(a) Greatest depth	33	41	24
(b) Average depth	32	33	...
(3) Range of main root branches from main stem—			
(a) Greatest range	47	60	28
(b) Average range	29	29	...

The increase of yield of seed cotton on the ridged plot amounting to 24 per cent. corresponds, therefore, with an increase in root development evidently caused by the growth in the early stages unimpeded by water-logging and by the deep intertillage between the furrows, which allowed the roots to spread out without difficulty in the later stages.

The growth, above ground, on the ridged plot showed also a larger development of flower buds. The total number

of flower buds on a plot of one-tenth acre was as follows (based on examination of one hundred plants):—

	Number of flower buds.	Increase over flat plot per cent.
(1) Flat, with usual inter-tillage	97,600	...
(2) Ridged, with shallow inter-tillage	108,200	11
(3) Ridged, with deep inter-tillage	113,350	16

So far the figures given are from the crops of 1922-23 and 1923-24. The records for these plots were, however, continued for 1924-25 which was an excellent season for growth and gave figures as follows:—

1ST EXPERIMENT.

Ridging without Manure.

Cotton (Brouch Deshi, Strain 1027 A. L. F.).

Treatment.	1924-25, Seed cotton yield per acre.	Increased yield over flat plot per cent.
	lb.	Per cent.
(1) Flat, with usual inter-tillage	800	...
(2) Ridged, with shallow inter-tillage.	875	9½
(3) Ridged, with deep inter-tillage	1,006	26

Jowar (Perio).

Treatment.	1924-25, Yield per acre.		Increased yield over flat plot.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	Per cent.	Per cent.
(1) Flat, with usual inter-tillage.	817	2,110	...	...
(2) Ridged, with shallow inter-tillage.	970	2,317	19	10
(3) Ridged, with deep inter-tillage.	1,097	2,210	34	5

We have thus, in what was recognised as a very good season without manure, got an exceptionally high yield of cotton on all the plots, but the ridges have still had a very similar effect from that of the previous years, and the ridges combined with deep inter-tillage have given an increase of 26 per cent. of *kapas* as compared with the flat plot. In the case of *jowar*, again without manure, but with more efficient inter-tillage than in the previous years by means of the middle Buster (see page 23) an increase of 31 per cent. of grain was found with ridging and deep inter-tillage. The fodder increased less but the present result agrees with those previously recorded.

We have, therefore, evidence from every point of view that ridging the land in the manner described brings about improved development of the plants resulting in a larger yield of the crop desired.

2ND EXPERIMENT.

Manuring of Ridged Land.

The next question is as to whether, when the land is ridged, manuring will be effective, and if so, how should manure be applied to achieve the best result. Planting the crop on ridges exactly in the manner described above, ten tons of cattle manure per acre were applied in three different fashions as follows:—

(a) 10 tons of cattle manure were applied *in the furrows* before sowing the crop.

(b) $7\frac{1}{2}$ tons of cattle manure were applied in the furrows before planting the crop, and $2\frac{1}{2}$ tons on the ridges before sowing the crop.

(c) $7\frac{1}{2}$ tons of cattle manure were applied in the furrows before planting the crop, and $2\frac{1}{2}$ tons on the ridges at the time of sowing the crop.

Let us compare the yield of the plots so treated in comparison with a plot without manure. The figures are given below:—

Cotton (Broach Deshi, Strain 1027 A. L. F.).

Treatment per acre.	Seed cotton yield per acre.		Average seed cotton yield per acre.	Increased yield in 1922-23 due to manure.
	1922-23.	1923-24.		
	lb.	lb.	lb.	Per cent.
(1) Ridged without manure.	660	575	617	...
(2) Ridged, 10 tons cattle manure in furrows.	757	668	712	15
(3) Ridged $7\frac{1}{2}$ tons cattle manure in furrows, $2\frac{1}{2}$ tons on ridges before planting.	694	572	633	5
(4) Ridged, $7\frac{1}{2}$ tons cattle manure in furrows, $2\frac{1}{2}$ tons on ridges at planting.	705	574	639	7

Jowar (Perio).

Treatment per acre.	Yield per acre.				Average yield per acre.		Increased yield in 1922-23 due to manure.	
	1922-23.		1923-24.					
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	lb.	lb.	lb.	lb.		
(1) Ridged, with- out manure.	1,055	2,167	983	1,422	1,019	1,794	...	...
(2) Ridged, 10 tons cattle ma- nure in fur- rows.	1,017	2,498	1,177	1,902	1,097	2,200	-4	+15
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	963	2,475	1,097	1,982	1,030	2,227	-9	+14
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,033	2,401	1,087	1,823	1,060	2,112	-2	+11

These results are clear and are of great interest and importance. They show that in the case of a deep rooting crop like cotton, using a slow acting manure like cattle manure, the best effect can be obtained by burying the manure in the furrows, so that as soon as the water conditions of the soil allow, the roots can be attracted to the manure, thus at the same time increasing the root range of the plants, and giving them ample food to consume. The effect was striking during the growth of the plants, for while this cotton plot appeared poor until the end of October, it ran ahead very rapidly after this date. The manure applied by the other methods is much less effective, and has disappeared in the second year. Taking, with the cotton crop, the combined effect of ridging and of the application of ten tons of cattle manure in the furrows, we have an increased yield of seed cotton as follows:—

- (1) Manure applied for cotton crop itself—42 per cent.
- (2) Manure applied for previous crop of *jowar*—42 per cent.

Of this by far the greater part is due to the ridging, and a less proportion is due to the manure. The first figure is for a wet year, the second for a dry year.

In the case of the other crop of the rotation, the *jowar*, the immediate effect of the manure, applied in any way, is *not* an increase in yield of grain but rather the reverse, but there is a considerable increase in the amount of straw. Again, the putting of the whole dose of manure in the furrows has given the highest yield of straw, though the application of a portion of the manure *before sowing*, on the top of the ridges has almost equalled it. The effect in the second year is marked both with the grain and straw, but more marked on the *straw*. This is interesting because the usual method of manuring in Lower Gujarat is to apply manure to the cotton, so that the *jowar* gets any residual benefit in the second year. Taking the combined effect of ridging and of the application of ten tons of cattle manure in the furrows, we have an increased yield of *jowar* grain and fodder as follows:—

- (1) Manure applied for the *jowar* crop itself—
Grain, 16 per cent.
Fodder, 53 per cent.
- (2) Manure applied for previous crop of cotton —
Grain, 51 per cent.
Fodder, 17 per cent.



PLATE 4.—Jowar 3' x 1' flat yield of grain 952 lb. per acre.



PLATE 5.—Jowar 6' x 2' x 1½' Ridged yield of grain 1,576 lb. per acre.

As in the case of cotton, by far the greater part of the increase in yield is due to the ridging, and a much smaller proportion to the manure.

The figures so far given are from the crops of 1922-23 and 1923-24. The records for these plots were, however, continued for 1924-25, which, as stated before, was an exceptionally good season. The results obtained were as follows :—

Effect of Manure on Ridged Plots applied in 1924-25 to the Cotton or Jowar Crop.

Cotton (Broach Deshi, Strain No. 1027 A. L. F.).

Treatment per acre.	1924-25, Seed cotton per acre.	Increased yield due to manure.
	lb.	Per cent.
(1) Ridged, without manure ...	1,006	...
(2) Ridged, 10 tons cattle manure in furrows.	1,154	15
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	1,069	6
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,090	8

Jowar (Perio).

Treatment per acre.	1924-25, Yield per acre.		Increased yield due to manure.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	Per cent.	Per cent.
(1) Ridged, without manure.	1,097	2,210	...	...
(2) Ridged, 10 tons cattle manure in furrows.	1,351	3,590	23	62½
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	1,309	3,382	11	53
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,357	3,486	24	58

These figures amply confirm what has been said before as to the effect of the manure on the ridged plots, and as to the manner of applying it and seem to make clear that in using the ridging system we have discovered how to make cattle manure effective. The yields obtained even for a good year, are very high for this part of Gujarat, and in the case of *jowar* show that in a favourable season, the effect may be very considerable even with this crop.

The combined effect in 1924-25 of ridging, and of the application of manure in furrows to the crops themselves is as follows:—

- (1) Cotton—44 per cent. increase of seed cotton.
- (2) Jowar—(a) 65 per cent. increase of grain.
(b) 70 per cent. increase of fodder.

The *nett* result of the experiments just detailed is to show how it is possible to increase the yield of the two main staple crops on the black soil of Lower Gujarat by over 40 per cent. in the case of seed cotton (*kapas*) and by a substantial amount in the case of *jowar*, more especially in the latter case in the straw and fodder.

But we are not satisfied with the yields obtained in these cases, and it would seem more than probable that when the check to the plants due to partial water-logging is removed by ridge planting, a more careful study of the manuring adopted will lead to a still larger increase in the yield. To test this point a series of plots were laid out in 1923-24 in which, while retaining or omitting the manuring with cattle manure in the furrows between the ridges a rapidly acting top dressing of castor cake was given to the young plants on the top of the ridges. The ridges and the spacing of the plants was as before. Four plots (in duplicate) were used as follows, the quantities of manure being per acre:—

- (1) Flat, with no manure.
- (2) Ridged, with ten tons cattle manure in the furrows.
- (3) Ridged, with 448 pounds castor cake per acre as top dressing.
- (4) Ridged, with ten tons cattle manure in the furrows and with 448 pounds castor cake as top dressing.

The actual results in point of yield are given in the attached table.

Cotton (Broach Deshi, Strain 1027 A. L. F.).
1923-24.

Treatment.	Yield of seed cotton per acre.			Increased yield from manure.
	A.	B.	Average.	
	lb.	lb.	lb.	Per cent.
(1) Flat, with no manure ...	519	474	496	...
(2) Ridged, with cattle manure.	632	610	621	25
(3) Ridged, with castor cake (top dressing).	530	494	512	3
(4) Ridged, with cattle manure and castor cake (top dressing).	600	657	628	27

Jowar (Perio).

Treatment.	Yield of Jowar per acre.						Increased yield from manure.	
	A.		B.		Average.		Grain.	Fodder.
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.		
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.
(1) Flat, but no manure.	792	1,267	795	1,342	793	1,304	...	...
(2) Ridged, with cattle manure.	1,062	1,505	1,070	1,710	1,066	1,607	34	23
(3) Ridged, with castor cake (top dressing).	912	1,492	875	1,545	893	1,518	13	16
(4) Ridged, with cattle manure and castor cake (top dressing).	1,205	1,982	1,227	1,975	1,216	1,978	53	52

In the case of cotton, we have progressed no further by the use of the top dressing of castor cake during the early

growth of the plant. It looks as if the plant could take care of itself well enough if protected from water-logging, until it is able to send its roots far a-field for food in its later growth. In fact the castor cake alone has had practically no effect. When used in conjunction with cattle manure, it has given no serious additional advantage.

In the case of *jowar*, the result is otherwise. As would be expected with a more shallow rooted plant, the advantage gained in the early growth as a result of the top dressing is not lost, and the combined effect of the two manures used is fully obtained when they are used in conjunction. 1923-24, when this experiment was carried out, *was a dry year*.

It may be interesting to show how the effect on yield was produced which has just been described. In the case of cotton an attempt was made to ascertain whether the increase in yield was due to a larger number of flower buds being formed, or to a larger proportion of buds forming matured bolls. For this purpose the number of buds and bolls was counted on 20 plants (taken at random) in each plot, with results as follows:—

Treatment.	Number of buds per plant.			Number of bolls per plant.			Proportion, bolls to buds. Per cent.
	A.	B.	Average	A.	B.	Average	
(1) Flat, with no manure.	199	161	180	37	29	33	18.3
(2) Ridged, with cattle manure.	231	239	235	47	45	46	19.6
(3) Ridged, with castor cake (top dressing).	233	220	226	40	38	39	17.3
(4) Ridged, with cattle manure and castor cake (top dressing).	231	232	231	40	42	41	17.7

It is clear that the advantage achieved by the treatment is due to the formation of a larger number of flower buds in each case. There is a tendency, when a stimulating top dressing is used in the early growth of the plants, for a smaller number of the buds ultimately to ripen into bolls.

In the case of *jowar* it is interesting to note the effect of the treatment on the height of the plants, and on the number of nodes contained in them. The following figures show this, based in each case on the examination of 100 plants:—

Treatment.	Height per plant.			Average number of nodes per plant.		
	A.	B.	Average.	A.	B.	Average.
	Inches	Inches	Inches			
(1) Flat with no manure.	40	41	40.5	13	13	13
(2) Ridged, with cattle manure.	44	44	44	14	14	14
(3) Ridged, with castor cake (top dressing).	41	44	42.5	14	14	14
(4) Ridged, with cattle manure and castor cake (top dressing).	47	46	46.5	15	15	15

Even in this case with a relatively shallow rooted crop the figures show that the stimulation in the early stages with castor cake was less effective than the cattle manure at a later stage of growth, so far as production of height is concerned. The combined treatment, however, led to an effect which was practically equal to that given by the two manures added together.

This result was followed up in the same plot in rotation in 1924-25. No further cattle manure was added, but the top dressing of castor cake was repeated for each of the two crops. The yield figures only are repeated in these cases, but they were as follows:—

*Cotton (Broach Deshi, Strain 1027 A. L. F.).
1924-25.*

Treatment.	Yield of seed cotton per acre.			Increased yield from manure.
	A.	B.	Average.	
	lb.	lb.	lb.	Per cent.
(1) Flat, with no manure ...	692	717	705	...
(2) Ridged, with cattle manure.	902	945	924	31
(3) Ridged, with castor cake (top dressing).	737	797	767	9
(4) Ridged, with cattle manure in 1923-24, and castor cake (top dressing).	1,065	1,127	1,096	55½

Jowar (Perio).

1924-25.

Treatment.	Yield of Jowar per acre.						Increased yield from manure.	
	A.		B.		Average.		Grain.	Fodder.
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.		
lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.	
(1) Flat, with no manure.	812	1,825	775	2,125	794	1,975	...	...
(2) Ridged, with cattle manure in 1923-24.	1,190	2,655	1,172	3,300	1,181	2,977	48	51
(3) Ridged, with castor cake (top dressing).	1,010	3,340	1,025	3,340	1,032	3,340	28	69
(4) Ridged, with cattle manure in 1923-24, castor cake (top dressing).	1,287	3,865	1,282	4,065	1,285	3,965	62	103

In the exceptionally good year, the results obtained by ridging and manuring in the manners described were greater than in the less favourable year preceding. But the direction of the results is on the whole the same, though no fresh cattle manure had been added. The quick acting top dressing of castor cake gave a bigger effect, both with *jowar* and with cotton, and in the latter case its continuation with the dose of cattle manure in the previous year, gave a much greater advantage than would have been expected. This matter obviously needs close study, and suggests a method of profitably utilising such concentrated fertilisers. But the general results are confirmed that the ridging system allows the effective use of manure in a way which was not possible before.

Summary of Results of Ridge Cultivation.

The general result of the tests on cultivation on ridges, and of the effect of manuring under such ridge cultivation in the black soil of Lower Gujarat, is that we may consider the advantage of ridge cultivation as proved, and as giving a

substantial advantage to the farmer adopting the method. The actual advantages may be summarised as follows:—

(1) Ridge cultivation affords the best device we know of, for draining the surface water from the actual plants under cultivation in June, July and August each year.

(2) Ridge cultivation prevents the land being partially water-logged in the upper eight or ten inches of the soil during the period of heavy rain (Plates 2, 3).

(3) The number of gaps in the rows of plants in the ridge system of cultivation is very much less than in the flat.

(4) The amount of weeding in the ridged plots has been considerably less than on the flat, but the experiments so far have been made on fairly clean fields.*

(5) The root development of both cotton and *jowar* is deeper on the ridged plots (Plate 6).

(6) The crop on the ridged plots get no check, and hence shows a more uniform rate of growth (Plates 1 to 5).

(7) The effect of ridging has not only been marked in a wet season, it is also felt in dry season, and hence is likely to be of advantage in any year in Lower Gujarat. This is probably due to the greater depth of root development which it allows.

(8) Under the ridge system of cultivation later inter-tillage is possible, even up to December, and deep inter-tillage has proved itself a distinct advantage to both cotton and *jowar* when done in the furrows.

(9) In the early stages of growth, the crop on ridges remains green while that on the flat becomes yellow during heavy rain. It is possible to work the soil on the ridges after heavy rains much earlier than on the flat.

The question of the best method of manuring under ridged conditions and of the best kind and quantity of manure to apply must be left unsettled for the moment. But it is clear that for cotton, the best method of applying cattle manuring is to bury it deep in the furrows. When this is done the crop makes a remarkable, rapid and luxuriant growth after the end of the normal monsoon.

* Experiments in 1924 in a less clean area showed that the amount of weeding is really less.

Method of Ridging Land.

The question now arises as to the best method to be adopted to make and maintain the ridges required in the method of ridge cultivation discussed. So far we have dealt with ridges made 14 inches high, with a distance of five feet between the ridges. These have been made by a combination of ploughing* and hand labour in the hot weather. The cost of doing this with the very heavy soils of Lower Gujarat which become almost unworkable when exposed to the sun in the dry weather, has been large, amounting to Rs. 62-8-0 per acre when made in May 1922. Although when made, we have proved that the ridges will last for three years at least, yet the cost is very high and is practically prohibitive. A method must, therefore, be devised by which suitable ridges can be made more cheaply, or good results must be shown to be obtained by smaller ridges.

The fact that considerable effect could be obtained by using lower ridges has been made clear by a test made in 1923, on cotton, using ridges three feet apart and nine inches high. These were opened by ridging ploughs at the time of inter-ploughing the previous *jowar* crop. No manure was applied in either case.

Treatment.	Yield seed cotton per acre.	Increase over flat plot.
	lb.	Per cent.
(1) Flat plot ...	435	...
(2) Ridged plot as above.	512	17

When we consider that 1923 was a dry year and hence specially favourable for *flat* cultivation the increase is very good, and compares well with the 22 per cent. increase which was obtained with the ridges of the full original size. It suggests a method of making useful ridges at a minimum cost, for this only costs Rs. 2-4-0 per acre above the ordinary amount spent on cultivation.

Modified methods have now been applied on a large scale in the Surat District, 285 acres being under ridge cultivation in 1923, 602 acres in 1924, and over 1,300 acres in 1925.

* Using the heavy "Gallows" plough of Messrs. Ransome Sims & Jeffries.

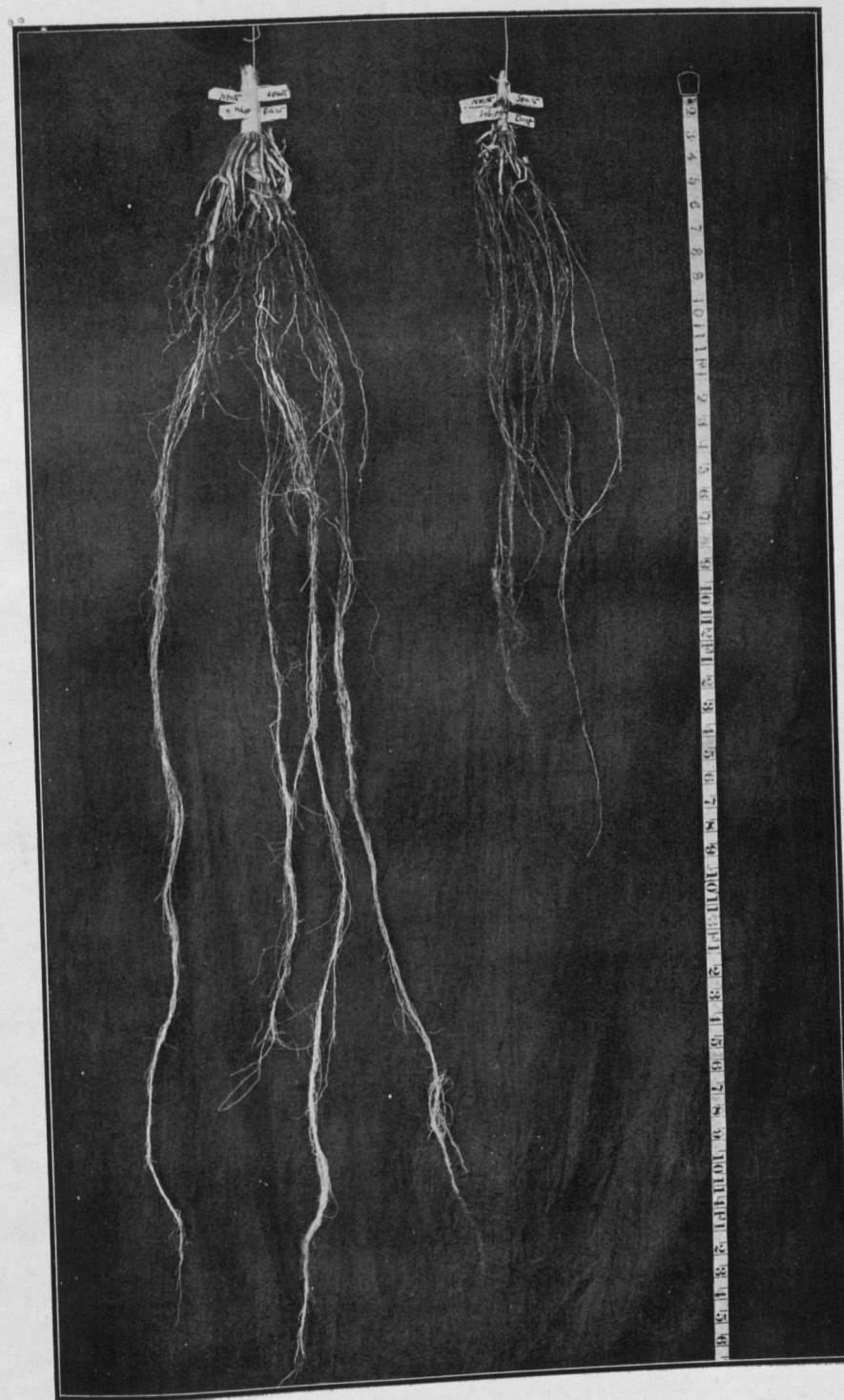


PLATE 6.—Root Systems of Jowar Plants on Ridge as well as on Flat.
Ridged on left: Flat on Right.

Three systems have been adopted :—

(1) When there is a favourable break in the rain in June-July, ridges nine inches high and three feet apart can be prepared by the Chattanooga Middle Breaker, Nos. 19 and 20, costing Rs. 55-8-0 and Rs. 58, respectively, worked by a single pair of bullocks, or by the P. and O. 10-inch Middle Buster costing Rs. 70. Middle Breakers are usually well suited for the sandy or lighter types of soils but are workable even in black or *besar* soils when the land is in proper condition in the monsoon. The Middle Buster is heavier to work than the Middle Breaker and is usually well suited for heavy black soils. It usually requires a pair of good sized cattle to make ridges ten inches high and three to four feet apart, by a special attachment of tail-sheets, while the Middle Breaker with a similar attachment, prepares ridges up to nine inches high, and three to four feet apart, and can be worked by a light type of animal.

The Middle Breakers are made with steel shares and cast iron mould boards, while the Middle Busters have both the share and mould boards of steel, so in the long run the initial expenditure done on purchasing a Middle Buster pays its way to the cultivator. As compared with the country implements such as blade harrows (which have usually a packing action, forming a hard pan deleterious to the progress of the young crop), both the types of implements described are specially provided with back rudders and cutters which prevent packing and pan formation (*vide* Plates 7A and 7B).

This is the simplest system, and the actual making of the ridges does not cost more than Rs. 1-4-0 per acre. The average outturn of work of one set of implements and one pair of bullocks comes to three acres per day.

(2) The method already described is also applicable with certainty when the land is left fallow during the rains for a *rabi* crop of wheat or *jowar*. Subsequently ridges are prepared with the above implements for the next cotton crop before the monsoon.

(3) If a crop of *jowar* be drilled on the flat in rows three feet apart and the land between the rows is ploughed in September or October by the P. and O. 10-inch Middle Buster (instead of by the country ploughs

according to the local method) ridges can be made three feet apart and nine inches high which, with slight repairs in the following cold weather, will work very well. This method can be followed by a cultivator who has only one pair of bullocks. It would cost Rs. 2-8-0 extra per acre with average work of $1\frac{1}{2}$ acres per day or more according to the condition of the soil.

This method not only prepares the land for the next crop, but is beneficial to that in which it is done. When ridges, nine inches high and three feet apart, are prepared by inter-ploughing with the Middle Buster between rows of *jowar* grown on the flat three feet apart in September-October, the standing rows of *jowar* are earthed up to give due support and prevent lodging, and to keep the crop well mulched so as to effect proper formation and development of grain. This is especially advantageous in dry seasons to the standing *jowar* crop to enable it to resist drought conditions, as was very markedly shown in 1923-24. The following are the results of final inter-tillage in the *jowar* crop by this method as compared with shallow inter-tillage, though the yield of fodder was reduced:—

Method of Inter-tillage.

	1922-23.		1923-24.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	lb.	lb.
Ridged, with shallow inter-tillage.	933	1,846	896	1,547
Ridged, with inter-tillage by the method described.	1,055	2,167	983	1,422

Even in a wet year (1922-23) while there was a considerable increase in yield of fodder, there was also an appreciable increase in yield of grain due to final deep inter-ploughing. Thus in both dry and wet seasons the method described of forming ridges by deep inter-tillage between the *jowar* rows has given considerable advantage. This is more than sufficient to pay the extra cost of this operation, while it also prepares the framework of the ridges for the next cotton crop.

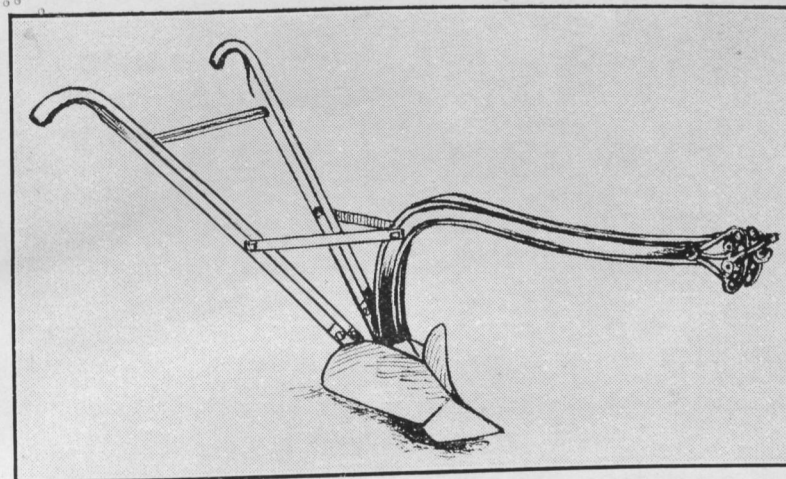


PLATE 7A.—Chattanooga Middle Breaker No. 19.

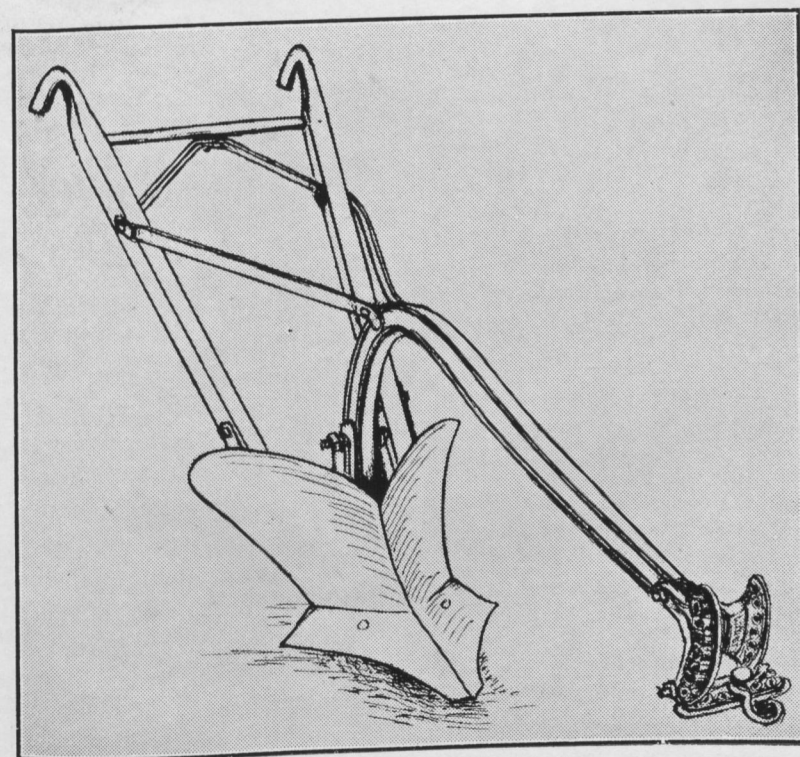


PLATE 7B.—P. & O. 10" Middle Buster.

Now the question arises, if this method be employed, how to remove the *jowar* stubbles from the tops of the ridges. This can be achieved by two methods:—

(1) by hand digging at a cost of Re. 1 per acre where manual labour is available,

(2) by the ordinary harrow of the Broach or Surat District in two operations in April and May at a cost of Rs. 1-8-0 per acre.

This disturbs the tops of the ridges somewhat seriously, but the mulch and the ridge framework are not entirely lost. The damage done can be repaired easily by the Middle Busters with tail-sheets, at a further cost of Rs. 1-8-0 per acre, working them twice in the same furrows. These ridges will be ready before the monsoon, ready for dibbling cotton three feet by three feet apart on their tops.

Then the question remains about the successive weedings and inter-culturings between the ridges with cotton crop grown in the manner described. The ordinary blade harrow is not found very efficacious for these operations. The most successful implement for this sort of inter-cultivation between the ridges has been found, from the experience of the last three years on a very large scale in the McCormick Cultivator No. 55 costing Rs. 45 (*vide* Plate 8A).

After the final rain in October the tops of the ridges are broken up by ordinary Broach harrow working cross-wise and Middle Busters are passed to reform the ridges. Then in the final furrows ordinary country ploughs are worked to keep a mulch in the furrows. This operation can also be done by passing the Middle Breakers or Busters after removing their mould boards. This will keep a sufficiently deep mulch near the plants on the top of newly formed ridges. This is very important in preventing the serious cracking of soils which will otherwise result in damaging the crop. By doing such an effective Middle Breaking or inter-ridging, the roots of the cotton plants are driven down to the lower moist substratum at an opportune time when the roots begin to go in search of moist substrata. This has the advantage of resisting drought in a dry year, while in a wet year the proper aeration, necessary for good bearing of bolls, is secured.

The cotton stalks are dug out by manual labour and just at the start of the monsoon, *jowar* can be skilfully drilled on the ridges after slight repairs of the same by Middle Busters or by small three-feet Reversible Disc Harrows. Thus the cotton-*jowar* rotation can be maintained successfully, keeping the land free from weeds and in good physical condition.

So far we have dealt with the practical methods for making ridges of the size and character which we think will usually be adopted. But to get the *maximum* benefit from the ridge system larger ridges five to six feet apart, and 14 inches high should be prepared.

The safest way to prepare such ridges is to do it immediately after the *jowar* harvest in January and February when the land can be ploughed seven to nine inches deep, by means of tractor ploughing. Then the clods should be crushed and ridges prepared by one of the big ridging ploughs such as that by Messrs. Ransome Sims & Jefferies (Plate 8B). When ridges are so made, they will be ready for the next monsoon and will remain permanent for at least four to six years with slight repairs. So made, the cost will be from Rs. 20 to Rs. 25 per acre.

Cotton is then dibbled on ridges 14 inches high and five to six feet apart, in single rows, the plants being placed two to three feet apart according to richness of soil, the richer soil having the wider distance, giving full scope for the development of the plants. The weeding and inter-culturing on such permanent ridges are best done by the Reversible Disc Harrows (*see* Plate 9) by the special in-throw arrangement straddling the ridges and the row crop, hilling up and burying the weeds by the tilting action of the discs, by adjusting the serrated connections on the pivotal casting. This implement has solved our long felt want of a suitable inter-culturing implement on ridges for the cotton crop and we have used it for the last two years. It can be worked by one pair of good sized bullocks. This has both the advantages of reducing the weeding to a minimum, and dealing with 50 per cent. more area than the ordinary blade harrows. Besides these, it has got two other advantages, (1) it prevents pan formation and (2) keeps the tops of the ridges deeply mulched which hinders cracking of the soil and tearing the roots asunder.

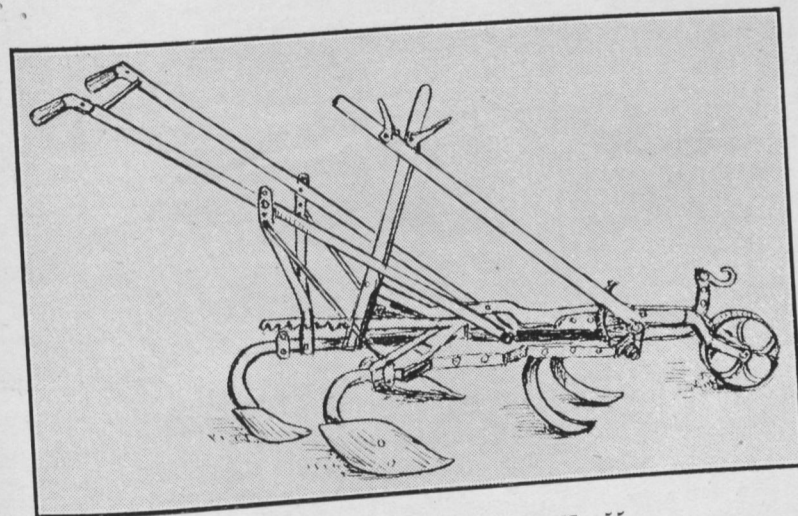


PLATE 8A.—McCormick Cultivator No. 55.

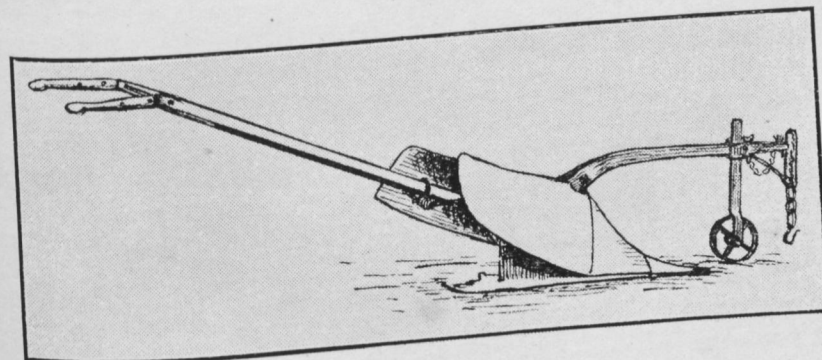


PLATE 8B.—Ridging plough.

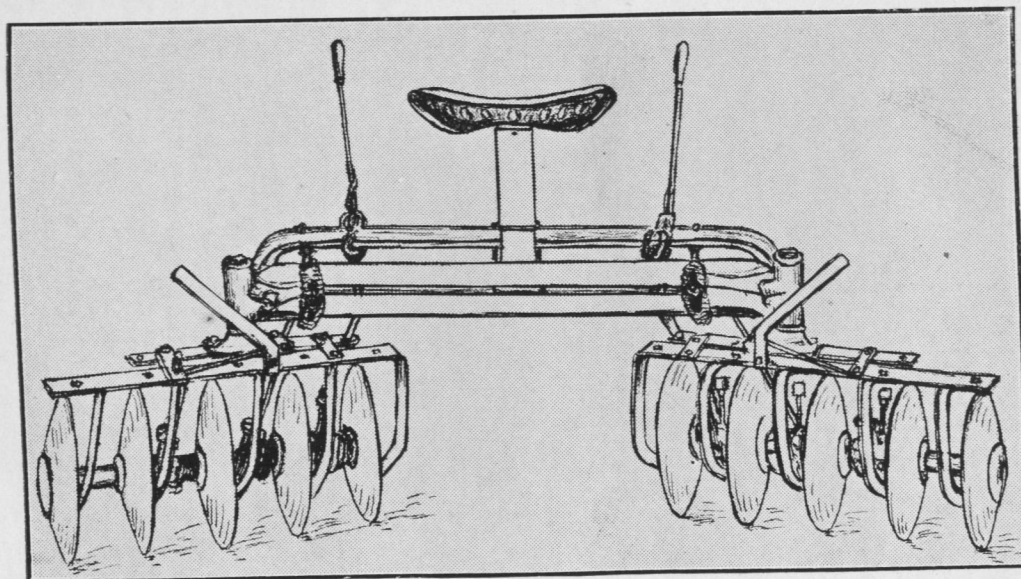


PLATE 9.—Reversible Disc Harrow.

Such a condition is most desirable for successful development of bolls in the later stages of the cotton crop on this type of black soil.

During the year 1924-25, 30 acres of ridges, six feet apart and 14 inches high on the Surat Farm, and 93 acres of ridges, five feet apart and fourteen inches high in the District, have been worked by the Reversible Disc Harrow in June after the rains by four repeated operations in the first break of monsoon at a cost of Rs. 7-8-0 per acre. But this can only be done when there is a break in the rains in June-July before sowing. The same implement has been successfully worked for inter-culturing the same cotton crop.

After the cotton crop is dug out, the ridges can be repaired by the above mentioned disc harrow in preparation for drilling the two rows of *jowar*, two and a half to three feet apart, on ridges five to six feet apart, respectively. This will keep the *jowar* lines above the furrows on both sides of the ridges. Inter-culturing in the early stage of the crop may be done by the McCormick Cultivator in the furrows as well as on the ridges. At the time of final inter-culturing in September-October, the inter-culture is done by the Middle Buster both in the furrows and on the tops of ridges by bullock power; this would earth up each *jowar* row from both the sides and thus the *jowar* plants get the chance of securing the deeper penetration of roots which is necessary for good grain formation, as dealt with previously.

Ridges thus split up by the above operation, can be made up into one by the Reversible Disc Harrow, removing the stubbles of *jowar* and burying them in the furrows, automatically. This affords a good chance of putting manure in the furrows, and so burying it deep when the ridges are thus remodelled. This is a very easy operation in even April and May, owing to the existing deep soft mulch worked up by the Middle Busters as described above. In this way every two years the position of the ridges can be maintained or changed easily if preferred by the cultivator at a nominal cost of Rs. 5 per acre.

Thus the repairing charges of ridges are merely nominal, if suitable opportunities are utilised by well-suited implements.

Conclusions.

The methods described in the present bulletin represent a very serious advance in methods of cultivation, which would seem to have a very wide application in the black soil tracts in Lower Gujarat and possibly over a much wider area. They show a method whereby, by growing crops on ridges and not on the flat, with judicious cultivation between the ridges, the yield of cotton (seed cotton) can be raised, whether in wet, dry or normal years by an average of 23 to 25 per cent., and that of *jowar* by an average of over 23 per cent. of grain and from 5 to 10 per cent. fodder. Further this method of growing crops forms a basis for the profitable use of manures and fertilisers, to dry crops, which has not hitherto been a paying proposition in these areas. This method has already come into use over 1,300 acres and is now extending as rapidly as assistance can be given to apply it.

Further the methods now worked out for applying this ridge system of cultivation in the Surat District and described in the present bulletin are cheap and can be worked with the ordinary bullock power available. True, they involve the use of some new implements not hitherto employed in the district in question. But these are available, and as they are within the means of the cultivators and can be stocked by the local association for agricultural improvements which now exist, there is reason to anticipate a large extension of the method described in the near future, and hence a considerable increase in the production and hence in the returns from the land.

APPENDIX.

It is a matter of considerable interest to know whether the additional aeration allowed in the soil by the ridge system described in the present bulletin leads to the presence of a larger amount of nitrification in the soil, and hence of a greater quantity of available nitrogen in the form of nitrates. We owe to the kindness of Mr. D. L. Sahasrabudhe, Agricultural Chemist to the Government of Bombay, the figures reported below of analysis of the soils made during the year 1923-24. Samples of soil and subsoil were collected throughout the season from August onward, both on ridges which were cropped and uncropped and on flat land adjacent. They were dried immediately and rapidly at a temperature of 50° to 60° C. The results of determinations of the nitrates and nitrites in dry soil are attached.

EFFECT OF RIDGING ON CONTENT OF NITRATES AND NITRITES IN SURFACE SOIL AND SUBSOIL UNDER COTTON AND JOWAR.

Nitrogen as Nitrates and Nitrites in Soil under Cotton.

	Surface soil.		Subsoil.	
	Ridge.	Flat.	Ridge.	Flat.
	Parts per 100,000.			
1923—				
August 25	·209	·212	·147	·151
October 15	·269	·220	·210	·116
October 25	·315	·252	·212	·156
November 26	·288	·270	·162	·119
December 21	·273	·181	·119	·120
1924—				
January 24	·142	·199	·134	·176
February 27	·218	·215	·143	·129
April 1	·247	·173	·163	·153
April 29	·193	·149	·155	·160
May 28	·208	·154	·125	·123
July 1	·162	·143	·130	·134
August 6	·159	·153	·146	·152

Both in the surface soil and subsoil the nitrates and nitrites are distinctly higher on the ridges than on the adjoining flat land. At the end of October the difference becomes very great.

Nitrogen as Nitrates and Nitrites in Soil under Jowar.

	Surface Soil.		Subsoil.	
	Ridge.	Flat.	Ridge.	Flat.
1923—		Parts per	100,000	
August 25	·160	·265	·153	·150
October 15	·302	·206	·212	·154
October 25	·199	·179	·160	·096
November 26	·166	·157	·156	·120
December 21	·241	·211	·151	·165
1924—				
January 24	·152	·150	·135	·119
February 27	·182	·217	·177	·160
April 1	·201	·380	·127	·221
April 29	·183	·155	·136	·193
May 28	·150	·086	·129	·063
July 1	·226	·158	...	·135
August 6	·153	·131	·219	·135

The results in general tell the same story as with cotton, though there are certain samples, such as those on February 27, April 1, which need explanation.

THE CHEMICAL COMPOSITION OF THE FOOD GRAINS, VEGETABLES AND FRUITS OF WESTERN INDIA.

I.—INTRODUCTION.

There has recently been a constantly increasing demand for information as to the composition of the vegetables, food grains and fruits of Western India. It is in response to these enquiries that the analytical figures determined in the Chemical Laboratory of the Agricultural Department have been compiled and are here offered to the public in the form of an agricultural bulletin. During the last 18 years a very large number of samples have been analysed, but most of these samples consist of soils, waters and various kinds of manures. Even out of the rest a large proportion consists of samples of feeding stuffs only used for cattle. It is hence that a relatively small number of analyses of human foods are available. Samples have never so far been collected particularly for this purpose, but those which have been sent either by Government officials, or by private persons have been analysed and the results recorded. Most of these were analysed in connection with some special investigation. The fruits, for instance, were analysed to find out the comparative quantities of sugars or acids in different varieties or to find out the changes produced during the process of ripening. Amongst food grains the wheat samples were analysed for their proteid contents when the proportions of these constituents in the various Bombay wheats were being studied. The oil percentage in a large number of oil seeds and their varieties was determined in connection with trials that were made to find out how the different varieties of the oil seeds, indigenous and exotic, behave when they are grown at such different places as Surat, Dhulia or Dharwar.

A very large number of analytical figures of foreign food stuffs have been published in England, America, Germany, &c. For the sake of comparison a few typical foreign analyses have been given in this bulletin. As long ago as the year 1886, A. H. Church, the then Professor of Chemistry in the Royal Agricultural College, Cirencester, published a book on "Food Grains of India" in which he has given analyses of the

B 2147

various Indian food grains. A few of these analyses as well as a few of those done by others in recent years have been referred to in this bulletin where necessary.

The various materials whose analyses are given in this bulletin are classified into (1) Food grains, (2) Vegetables and (3) Fruits and then each of these groups is further divided into sub-groups. The analytical figures given are the percentages of (1) moisture, (2) ether extract, (3) soluble carbohydrates, (4) woody fibre, (5) albuminoids and (6) ash. Nitrogen present in the albuminoids and sand in the ash is also given. In some cases the amount of sugars and acids is specially indicated. As these terms are not likely to be understood by all readers a short explanation of them, and also the meaning of the various analytical figures, is given below. This publication, therefore, may be useful to scientific men and also to the general public who, in increasing measure are anxious to know the composition of Indian food stuffs.

From the analysis of the bodies of all animals, including men, it has been ascertained that the organs consist chiefly of four elements, carbon, hydrogen, oxygen and nitrogen. The bones and teeth contain in addition calcium and phosphorus in large quantities, while the blood also contains iron, sodium and chlorine. The object of the food eaten is to supply all these elements to the body in a suitable form.

There are four chief groups of chemical compounds which can supply the requirements of the animal body and therefore constitute the bulk of our food. Three of these groups are the carbohydrates, fats and proteids from which the supply of carbon, hydrogen and nitrogen is chiefly derived, while the fourth group, consisting of mineral matter, provides the calcium, phosphorus, sodium, chlorine, iron and a few other elements that are required. It is the proportion of each of these classes of material in the various food stuffs which an analyst attempts to ascertain. Further every food stuff contains at least a small quantity of water, and this must also be determined.

The actual headings given in the analyses are as follows:—

Moisture.—Moisture percentage in most of the samples is given first. It means the water present in the sample. Vegetables in their natural condition contain up to 95 per cent. of water but food grains normally contain water from 8 to 12 per cent. The moisture determination is useful when we want to

compare the composition of different materials containing varying quantities of water.

Ether Extract.—This term includes the fat or oil contained in the material examined. It may contain other constituents, such as the green colouring matter in the case of leafy vegetables. But in most cases, the ether extract may be taken as expressing the amount of oil or fat present in the food stuff. This group of constituents is determined by extracting the food stuff, previously dried, with ether.

Fat and oil are of very great importance in foods as they are among the most concentrated constituents for the production of energy.

Soluble Carbohydrates.—The term "Soluble carbohydrates" is applied to a class of compounds which are similar in their composition but differ widely in their properties. The soluble or digestible carbohydrates include starch and sugar. These are also in some cases indicated by the term "nitrogen-free extract". The carbohydrates supply energy for internal or external work of the body.

Sugars.—In food grains the quantity of sugar, if present, is insignificant, but in the fruits the quantity of sugar is important and hence in the analysis of fruits the percentage of sugar is given. Sugars are in our analyses divided into two classes, namely, "non-reducing sugars" and "reducing sugars". Cane sugar is a typical instance of the former group while the sugar called glucose which is uncrystallisable represents the latter group.

Woody Fibre.—This represents the carbohydrates insoluble in water, dilute acid or dilute alkali, and naturally, therefore, may as a rule be taken as the non-digestible portion of the foods.

Acids.—Many fruits contain such acids as malic, citric and tartaric acids. These give a characteristic taste to fruits and fruit juices and the percentages of acidity is mentioned where it is important.

Albuminoids.—These are complex nitrogenous organic compounds, and are perhaps better termed "proteids". They are the chief source from which the human body is able to renew its tissue, and various

forms of proteids are of different value for this purpose. In this bulletin all forms of proteid are, however, shown together either under the term "albuminoids" or "proteids". These are estimated by determining nitrogen and multiplying that result by 6.25. The amount of nitrogen from which the albuminoids or proteids are estimated is generally given at the bottom of each table. Proteids are essential food constituents and they cannot be substituted by other substances.

Ash.—Ash is the mineral matter which is left behind when the food stuff is carefully and completely burnt. It contains the various inorganic constituents including the sand. The percentage of sand is generally mentioned at the bottom of the table. Mineral substances are essential food constituents for the body.

Besides the constituents mentioned above there are certain accessory food factors which accompany the various foods. Their presence has been discovered only recently. No work is, therefore, done in that connection in India. These accessory food factors are essential for the proper function of the body and the body organs. They are present in particular parts of the grains but they are especially present in good quantities in fresh vegetables and fresh fruits.

II.—FOOD GRAINS.

Food grains may conveniently be divided into three groups, namely, (A) Cereal grains, (B) Pulse grains and (C) Oil seeds.

A.—CEREAL GRAINS.

The cereal grains are rich in carbohydrates, particularly in starch while they contain less of albuminoids than the pulse grains. Wheat is an occasional exception to this and may contain albuminoids even up to 18 per cent. The albuminoids of wheat are peculiar in their character inasmuch as they are easy to separate and are tenacious. The more important cereal grains include rice, wheat, *bajri*, *jowar*, &c., while the minor cereals which are designed as "millets" include *nagli*, *vari*, *kodra*, &c.

Rice (Bot.—*Oryza sativa*).

The following are the analyses of some of the typical varieties of the Bombay Presidency, and also of some other parts of India:—

	Polished and cleaned Ambemohor. (Poona 1).	Polished and cleaned Ambemohor (Poona 2).	Polished and cleaned Kamod (Nasik).
	Per cent.	Per cent.	Per cent.
Moisture	7.70	11.50	7.48
Ether extract	1.05	0.75	1.20
* Albuminoids	6.75	6.50	6.51
Soluble carbohydrates	83.72	80.65	84.06
Woody fibre	0.05	Nil.	0.05
† Ash	0.73	0.60	0.70
	100.00	100.00	100.00
Containing—			
* Nitrogen	1.08	1.04	1.098
† Sand	Nil.	Nil.	Nil.

Analysis of some of the Konkan rices gave the following figures:—

	Polished and cleaned Dil- mohor or Jire- sal (Konkan).	Polished and cleaned Ambemohor (Konkan).	Polished and cleaned Ramsal (Konkan).	Polished and cleaned Kolumba (Karjat).
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	11.50	11.48	10.90	8.30
Ether extract	0.68	0.70	0.65	1.00
* Albuminoids	6.06	6.19	6.13	6.25
Soluble carbohydrates...	81.36	81.16	81.97	83.79
Woody fibre	Nil.	Nil.	Nil.	0.20
† Ash	0.40	0.47	0.35	0.46
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen	0.97	0.99	0.98	1.00
† Sand	Nil.	Nil.	Nil.	Nil.

The following samples are from outside Bombay, the first three of which were analysed in the Poona Laboratory :—

	Polished and cleaned Bezwada, small.	Polished and cleaned Rangoon Mandla.	Polished Rangoon Nani Mill.	* Decorticated grain, fine Winter, Bengal.	† Rice cleaned, Assam.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	10.35	8.22	5.98	12.46	12.66
Ether extract ...	0.80	1.35	1.00	0.94	1.77
* Albuminoids ...	6.69	7.15	7.06	6.38	6.43
Soluble carbohydrates ...	81.51	82.48	85.06	79.25	78.63
Woody fibre ...	Nil.	Nil.	0.10	0.18	0.25
† Ash ...	0.65	0.80	0.80	0.79	0.86
Containing—	100.00	100.00	100.00	100.00	100.00
* Nitrogen ...	1.07	1.14	1.13	1.02	1.03
† Sand ...	Nil.	0.10	Nil.	0.10	Nil.

Samples of cleaned and polished rice that were analysed from time to time show the following variations :—

Moisture ...	5.98 to 11.50	per cent.
Ether extract ...	0.65 to 1.77	do.
* Albuminoids ...	5.18 to 7.15	do.
Soluble carbohydrates ...	80.65 to 85.06	do.
Woody fibre ...	Nil to 0.20	do.
† Ash ...	0.35 to 0.80	do.

Containing—		
* Nitrogen ...	0.97 to 1.14	do.
† Sand ...	00.00 to 0.10	do.

Wheat (Bot.—Triticum sativum).

Many samples of wheat have been analysed. Some have been analysed for their nitrogen contents only, others for the composition of different varieties. The following is the

* Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 9 of 1908.

† Sen, J. N.—Composition of Some Indian Feeding Stuffs, Pusa Bulletin No. 70 of 1917.

variation in the results obtained in wheat from the Bombay Presidency :—

Moisture ...	8.85 to 12.50	per cent.
Ether extract ...	1.40 to 2.70	do.
* Albuminoids ...	14.00 to 18.87	do.
Soluble carbohydrates ...	63.03 to 72.10	do.
Woody fibre ...	1.10 to 2.40	do.
† Ash ...	1.30 to 2.15	do.

Containing—		
* Nitrogen ...	2.00 to 3.04	do.
† Sand ...	Nil to 0.1	do.

Following is a table of analysis of eight different varieties of wheat that are commonly grown in the Deccan :—

	Shet Parner Bukshi.		Shet Parner (Glabrous).	Local, West Khandesh.
	(1)	(2)		
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	12.50	11.90	11.35	11.70
Ether extract ...	1.80	1.80	2.10	2.00
* Albuminoids ...	17.62	16.12	15.00	16.68
Soluble carbohydrates ...	65.13	67.48	67.70	66.47
Woody fibre ...	1.30	1.20	2.00	1.40
† Ash ...	1.65	1.50	1.85	1.75
Containing—	100.00	100.00	100.00	100.00
* Nitrogen ...	2.82	2.58	2.40	2.67
† Sand ...	Nil.	0.15	0.05	0.05

	Banshi.	Mundiai.	Australian Hybrid.	Banshi R. R.	Khapli.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	11.05	11.45	12.10	12.20	12.40
Ether extract ...	2.30	2.50	1.80	2.00	2.70
* Albuminoids ...	16.50	15.62	15.25	16.18	18.87
Soluble carbohydrates ...	66.45	65.88	67.35	66.57	63.03
Woody fibre ...	2.00	2.40	1.80	1.30	1.10
† Ash ...	1.70	2.15	1.70	1.75	1.90
Containing—	100.00	100.00	100.00	100.00	100.00
* Nitrogen ...	2.64	2.50	2.44	2.59	3.02
† Sand ...	Nil.	Nil.	0.10	0.05	0.10

Some forty-six samples of wheat from the Bombay Presidency were analysed for the nitrogen contents only. The samples showed the following variations:—

Wheats from the Bombay Presidency. Nitrogen 2.00 to 2.71 per cent.

Analyses of some of the important wheats grown in other parts of India also are given in the following table:—

	* Cawnpore Bearded.	* Cawnpore Beardless.	† Kathya, Cawnpore white, soft.	† Rust-proof Cawnpore white, hard.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	13.35	13.19	11.00	9.94
Ether extract	1.73	1.60	1.53	1.50
† Albuminoids	8.47	9.75	9.25	9.25
Soluble carbohydrates	73.08	72.03	73.65	75.96
Woody fibre	1.57	1.93	1.33	1.50
§ Ash	1.80	1.50	3.24	1.85
	100.00	100.00	100.00	100.00
Containing—				
† Nitrogen	1.36	1.56	1.48	1.43
§ Sand	0.05	0.10	0.25	0.05

It is interesting for the sake of comparison, to have the analyses of various samples of wheats and their averages grown in various parts of the world. ||

	Water.	Proteids.	Soluble carbohydrates.	Fat.	Cellulose.	Salts.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
England	...	10.99	69.21	1.86	2.90	1.67
India	...	10.99	70.90	2.08	1.92	1.45
All Europe except Russia (208 samples)	13.7	12.30	67.90	1.80	2.50	1.80
All countries (948 samples average).	13.3	12.03	68.67	1.85	2.31	1.77
American wheat (average of 407 samples).	10.2	12.20	71.70	2.20	1.80	1.90

* Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 10 of 1901.

† Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 9 of 1903.

|| Tibbles William.—Foods, Their Origin, Composition and Manufacture, 1912.

Jowar (Bot.—Andropogon sorghum).

Analyses of seven varieties of *jowar* are given in detail in the following table:—

	Shalu.	Gidgap.	Gudagi.	American Sorghum.	Lalbondi.	Utavli.	Nilwa.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6.20	6.20	5.80	5.80	6.20	4.9	6.10
Ether extract	0.65	3.45	2.90	3.45	3.25	2.85	3.15
* Albuminoids	11.81	10.13	10.25	9.50	10.06	12.69	10.56
Soluble carbohydrates.	77.59	76.62	77.00	73.80	77.44	76.26	76.69
Woody fibre	2.15	1.0	1.75	4.35	1.35	1.30	1.70
† Ash	1.60	2.60	2.30	3.10	1.70	2.00	1.80
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Containing—							
* Nitrogen	1.89	1.62	1.64	1.32	1.61	2.03	1.69
† Sand	0.20	0.94	0.56	1.34	0.10	0.30	0.08

Jowars from other parts of India show the following composition:—

	† Jowar, Nagpur.	§ Punjab brown.	§ Punjab white.	Cawnpore white.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	9.96	11.33	12.04	11.37
Ether extract	7.66	3.16	3.13	2.58
* Albuminoids	7.64	8.94	8.19	8.19
Soluble carbohydrates	70.15	71.88	73.44	73.46
Woody fibre	2.24	2.09	1.37	1.66
† Ash	2.30	2.60	1.83	1.74
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen	1.23	1.43	1.31	1.31
† Sand	0.63	0.70	0.19	0.10

† Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 10 of 1901.

§ Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 9 of 1903.

Maize (Bot.—*Zea Mays*).

The following is the analysis of maize, both from Bombay and other parts of India:—

	Maize, Poona (Deccan).	* Maize, Punjab white.	* Maize, "King Philip" (imported), Cawnpore.
	Per cent.	Per cent.	Per cent.
Moisture	5.62	11.83	10.72
Ether extract	3.65	4.53	4.22
† Albuminoids	8.90	8.25	11.62
Soluble carbohydrates	75.58	72.03	70.29
Woody fibre	3.75	1.16	1.46
‡ Ash	2.50	2.10	1.69
Containing—	100.00	100.00	100.00
† Nitrogen	1.44	1.32	1.86
‡ Sand	0.40	0.25	0.10

Bajri or Bajra (English—Bulrush millet) (Bot.—*Pennisetum typhoideum*).

Four typical samples from the Bombay Presidency and one from the Punjab show the composition as given in the following table:—

	Ahmed- nagar District.	Poona District.	Ahmedabad District.		* Punjab.
			Gujarat (Prantij Taluka).	Gujarat (Daskroi Taluka).	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6.74	7.46	6.60	6.26	10.08
Ether extract	5.60	5.25	5.00	5.50	4.93
† Albuminoids	12.87	9.81	10.93	11.68	11.12
Soluble carbohydrates.	73.53	74.62	75.07	74.08	71.07
Woody fibre	0.50	0.60	Traces.	0.60	0.76
‡ Ash	1.76	2.26	2.40	1.90	2.04
Containing—	100.00	100.00	100.00	100.00	100.00
† Nitrogen	2.06	1.57	1.75	1.87	1.78
‡ Sand	0.23	Nil.	0.53	0.33	0.40

* Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 9 of 1903.

Inferior Millets.

Samples of millets were not sent for analysis to the Poona Laboratory but as they form an important group of cereals, they have been included here from results already published.

	* Nagli, Ragi or Bavto (Eleusine coracana).		† Vari or Common Millet (<i>Panicum miliaceum</i>) Poona.	* Kodra or Harik, cleaned (<i>Paspalum serobiculatum</i>)		‡ Bajra (<i>Ananurus panicula- tus</i>).
	Poona.	Mysore.	Poona.	Poona.	Ratnagiri.	Poona.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	14.36	13.22	7.95	8.01	9.07	8.90
Ether extract.	1.34	1.20	4.11	3.36	3.34	5.25
† Albuminoids	6.44	5.39	6.81	5.81	5.46	15.43
Soluble carbohydrates.	73.34	75.13	67.26	70.06	70.77	65.82
Woody fibre	1.83	2.10	7.63	8.43	9.37	1.95
§ Ash	2.69	2.98	6.24	4.29	1.39	2.65
Containing—	100.00	100.00	100.00	100.00	100.00	100.00
† Nitrogen.	1.03	0.86	1.09	0.93	0.87	2.47
§ Sand	...	...	4.08	2.95	1.09	0.25

B.—PULSE GRAINS.

Pulse grains are seeds of leguminous plants. They are rich in nitrogen and hence in their albuminoid contents. The pulse grains form a very important part of the food on account of the high percentage of the albuminoids which are muscle forming materials as these form the chief nitrogenous food of large part of the population. The analyses given are either of the grains or of the split pulse. The exact condition of the material is mentioned in the tables:—

[See next page for Tables.]

* Sen, J. N.—Composition of Some Indian Feeding Stuffs, Pusa Bulletin No. 70 of 1917.

† Leather, J. W.—Indian Food Grains and Fodders, Agricultural Ledger No. 9 of 1903.

Tur (Eng.—Pigeon pea) (*Bot.*—*Cajanus indicus*).

(1) *Spilt grains, with husk removed.*

	Deccan.	Gujarat.	Cawnpore.
	Per cent.	Per cent.	Per cent.
Moisture	6.00	2.52	6.64
Ether extract	1.60	1.35	1.60
* Albuminoids	21.12	22.89	19.93
Soluble carbohydrates	65.80	69.31	67.47
Woody fibre	1.10	1.00	1.40
† Ash	3.30	2.93	2.96
	100.00	100.00	100.00
Containing—			
* Nitrogen	3.38	3.66	2.87
† Sand	0.43	Nil.	Trace.

(2) *Unspilt grains with husk.*

	Deccan.	Gujarat.
	Per cent.	Per cent.
Moisture	6.96	6.32
Ether extract	2.50	1.50
* Albuminoids	19.57	20.75
Soluble carbohydrates	60.77	60.77
Woody fibre	6.70	6.40
† Ash	3.50	4.26
	100.00	100.00
Containing—		
* Nitrogen	3.13	3.32
† Sand	Nil.	Nil.

	Udid (Black gram) (Bot.— <i>Phaseolus radiatus</i>).	Guar (Cluster bean) (Bot.— <i>Cyamopsis psoraloides</i>).	Matki (Kidney bean) (Bot.— <i>Phaseolus acontifolius</i>).
	Per cent.	Per cent.	Per cent.
Moisture	6.05 to 11.95	7.60 to 15.25	4.60 to 8.15
Ether extract	1.25 to 2.60	2.65 to 3.60	0.65 to 1.75
* Albuminoids	19.81 to 27.50	27.43 to 30.37	22.56 to 25.50
Soluble carbo- hydrates.	50.05 to 60.69	42.60 to 47.67	58.49 to 63.20
Woody fibre	4.25 to 5.90	7.00 to 8.20	4.30 to 5.45
† Ash	3.45 to 5.35	3.50 to 4.65	3.70 to 6.30
Containing—			
* Nitrogen	3.17 to 4.40	4.39 to 4.86	3.32 to 4.08
† Sand	0.15 to 1.00	0.05 to 0.45	0.15 to 2.35

	Kulthi (Horse gram) (Bot.— <i>Dolichos biflorus</i>).	Gram (Bot.— <i>Cicer arietinum</i>).	Masur (Lentil) (Bot.— <i>Ervum lens</i>).	Soy beans (Bot.— <i>Glycine soja</i>).
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	4.30 to 10.25	7.38 to 9.80	8.15	5.25
Ether extract	0.65 to 1.84	4.11 to 6.10	1.75	16.85
* Albuminoids	20.75 to 22.25	19.44 to 20.69	25.50	37.00
Soluble carbohydrates	56.04 to 63.20	52.26 to 59.41	63.20	31.00
Woody fibre	4.85 to 5.50	2.25 to 9.59	5.45	5.05
† Ash	4.20 to 7.45	2.70 to 3.25	6.30	4.80
Containing—				
* Nitrogen	3.32 to 3.56	3.11 to 3.31	4.08	5.92
† Sand	0.72 to 1.70	0.05 to 0.25	2.35	0.25

The following are the analyses of some important pulse grains from other parts of India taken from Indian Food Grains and Fodders by J. W. Leather, No. 9 of 1903:—

	Tur (Pigeon pea) (<i>Cajanus indicus</i>).		Common gram (<i>Cicer arietinum</i>) (white, large. Kabuli, Cawnpore.	Wa te Val (Bot.— <i>Dolichos ablab</i>) (Poona 1).	† White Val (Bot.— <i>Dolichos lablab</i>) (Poona 2).
	Cawnpore seed, white (1)	Cawnpore seed, red (2)			
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	10.87	10.94	10.36	9.55	9.08
Ether extract	1.46	1.03	4.22	2.03	1.11
* Albuminoids	14.25	16.62	22.81	23.44	20.75
Soluble carbo- hydrates.	63.68	62.92	57.48	53.26	58.38
Woody fibre	6.22	4.76	1.93	7.42	6.78
† Ash	3.50	3.73	3.20	4.30	3.90
	100.00	100.00	100.00	100.00	100.00
Containing—					
* Nitrogen	2.28	2.66	3.65	3.75	3.32
† Sand	0.05	0.05	0.05	0.10	0.05

† This is a particular variety of *val* known as *kadwa* in the Deccan. It is largely cultivated after rice in the Rabi season in the Konkan and in the other parts where rice is grown.

C.—OIL SEEDS.

Every seed contains at least a small quantity of oil, but seeds containing more than 15 per cent. of oil are generally called oil seeds. In the analyses of these seeds only the oil is given because that is the chief constituent for which they are in many cases grown.

The oil seeds have been enlisted here as they also form an important class of food material. As many as 200 and more samples or oil seeds of different kinds and varieties from various places have been received and analysed and the results of most of these have been embodied in the following tables:—

(1) Groundnut (*Arachis hypogaea*).

The oil determinations were made on the kernel after removal of the shell.

Name.	No. of samples	Moisture on kernel.	Oil (on kernel).	Kernel.	Shell.
		Per cent.	Per cent.	Per cent.	Per cent.
(a) Egyptian	7	1.99 to 3.85	47.90 to 54.31	68.68 to 84.24	20.47 to 30.64
(b) Mozambique	10	2.00 to 6.95	41.63 to 53.12	60.00 to 78.72	21.28 to 40.00
(c) Brazil	3	2.15 to 3.63	49.91 to 52.41	73.14 to 80.68	19.32 to 21.06
(d) Spanish peanut	16	1.76 to 5.92	44.38 to 54.34	74.02 to 84.43	15.57 to 29.03
(e) Senegal	13	1.78 to 6.73	41.99 to 52.40	69.50 to 78.52	21.48 to 30.50
(f) Virginia	9	1.92 to 6.18	43.45 to 51.17	70.00 to 82.97	21.99 to 27.74
(g) Pondicherry	8	2.26 to 6.28	46.66 to 53.15	70.50 to 81.89	23.08 to 30.00
(h) Big Japan	10	1.76 to 7.08	43.42 to 50.72	67.81 to 78.57	21.44 to 32.09
(i) Small Japan	7	2.19 to 4.52	46.11 to 53.67	76.51 to 78.38	21.62 to 25.49
(j) Local varieties	18	1.83 to 4.39	43.06 to 48.24	65.26 to 80.20	21.70 to 35.62

(2) Cotton Seed (*Gossypium*).

Determinations were done on the whole seeds.

Name.	No. of samples.	Moisture.	Oil.
		Per cent.	Per cent.
<i>Gossypium herbaceum</i> —			
(a) Surat	10	5.10 to 9.90	16.70 to 18.80
(b) Surti Broach	1	...	21.65
(c) Goghari E. 5	1	...	16.25
<i>Gossypium neglectum</i> —			
(a) Jalgaon (East Khandesh)	1	8.00	19.15
(b) Dhulia (West Khandesh)	1	8.50	17.35
<i>Gossypium hirsutum</i> —			
(a) Gadag	1	...	19.92
<i>Gossypium herbaceum</i> —			
(a) Dharwar	1	...	18.15

(3) Coconut (*Cocos nucifera*).

The oil determinations were made on the dried flesh of the nut.

Name.	No. of samples.	Moisture.	Oil.
		Per cent.	Per cent.
...	22	2.60 to 6.95	60.0 to 71.0

(4) Til or Sesamum Seed (*Sesamum indicum*).

Name.	No. of samples.	Moisture.	Oil.
		Per cent.	Per cent.
(a) Black Til	25	2.0 to 5.2	44.6 to 56.9
(b) Red Til	7	...	45.7 to 55.5
(c) White Til	37	2.0 to 4.4	44.9 to 58.2

(5) Safflower Seed (*Carthamus tinctorius*).

The oil determinations were made on the whole seed, including the husk.

Seven samples gave oil 28.5 to 34.7 per cent. In one case oil was determined from the same seed with and without husk. The seed with husk gave 29.7 per cent. of oil but when the husk was removed the inner kernel gave 60.5 per cent. oil.

(6) Linseed (*Linum usitatissimum*).

Nine samples gave oil 39.9 to 43.3; the white varieties seem to contain slightly more oil than the brown or the red ones from the same place:

Nagpur white	...	43.0 per cent. oil.
Nagpur brown	...	41.0 do.
Dohad farm white	...	42.8 do.
Dohad farm red	...	40.8 do.

(7) Niger Seed (*Guizotia abyssinica*).

Ten samples gave —

Moisture	...	2.20 to 3.88 per cent. oil.
Oil	...	40.87 to 45.58 do.

(8) Sunflower (*Helianthus annuus*).

Only one sample was analysed and it gave 4.00 per cent. moisture and 46.0 per cent. oil on kernels.

(9) Castor Seed (*Ricinus communis*).

The results of analyses of castor seed (*Ricinus communis*) though non-edible have especially been given, as the seed is

rich in oil content and can compare fairly well with other oil seeds. Not only that but the castor oil is of great economic importance.

Sixty-two samples including some of its varieties have been analysed and the results are given in the following table:—

Seed.	No. of samples	Moisture.	Oil.
		Per cent.	Per cent.
Castor (general) ...	19	2.97 to 6.97	38.57 to 57.40
„ (big variety) ...	17	2.97 to 6.25	46.63 to 55.43
„ (small variety) ...	20	3.17 to 6.06	43.39 to 57.40
„ (without awns) ...	6	4.24 to 5.20	48.28 to 51.86

III.—VEGETABLES.

Vegetables contain a large percentage of water sometimes going up to 95 per cent. The dry matter contains 40 to 85 per cent. of soluble carbohydrates. Compared with the grains a given weight of vegetables contains but a small quantity of materials to supply the energy for the human body. Some of them, especially the leafy vegetables, are, however, rich in mineral matter, which is equally essential to the body, and vegetables therefore are very valuable as foods. Phosphoric acid has been determined in some vegetables, as this information was required in order to ascertain whether Indian vegetables were quite as good as English vegetables in supplying phosphoric acid. The figures for phosphoric acid are given at the end of the present section.

Fresh vegetables are now-a-days considered as very valuable apart from the actual weight of food material provided. They are so essential that, if possible, they should form a necessary part of our daily food. The importance of fresh vegetables seems to be due to the fact that they possess accessory food factors better known perhaps as vitamins.

The samples of vegetables analysed so far have been grouped together under three heads, viz.:—

(a) Vegetables that are eaten as whole plants, i.e., leaves together with tender portions of shoots.

(b) Vegetables only the fruits (pods, &c.,) of which are taken up for use.

(c) Vegetables which could not conveniently be grouped in either of the above classes.

These groups are further classified according to the Natural Orders of plants as far as practicable.

A.—WHOLE PLANTS AS VEGETABLES.

Some of the vegetables mentioned below are well known in the Deccan and the analytical figures of these are given under their Marathi names. As these may not be easily understood by all, a brief mention of the growth and economic use of some of them under each sub-division will be found useful. The analysis given after quoting the amount of water contained in the fresh vegetable, gives the remaining figures on the completely dried material.

Red Math (Amarantus blitum).—This is a plant with small obtuse leaves. The stems and branches of the plant are red colored. This is grown as a vegetable in garden lands. The vegetable is ready in about six weeks. It is only the leaves and tender shoots that are used for vegetable purposes.

Rajgira (Amarantus paniculatus).—Grown at any time of the year in gardens. The leaves and tender shoots are used as vegetables. The crop is ready for cutting in six weeks. The plant is also cultivated for its seed.

Palak (Spinacea oleracea).—Grown in garden lands at any time of the year. The leaves and tender stems are used as vegetables. The vegetable is ready for cutting in about six weeks.

Chandanbatwa (Chenopodium ambrosioides).—Leaves and tender stems are used as vegetables. The crop is ready to cut in about six weeks.

	Red Math (Amarantus blitum).	Rajgira (Amarantus paniculatus).	Palak (Spinacea oleracea).	Chandan- batwa (Che- nopodium ambrosi- oides).
	(N. O.—Amaranthaceae.)		(N. O.—Chenopodeaceae.)	
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	84.00	80.00	84.00	86.59
On dry matter.				
Ether Extract ...	4.12	2.70	6.25	5.14
* Albuminoids ...	18.75	17.81	0.75	18.18
Soluble carbohydrates ...	50.63	50.69	63.88	59.23
Woody fibre ...	7.25	10.40	9.12	7.31
† Ash ...	19.25	18.40	20.00	10.14
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen ...	3.00	2.85	0.12	2.91
† Sand ...	0.81	0.80	0.75	2.61

Kardi (*Carthamus tinctorius*).—Cultivated at any time of the year. The tender leaves and stems are used as vegetable from the fourth to the sixth week after sowing. In the Bombay Deccan the variety grown for vegetable is the same as the one grown for oil-yielding seed, having spines. When the plant is young it has no spines and it is during the young state, therefore, that it is utilised for vegetable.

Methi (*Trigonella Foenum Graecum*).—Grown in garden lands. It does not thrive in the hot weather. The leaves and tender roots are used as vegetable. The crop is ready to cut in four to five weeks. If kept longer the seed obtained is used as a pulse.

Chuka, Bladder Dock (*Rumex vesicarius*).—This is cultivated in gardens at any time of the year. The leaves and tender stems are used as vegetable. They are sour in taste. The crop is ready to cut a month after sowing.

Kothimbir, Coriander (*Coriandrum sativum*).—Cultivated almost everywhere. When green, it forms an excellent vegetable and is generally used in curries and chutneys.

	Kardi (<i>Carthamus tinctorius</i>).	Methi (<i>Trigonella Foenum Graecum</i>).	Chuka (<i>Rumex vesicarius</i>).	Kothimbir (<i>Coriandrum sativum</i>).
	N. O.— (Compo- site).	(Legumi- noseae).	(Polygon- naceae).	(Umbelli- ferae).
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	86.00	77.00	92.00	84.00
On dry matter.				
Ether extract	6.14	4.80	4.62	3.12
*Albuminoids	28.12	16.21	16.27	24.46
Soluble carbohydrates	44.46	56.11	57.86	43.30
Woody fibre	9.14	11.51	10.50	9.75
†Ash	12.14	11.37	10.75	19.37
Containing—	100.00	100.00	100.00	100.00
*Nitrogen	4.50	2.61	2.62	3.93
†Sand	0.43	0.93	0.75	1.50

B.—VEGETABLES WHERE THE FRUITS ARE USED.

Red Pumpkin (*Cucurbita maxima*).—It is sown at any time of the year and begins to bear in about three months. The fruit has a reddish flesh. It is sometimes so large as to measure eighteen inches in diameter.

Long White Gourd (*Lagneria vulgaris*).—The fruit is long, sometimes up to three feet. The plant begins to bear in two or three months after the seed is sown. The fruit is used as vegetable and also for sweets.

Padval, Snake gourd (*Tricosanthes anguina*).—This is grown on garden lands. It begins to bear in two months. The fruit is used as a vegetable. The fruit is long and is marked lengthwise with white stripes.

	Bhopla red, red pumpkin (<i>Cucurbita maxima</i>).	Bhopla Dudhya, long white gourd (<i>Lagneria vulgaris</i>).	Padwal (<i>Tricosanthes anguina</i>).
	N. O.—(<i>Cucurbitaceae</i>).	N. O.—(<i>Cucurbitaceae</i>).	N. O.—(<i>Cucurbitaceae</i>).
	Per cent.	Per cent.	Per cent.
Moisture	89.50	90.36	95.00
On dry matter.			
Ether extract	1.00	1.24	2.20
*Albuminoids	6.12	0.87	13.75
Soluble carbohydrates	77.33	75.28	67.85
Woody fibre	8.55	18.05	10.60
†Ash	7.00	4.56	5.60
Containing—	100.00	100.00	100.00
*Nitrogen	0.98	0.14	2.20
†Sand	0.17	0.21	Nil.

Karle (*Momordica charantia*).—This is grown in garden lands. It begins to bear in two months. The surface of the fruit is roughened with knobs. The fruit which is used as a vegetable is bitter and has to be well boiled and squeezed before the vegetable is used. The removal of the upper skin also removes the bitterness.

Dodka or the sharp cornered cucumber (*Luffa acutangula*).—The crop is sown in June or July and begins to bear in two months or a little more. The fruit which is eaten as a vegetable is dark green with sharp ridges from end to end.

Vange or Brinjal, Egg-plant (*Solanum melongena*).—The fruit of the plant is one of the most important vegetables. If the seed is sown in June, seedlings can be transplanted in July and the plants begin to bear from September onwards for about four months under irrigation.

	Karla (<i>Momordica</i> <i>charantia</i>).	Dodka (<i>Luffa</i> <i>acutangula</i>).	Vango, Brinjal, long, seed- less (<i>Solanum</i> <i>melongena</i>).	Vango Brinjal, small, seeded (<i>Solanum</i> <i>melongena</i>).
	(N. O.— <i>Cucurbitaceae</i> .)		(N. O.— <i>Solanaceae</i> .)	
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	88.75	91.97	90.80	88.26
On dry matter.				
Ether extract	2.93	2.98	8.10	4.20
*Albuminoids	1.62	0.87	16.44	16.37
Soluble carbohydrates	85.41	73.47	58.36	55.23
Woody fibre	1.51	16.56	9.60	17.00
† Ash	8.53	6.12	7.50	7.20
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen	0.26	0.14	2.63	2.62
† Sand	0.17	0.17	0.90	0.70

Guar or Gawar, Cluster bean (Cyamopsis psoralioides).—Guar is grown on garden lands. Green pods are used as vegetable.

Bhendi, Edible Hibiscus (Hibiscus esculentus).—Grown in garden lands. The green pods are used as vegetable. If the seed is sown in June the plants begin to bear in September and go on bearing till the end of November.

	Guar, green (<i>Cyamopsis</i> <i>psoralioides</i>).	Peas, seed, green (<i>Pisum</i> <i>sativum</i>).	French beans, green (<i>Phaseolus</i> <i>vulgaris</i>).	Bhendi (<i>Hibiscus</i> <i>esculentus</i>).
	(N. O.— <i>Leguminosae</i> .)		(N. O.— <i>Malvaceae</i> .)	
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	86.00	77.00	95.00	89.80
On dry matter.				
Ether extract	1.28	1.00	2.00	1.76
*Albuminoids	21.43	26.31	23.75	20.18
Soluble carbohydrates	52.29	57.61	40.25	62.77
Woody fibre	15.00	9.56	22.00	7.55
† Ash	10.00	5.52	12.00	7.74
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen	3.43	4.21	3.80	3.23
† Sand	Nil.	Nil.	Nil.	0.19

C.—OTHER VEGETABLES.

Mula or Indian Radish (Raphanus sativus).—Grown in garden lands. The leaves are fit for use in six weeks and the roots in two months. The plant bears pods in a fortnight more and continues bearing for a month and a half. The leaves, roots and pods are eaten as vegetable.

	Cabbage (<i>Brassica</i> <i>oleracea</i>).	Cauliflower (<i>Brassica</i> <i>oleracea</i>) Var— <i>Botrytis</i> .	Knol-khol (<i>Brassica</i> <i>oleracea</i>) Var— <i>Caulocarpa</i> .	Mula or Indian Radish (<i>Raphanus</i> <i>sativus</i>).
	(N. O.— <i>Cruciferae</i> .)			
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	92.00	90.00	92.80	91.00
On dry matter.				
Ether extract	3.00	3.30	3.19	4.00
*Albuminoids	19.50	36.40	27.75	18.00
Soluble carbohydrates	61.38	41.30	47.12	52.66
Woody fibre	8.87	10.50	9.30	9.34
† Ash	7.25	8.50	12.64	16.00
	100.00	100.00	100.00	100.00
Containing—				
* Nitrogen	3.12	5.80	4.44	2.88
† Sand	0.12	0.100	0.139	0.33

Yam (Dioscorea alata).—It is an important vegetable in the garden lands of Gujarat, but in other parts it is sparingly grown. It is essentially a rain crop. It ripens in October. The tuber is used as a vegetable.

Suran, Elephant's foot (Amorphophallus campanulatus). This crop is important in certain parts of Gujarat, especially in the valleys of the rivers. In the Deccan it grows on soil suited for irrigation. It is a four year crop although it is harvested and replanted every year. It is the corn which gives the vegetable and which has the appearance of an elephant's foot. The corn, if stored well, keeps good for a considerable period. It is used for vegetable just as potato or sweet potato.

Sweet potatoes (Ipomea batata).—Are generally grown during the cold season and under irrigation, but in light dry

land a rain crop is sometimes obtained, and it can be grown at any time of the year in the Deccan. The crop generally ripens in about six months. Sweet potatoes provide a good food material. Dried tubers are sometimes ground into flour which is baked into cakes.

	Carrots, yellow (<i>Daucus</i> <i>carota</i>).	Carrots, red (<i>Dau-</i> <i>cus carota</i>).	Yam (<i>Dios-</i> <i>corea alata</i>).	Suran (<i>Amorpho-</i> <i>phallus</i> <i>campanu-</i> <i>latus</i>).	Sweet potatoes (<i>Ipomea</i> <i>batatas</i>).
	(N. O.- <i>Um-</i> <i>belliferae</i> .)	(N. O.- <i>Um-</i> <i>belliferae</i> .)	(N. O.- <i>Dio-</i> <i>scoraceae</i> .)	(N. O.- <i>A-</i> <i>roideae</i> .)	(N. O.- <i>Con-</i> <i>volvulaceae</i> .)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ..	81.40	77.86	73.00	78.00	68.00
On dry matter.					
Ether extract ...	1.72	1.12	0.44	0.50	4.50
* Albuminoids ...	7.63	7.05	7.85	12.18	21.45
Soluble carbo- hydrates.	74.96	73.60	86.19	76.28	69.18
Woody fibre ...	6.56	10.52	1.48	4.00	1.75
† Ash ...	9.08	7.71	4.04	7.04	3.12
	100.00	100.00	100.00	100.00	100.00
Containing—					
* Nitrogen ...	1.23	1.12	1.26	1.90	3.43
† Sand ...	0.48	0.22	0.47	0.18	0.12

	Potatoes (Deccan) (<i>Solanum tubero-</i> <i>sum</i>).	Onions, red (<i>Allium cepa</i>).
	(N. O.- <i>Sola-</i> <i>naceae</i>)	(N. O.- <i>Liliaceae</i> .)
	Per cent.	Per cent.
Moisture ...	80.66	85.60
On dry matter.		
Ether extract ...	0.77	2.17
* Albuminoids ...	16.75	11.62
Soluble carbohydrates	73.58	78.53
Woody fibre ...	2.93	4.02
† Ash ...	5.97	3.66
	100.00	100.00
Containing—		
* Nitrogen ...	2.67	1.86
† Sand ...	Nil.	0.635

The following figures give the percentage of phosphoric acid contained in some vegetables calculated on dry matter.

Vegetable.	Botanical name.	Moisture.	Phosphoric Acid (P ₂ O ₅)
		Per cent.	Per cent.
1. <i>Palak</i> ...	<i>Spinacea oleracea</i> ...	84.00	1.50
2. <i>Chandanbatwa</i> .	<i>Chenopodium ambrosio-</i> <i>des</i> .	86.59	1.76
3. <i>Methi</i> ...	<i>Trigonella Foenum grae-</i> <i>cum</i> .	77.50	1.09
4. <i>Kardi</i> ...	<i>Carthamus tinctorius</i> ...	86.00	1.76
5. <i>Red Math</i> ...	<i>Amarantus blitum</i> ..	84.08	2.02
6. <i>Pokla</i> ...	<i>Amarantus mungostannus</i> .	82.00	1.79
7. <i>Rajgira</i> ...	<i>Amarantus paniculatus</i> ...	80.00	1.70
8. <i>Kothimbir</i> (<i>Coriander</i>).	<i>Coriandrum sativum</i> ...	84.00	1.45
9. <i>Chuka</i> ...	<i>Rumex vesicarius</i> ...	92.50	1.29
10. <i>Dudhya Bhopla</i> .	<i>Lageria vulgaris</i> ...	90.36	0.85
11. <i>Red Bhopla</i> ...	<i>Cucurbita maxima</i> ...	94.82	2.22
12. <i>Karle</i> ...	<i>Momordica charantia</i> ...	88.77	1.95
13. <i>Dodka</i> ...	<i>Luffa acutangula</i> ...	91.97	1.63
14. <i>Carrots</i> ...	<i>Daucus carota</i> ...	81.40	0.87
15. <i>Radish</i> ...	<i>Raphanus sativus</i> ...	91.00	1.32
16. <i>Suran</i> ...	<i>Amorphophallus campanu-</i> <i>latus</i> .	78.00	0.69
17. <i>Yam</i> ...	<i>Dioscorea alata</i> ...	73.00	0.53

IV.—FRUITS.

Fruits are characterised by containing a large amount of water varying from 80 to 90 per cent. The fruits generally contain edible and non-edible portions. It is the edible portion with which we are concerned. The percentage of non-edible portion is, however, given in some cases. The remainder of the fruit usually consists of sugars, organic acids, starch, gums, mineral matter, and aromatic substances known as essential oils, which usually give the characteristic flavour and aroma to the fruit. A small quantity of colouring matter is also present in many. Fruits contain only a very small quantity of proteids or flesh forming material. The taste of fruits is mainly due to the blending of sugars with organic acids and their aroma is due to the essential oils. In the analyses of fruits, therefore, only sugars and acids have been determined. The food constituents of the fruits are useful in supplying a part of the requirements of the human body but their importance is due in large portion to

the presence of accessory food factors known as vitamins which seem to be essential in our food, as already mentioned under vegetables. The juice of fresh fruits is exceedingly valuable to children on account of these vitamins, and fresh fruit should invariably form a part of our food if possible.

A certain number of dry dates and figs were analysed in connection with experiments in fruit drying. These dry fruits are included under this section as their analyses may be found of interest.

PLANTAINS.

(Banana. Bot.—*Musa paradisiaca*).

The varieties of plantains that have been analysed so far, can be classified as those containing a large amount of sugars, those containing a small amount of sugars, and also those that stand midway between these two. Those varieties, which contain large amount of sugars, include, it is needless to add, some of the well known types of the Deccan, such as *Sonkeli*, *Welchi*, *Mutheli*, &c., and of the Karnatic such as the *Raswal*.

(1) Some varieties such as the *Partoli*, *Bichirbali*, *Dwarf*, *Sahasrafani*, &c., give a very high percentage of sugars, with a high proportion of non-reducing sugars. The Dwarf variety contains as much as 26.18 per cent. of total sugars, with 18.30 per cent. of non-reducing sugars.

The analysis of these varieties is given below:—

	Partoli.	Bichirbali.	Dwarf.	Sahasra-fani.
	Per cent.	Per cent.	Per cent.	Per cent.
Skin ...	11.30	18.10	17.16	10.10
Edible matter ...	...	81.90	82.82	89.90
<i>On edible matter.</i>				
Moisture ...	64.00	68.00	64.00	66.66
Reducing sugars ...	9.74	3.86	7.08	9.26
Non-reducing sugars ...	12.90	17.81	18.30	12.74
Total sugars ...	22.64	21.67	26.18	22.00

The following table will show the variation of sugar contents in the above varieties:—

Skin ...	10.10 to 18.10 per cent.
Edible matter ...	81.90 to 89.90 do.
<i>On edible matter.</i>	
Moisture ...	64.00 to 68.00 do.
Reducing sugars ...	3.86 to 9.74 do.
Non-reducing sugars ...	12.74 to 18.30 do.
Total sugars ...	21.67 to 26.18 do.

(2) Varieties known as *Pattamodarung bali*, *Latundan bali*, *Anne bali*, &c., contain low percentage of sugars. The percentage of both reducing and non-reducing sugars is low in these cases.

The following tables will make the above statement clear:—

	Pattamoda-rung bali.	Latundan bali.	Anne bali.
	Per cent.	Per cent.	Per cent.
Skin ...	27.40	25.7	25.30
Edible matter ...	72.60	74.3	74.70
<i>On edible matter.</i>			
Moisture ...	72.00	70.00	80.00
Reducing sugars ...	4.31	4.32	4.08
Non-reducing sugars ...	6.99	7.47	6.74
Total sugars ...	11.30	11.69	10.82

The variation in the plantains containing low per cent. of sugars is as follows:—

Skin ...	25.30 to 27.40 per cent.
Edible matter ...	72.60 to 74.90 do.
<i>On edible matter.</i>	
Moisture ...	70.00 to 80.00 do.
Reducing sugars ...	4.08 to 4.31 do.
Non-reducing sugars ...	6.74 to 7.47 do.
Total sugars ...	10.82 to 11.69 do.

(3) There are a few more varieties, viz., *Mysore bali*, *Yellahi bali*, *Raskel*, &c., which give fairly high percentage of sugars as shown by the following table:—

	Mysore bali.	Yellahi bali.	Raskel.
	Per cent.	Per cent.	Per cent.
Skin	13.60	12.43	13.10
Edible matter	86.34	87.57	86.90
<i>On edible matter.</i>			
Moisture	66.00	68.00	68.00
Reducing sugars	16.00	10.00	11.50
Non-reducing sugars	3.59	9.20	8.00
Total sugars	19.59	19.20	19.50

The following are the variations in the samples analysed:—

Skin	12.43 to 13.66	per cent.
Edible matter	86.34 to 87.57	do.
<i>On edible matter.</i>		
Moisture	66.00 to 68.00	do.
Reducing sugars	10.00 to 16.00	do.
Non-reducing sugars	3.59 to 9.20	do.
Total sugars	19.20 to 19.59	do.

(4) The common varieties, which are obtained in the Poona market and which are mostly grown in the Deccan, and known as (1) Poona variety, (2) *Basarai*, (3) *Bangali*, (4) *Rakhadi*, (5) *Junnar* give in general an amount of sugar which places them in the intermediate class.

The following table will bear out the above statement:—

	Poona.	Basarai.	Junnar	Bangali.	Rakhadi.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Skin	20.30	32.55	27.12	17.05	30.80
Edible matter	79.70	67.45	72.88	82.95	69.20
<i>On edible matter</i>					
Moisture	72.00	74.00	82.00	77.08	65.00
Reducing sugars	4.58	5.32	5.53	8.06	2.38
Non-reducing sugars	10.49	10.71	7.67	4.04	10.24
Total sugars	15.07	16.03	13.20	12.50	12.62

The variation in the analysis of the above varieties is as follows:—

	Per cent.
Skin	17.05 to 32.55
Edible matter	67.45 to 82.95
<i>On edible matter.</i>	
Moisture	65.00 to 82.00
Reducing sugars	2.38 to 8.06
Non-reducing sugars	4.44 to 10.71
Total sugars	12.33 to 16.03

It will be interesting to note the analysis of some of the most typical and popular varieties grown in this part of the presidency. The *Sonkeli* and *Velchi* of Poona are prized for their sweetness and quality. The *Mutheli* and *Rajeli* of the Thana District and *Rasbali* or *Raswal* of the Karnatic are similarly valued most in the respective places in which they grow. Analyses of these different varieties are given below:—

	Sonkeli.	Velchi.	Mutheli.	Rajeli.	Raswal.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Skin	14.00	13.00	15.82	13.99	23.00
Edible matter	86.00	87.00	84.18	86.01	77.00
<i>On edible matter.</i>					
Moisture	68.00	65.00	76.00	76.00	68.00
Reducing sugars	9.77	10.42	5.50	10.20	4.50
Non-reducing sugars	12.67	10.24	14.60	7.14	14.00
Total sugars	22.44	20.66	20.10	17.34	18.50

The following results of analysis of other samples of three different varieties are specially given, because the nitrogen and phosphoric acid contained in them are also determined:—

	Sonkeli.	Velchi.	Rajeli.
	Per cent.	Per cent.	Per cent.
<i>On edible matter.</i>			
Moisture	66.00	62.00	76.60
Nitrogen	0.21	0.19	0.19
Phosphoric acid (P ₂ O ₅)	0.14	0.15	0.18
Reducing sugars	17.50	22.63	15.20
Non-reducing sugars	3.20	5.10	4.30
Total sugars	20.70	27.73	19.50

POMEGRANATES (*Bot.—Punica granatum*).

About a dozen samples of pomegranates have been analysed. The analytical figures are interesting so far as the acidity and sugars are concerned.

The following table shows the general variation:—

	Per cent.
Non-edible matter (rind and seed) ...	28.63 to 49.4
Seed only ...	19.10 to 16.80
Juice ...	57.47 to 71.37
<i>On juice.</i>	
Acidity (in grams of H_2SO_4) ...	0.37 to 0.78
Reducing sugars ...	5.11 to 14.56
Total sugars ...	5.11 to 14.56

Among these samples, a very good sample of pomegranate was received the analytical results of which, being very striking, are given below. The Muskat type of pomegranate was also analysed and the results show the ingredients in a very marked degree:—

	A typical good fruit of ordinary variety.	Muskat pomegranate.
	Per cent.	Per cent.
Non-edible portion (Skin) ...	49.40	30.26
(Seed) ...	32.60	16.71
Juice ...	16.80	13.55
	50.60	69.74
<i>On Juice.</i>		
Acidity (in grams of H_2SO_4) ...	0.516	0.27
Reducing sugars ...	14.56	11.32
Non-reducing sugars ...	Nil.	Nil.
Total sugars ...	14.56	11.32

GRAPES (*Bot.—Vitis vinifera*).

A number of grape samples including different varieties have been analysed. The analysis of common or *Bhokari* variety when ripe is as under:—

	On original fruit.
	Per cent.
Moisture ...	72.8 to 77.2
Ash ...	0.36 to 0.64
Acidity (in grams of H_2SO_4) ...	0.23 to 0.53
Total (reducing) Sugars ...	15.69 to 18.60

Some of the types of grapes were also analysed especially for their sugar contents. The results are given below:—

Type.	Total (reducing) sugars. On original fruit.
	Per cent.
<i>Phakadi</i> ...	16.40
<i>Pandhari</i> ...	18.09
<i>Bhokari</i> ..	18.60
<i>Black Prince</i> ...	17.10
<i>Khandahari</i> ...	19.70
<i>Kali Sahebi</i> ...	22.0

Figs (*Bot.—Ficus carica*).

A large number of samples have been analysed in the case of figs as grown in the Poona District. It has been found that ripe samples received during the months of January and early February had not developed the sugars to their maximum; while those analysed in late February, March and April show a very high percentage of sugars. The following results of analysis will bear out the above facts vividly:—

(1) Variation in 7 samples analysed in early February:—

	Per cent.
Moisture ...	74.5 to 81.80
* Non-reducing sugars ...	2.89 to 5.76
* Reducing sugars ...	34.64 to 51.42
* Total sugars ...	38.31 to 51.43

(2) Variation in 22 samples analysed late in February and in early March:—

	Per cent.
Moisture ...	69.0 to 81.0
* Non-reducing sugars ...	3.62 to 15.65
* Reducing sugars ...	33.15 to 58.63
* Total sugars ...	45.21 to 64.33

* Calculated on dry matter.

(3) Variation in 30 samples analysed in April:—

	Per cent.
Moisture	... 74.63 to 87.18
* Non-reducing sugars	... 2.66 to 8.2
* Reducing sugars	... 29.07 to 54.16
* Total sugars	... 31.01 to 60.18

Analysis of unripe fruits is given for the sake of comparison:—

	Fruits unripe.	Fruit fully developed but not ripe.
	Per cent.	Per cent.
Moisture	... 83.37	87.8
* Non-reducing sugars	... 0.85	Nil.
* Reducing sugars	... 7.91	48.2
* Total sugars	... 8.76	48.2

Analysis of fruit completely ripe on plant:—

	Per cent.
Moisture	... 47.80
* Reducing sugars	... 55.73
* Non-reducing sugars	... 3.72
* Total sugars	... 59.45

* Calculated on dry matter.

GUAVAS (Bot.—*Psidium guajava*.)

About three dozen samples of guavas have been analysed and in addition a few samples of different varieties. The results have been given in different tables:—

	Guava fruits general.	Guava fruits ripened on trees.
	Per cent.	Per cent.
<i>With seed removed.</i>		
Moisture	... 76.82 to 87.83	78.5 to 81.40
* Reducing sugars	... 8.85 to 12.64	5.48 to 13.96
* Non-reducing sugars	... 8.15 to 15.65	9.54 to 20.10
* Total sugars	... 18.27 to 29.18	22.02 to 30.10

* Calculated on dry matter.

Results of analysis of some of the varieties of guava:—

	Kothrud.	Dharwar.	Miraj.	Dholka white	Dholka red.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
<i>With seed removed.</i>					
* Moisture	... 75.4	76.76	77.46	82.0	75.77
* Reducing sugars	... 8.81	10.04	12.31	7.61	7.0
* Non-reducing sugars.	... 10.36	18.46	17.30	11.94	10.37
* Total sugars	... 19.17	28.50	29.61	19.55	17.37

* Calculated on dry matter.

CITRONS (or fruits of the citrus family).

In the citrus family, we get a number of kinds of fruit and each one has a peculiarity of its own. Samples of each variety have been analysed, and the results are given below:—

LEMONS (Bot.—*Citrus medica*—variety *acida*).

	Kagadi lemon.	Sour lime.	Sind lime.	Long lime.
Moisture	... 77.50	76.00	86.05	84.57
Juice	... 57.60	56.80	39.73	51.82
<i>On Juice.</i>				
Reducing sugars	... 0.20	0.18	0.86	Traces.
Non-reducing sugars	... 0.24	0.18	0.52	Nil.
Total sugars	... 0.49	0.36	1.38	
Acidity—In grams citric acid...	7.50	7.74	10.70	10.88
In grams of sulphuric acid.	5.25	5.42	7.50	7.62

POMELO (Bot.—*Citrus decumana*). Shaddock of West Indies, or Pomela, as it is ordinarily called has also been analysed and the results of two samples are given below:—

	Sample I.	Sample II.
	Per cent.	Per cent.
Moisture	... 82.56	90.00
Juice	... 25.86	...
<i>On Juice.</i>		
Reducing sugars	... 2.79	2.22
Non-reducing sugars	... 1.77	3.22
Total sugars	... 4.56	5.44
Acidity—In grams of citric acid	... 1.15	...
In grams of sulphuric acid	... 0.81	...

ORANGES (*Bot.—Citrus aurantium*).—Some samples of oranges have been analysed and the results obtained are divided into two groups:—The Nagpur oranges which generally contain less of acid have been put together in one group and those that are obtained in the Poona bazar or the Poona local varieties have been put into the other:—

		Per cent.
A. Nagpur oranges—		
Rind and seed (non-edible)	...	38·00 to 44·00
Juice	...	52·00 to 62·00
On Juice.		
Reducing sugars	...	3·42 to 4·30
Non-reducing sugars	...	3·46 to 3·96
Total sugars	...	7·35 to 7·90
Acidity—In grams of citric acid	...	0·81 to 1·21
In grams of sulphuric acid	...	0·56 to 0·847
B. Poona oranges—		
Moisture	...	82·59 to 85·97
Pulp	...	62·22 to 73·33
* Reducing sugars	...	11·62 to 13·32
* Non-reducing sugars	...	10·15 to 20·93
* Total sugars	...	21·77 to 34·25
* Acidity—In grams of citric acid	...	35·25 to 42·69
In grams of sulphuric acid	...	24·67 to 29·88
* Calculated on dry matter.		

MOSAMBE (*Bot.—Citrus aurantium*).

It is a very sweet fruit of the citrus family and an analysis of only one fruit is given as a type:—

	Per cent.
Moisture	83·00
* Reducing sugars	4·16
* Non-reducing sugars	9·58
* Total sugars	13·74

* Calculated on edible parts.

MANGOES (*Bot.—Mangifera Indica*).

About a dozen samples of mango fruits have been analysed including some special varieties such as Pairi, Alphonso, &c. A few typical results of analysis are given below:—

	Ordinary mango fruit (ripe).	Pairi mango fruit (ripe).	Alphonso mango fruit (ripe).
On pulp.			
Moisture	Per cent. 81·3	Per cent. 79·30	Per cent. 80·50
* Reducing sugars	...	...	...
* Non-reducing sugars	...	...	...
* Total sugars	...	...	...
Acidity—In terms of sulphuric acid	...	...	...

* Calculated on dry matter.

Results of analysis of two samples (of Pairi and Alphonso) which have been analysed for other ingredients also such as ether extract, albuminoids, carbohydrates, &c., are given below:—

	Pairi.	Alphonso.
On pulp.		
Moisture	Per cent. 84·00	Per cent. 79·00
Ether extract	...	...
Woody fibre	...	...
Carbohydrates	...	...
* Albuminoids	...	...
Ash	...	...
Sugars (total)	...	...
* Containing—	...	...
Nitrogen	...	...

Only one sample has been analysed for its potash, phosphoric acid, &c., and the result thereof is quoted below:—

	Per cent.
On pulp.	
Moisture	83·00
Potash	0·15
Phosphoric acid	0·05
Lime	0·12
Magnesia	0·10

Some stray or miscellaneous samples of fruits other than those given so far have been received and analysed from time to time. The results obtained have been given below:—

JACK FRUIT (*Bot.—Artocarpus integrifolia*).

	Unripe fruit	Ripe fruit.	
	Material used as vegetables in Indian dishes.	Outer yellow fleshy pulp round the seed.	Inner seed.
Moisture	61·26	69·20	42·32
Ether extract	0·88	0·28	0·44
Albuminoids	3·75	2·25	7·19
Digestible carbohydrates	26·21	26·08	41·95
Fibre	3·30	0·58	1·50
Ash	1·60	0·11	1·60

CUSTARD APPLE, &c. (Bot.—*Anona Sp.*).

		Sitafal (Custard apple) (Bot.— <i>Anona</i> <i>squamosa</i>).	Ramfal (Bullock's heart) (Bot.— <i>Anona reticulata</i>).	
			Big.	Small.
<i>On pulp.</i>				
Moisture	...	64.62	61.67	643.3
Reducing sugars	...	5.68	31.47	29.30
Non-reducing sugars	...	0.87	Nil.	Nil.
Total sugars	...	6.55	31.47	29.30

JAMBUL (Bot.—*Eugenia jambolana*).

	Jambul (Bot.— <i>Eugenia jambolana</i>).
Edible matter	68.00
<i>On edible matter.</i>	
Reducing sugars	8.09
Non-reducing sugars	9.26
Total sugars	17.35
Acidity—In terms of sulphuric acid	1.21

DRY FRUIT.

Among the class of dry fruit only two kinds of fruit, viz., dates and figs have been analysed.

Dates.—Under these 8 samples—each of different variety—have been analysed in detail, and the results of all of them will be found in the following tables:—

The following are Sind varieties raised from seedlings:—

	Black.	Red.	Black tops.	Yellow dates.
	Per cent.	Per cent.	Per cent.	Per cent.
Seed	7.70	13.33	22.22	20.45
Edible matter	82.30	86.67	77.78	79.55
<i>On edible matter.</i>				
Moisture	25.00	60.00	35.00	55.00
Woody fibre	2.34	1.90	2.22	2.50
Reducing sugars	59.16	19.38	46.27	16.23
Non-reducing sugars	4.20	Nil.	Nil.	Nil.
Total sugars	63.36	19.38	46.27	16.23

	Long tapering.	Muskat.	Crown.
	Per cent.	Per cent.	Per cent.
Seed	11.36	7.50	7.85
Edible matter	88.64	92.50	92.15
<i>On edible matter.</i>			
Moisture	40.00	22.10	23.14
Woody fibre	2.14	1.82	1.88
Reducing sugars	44.07	76.00	69.80
Non-reducing sugars	1.04	Nil.	Nil.
Total sugars	45.11	76.00	69.80

Figs, dry.—In case of samples of dry figs only a few foreign varieties have been analysed for their moisture and sugar contents and the results have been given below:—

	Persian.	Persian.	Afghanistan.	Grecian.	Smyrna.	California.	Poona.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	19.15	19.90	19.04	19.14	18.25	19.92	19.95
Sugars	46.30	45.70	46.64	46.50	57.34	57.34	45.95

I am much indebted to Mr. V. N. Gokhale, B.Ag., B.Sc., Lecturer in Chemistry at the Poona Agricultural College, for the help rendered by him in compiling the matter of this Bulletin.

INDEX TO ENGLISH AND VERNACULAR NAMES.

Name.	Pages.	Name.	Pages.
Bajri	... 9	Lemons	... 31
Bananas	... 24-27	Lentil	... 13
Bavto	... 11	Linseed	... 15
Bhopla, dudhya	... 19, 23	Long white gourd	... 19
Bhopla, red	... 18, 19, 23		
Black gram	... 12	Maize	... 9
Bladder Dock	... 18	Mangoes	... 32, 33
Brinjal	... 19, 20	Masur	... 13
Bulrush millet	... 10	Math (red)	... 17, 23
		Methi	... 18, 23
Cabbage	... 21	Mozambe	... 32
Carrots	... 23, 23	Mula	... 21
Castor seed	... 15	Mutki	... 12
Cauliflower	... 21		
Chandanbatwa	... 17, 23	Nagli	... 11
Chuka	... 18, 23	Niger seed	... 15
Cluster beans (grain)	... 12		
Do. (vegetable)	... 20	Onions	... 22
Cocoanut	... 15	Oranges	... 32
Common millet	... 11		
Coriander	... 18, 23	Padval	... 19
Cotton seed	... 14	Palak	... 17, 23
Custard apple	... 31	Pea nut	... 13
		Pigeon pea	... 12
Dates	... 34, 35	Plantains	... 24-27
Dodka	... 19, 20, 23	Pokla	... 23
Dudhya bhopla	... 19, 23	Pomegranate	... 28
		Pomeloos	... 31
Edible Hibiscus	... 20	Potatoes	... 22
Egg plant	... 19	Pumpkin, red	... 18, 19
Elephant's foot	... 21, 22		
Figs	... 29, 30	Radish, Indian	... 21, 23
Figs (dry)	... 35	Ragi	... 11
		Rajgira (grain)	... 11
Gourd, long, white	... 19	Do. (vegetable)	... 17, 23
Do. snake	... 19	Ramfal	... 34
Gram	... 13	Red bhopla	... 18, 19, 23
Grapes	... 23, 29	Red math	... 17, 23
Groundnut	... 14	Red pumpkin	... 18, 19, 23
Guar (grain)	... 12	Rice	... 5, 6
Do. (vegetable)	... 20		
Guavas	... 30, 31	Safflower seed	... 15
		Do. vegetable	... 18, 23
Harik	... 11	Sesamum	... 15
Hibiscus, edible	... 20	Sitatal	... 34
Horse gram	... 13	Snake gourd	... 19
		Soy beans	... 13
Indian radish	... 21	Sunflower	... 15
		Suran	... 21, 22, 23
Jack fruit	... 35	Sweet potatoes	... 21, 22
Jambul	... 31		
Jowar	... 9	Til	... 15
		Tur	... 14
Kadwa	... 13		
Kardi (seed)	... 15	Udid	... 12
Do. (vegetable)	... 18, 23		
Karle	... 19, 23	Val	... 13
Kidney bean	... 12	Vange	... 19, 20
Knol-khol	... 21	Vari	... 11
Kodra	... 11		
Kothimbir	... 18, 23	Wheat	... 6-8
Kulthi	... 13	White long gourd	... 19
		Yam	... 21, 22, 23

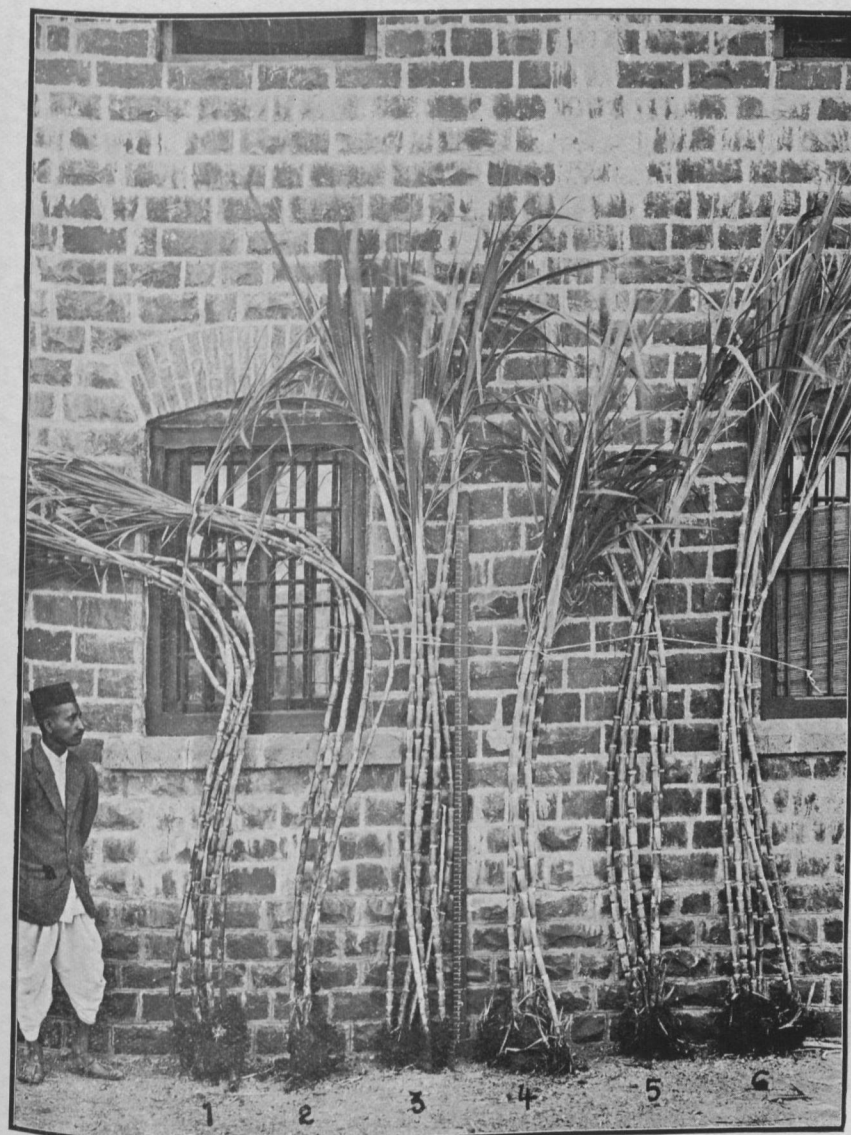
INDEX TO BOTANICAL NAMES.

Name.	Pages.	Name.	Pages.
Allium sepa	... 22	Glycine soja	... 13
Amarantus blitum	... 17, 23	Gossipium	... 14
Amarantus mungostannus	... 23	Guizotia abyssinica	... 15
Amarantus paniculatus	... 11, 17, 23	Helianthus annuus	... 15
Amorphophallus campanulatus	... 21, 22, 23	Hibiscus esculentis	... 20
Andropogon sorghum	... 9	Ipomea batata	... 21, 22
Anona reticulata	... 34	Jaggeria vulgaris	... 19, 23
Anona squamosa	... 34	Linum usitatissimum	... 15
Arachis hypogaea	... 14	Luffa acutangula	... 19, 23
Artocarpus integrifolia	... 33	Mangifera Indica	... 32
Brassica oleracea	... 21	Momordica charantia	... 19, 23
Cajanus indicus	... 12	Musa paradisiaca	... 24-28
Carthamus tinctorius—		Oryza sativa	... 5, 6
Seed	... 15	Panicum miliaceum	... 11
Vegetable	... 13, 23	Paspalum scrobiculatum	... 11
Chenopodium ambrosioides	... 17, 23	Pennisetum typhoides	... 10
Cicer arietinum	... 13	Phaseolus aconitifolius	... 12
Citrus aurantium	... 32	Phaseolus radiatus	... 12
Citrus decumana	... 31	Psidium guajava	... 30, 31
Citrus medica	... 31	Punica granatum	... 28
Cocos nucifera	... 15	Raplanus sativus	... 21, 23
Coriandrum sativum	... 18, 23	Ricinus communis	... 15
Cucurbita maxima	... 19, 23	Rumex vesicarius	... 18, 23
Cyamopsis psoralioides—		Solanum melongena	... 19
Seed	... 12	Solanum tuberosum	... 22
Vegetable	... 20	Spinacea oleracea	... 17, 23
Daucus carota	... 22, 23	Trigonella Foeniculum greacum	... 18, 23
Dioscorea alata	... 21, 22, 23	Trigosanthus anguina	... 19
Dolichos biflorus	... 13	Triticum sativum	... 6, 7, 8
Dolichos lablab	... 13	Vitis vinifera	... 28, 29
Eleusine coracana	... 11	Zea mays	... 10
Ervum lense	... 13		
Eugenia jambulana	... 34		
Ficus carica	... 29, 30, 35		

CONTENTS.

	Page
I. INTRODUCTION	1
II. AIMS AND OBJECTS—	
(a) Selection of varieties	... 2
(b) Conditions under which they are grown	... 2
(c) Objects	... 3
III. DESCRIPTION OF VARIETIES—	
(a) General cane	... 3
(b) Charts and synopsis	... 5
(c) Botanical description of individual variety and composition	... 10
IV. EXPERIMENTS WITH TILLERING, ROOT-SYSTEM AND ARROWING—	
(a) Tillering	... 23
(b) Root-system	... 28
(c) Arrowing	... 28
V. CHEMICAL COMPOSITION OF CANE AND JUICE OF VARIETIES	... 31
VI. PERFORMANCES—	
(a) Observations	... 35
(b) Comparison of yields	... 35
(c) Merits and demerits	... 38
VII. GENERAL OBSERVATIONS	... 39
VIII. CONCLUSIONS	... 43
APPENDIX A (Manufacturing statement)	... 44
APPENDIX B (Temperature and Rainfall Record)	... 45

SUGARCANE VARIETIES
at
MANJRI.



- 1 Red Sports.
- 2 D 109.
- 3 Pundia (check).

- 4 White Transparent.
- 5 Manjav.
- 6 Java.

SUGARCANE VARIETIES
at
MANJRI.



- | | |
|-------------------|----------|
| 7 B 1528. | 9 B 208. |
| 3 Pundia (check). | 10 S 48. |
| 8 Waxy Red. | |

EXOTIC SUGARCANE VARIETIES IN THE BOMBAY DECCAN.

I. INTRODUCTION.

The sugarcane is a kind of gigantic grass which from all evidence at present in existence, developed in Eastern Asia, and has from this centre been distributed throughout the tropical world. During the period of its cultivation, it has developed very many varieties, each with its special characters, whose advantages and whose adaptability is very different. Many of these varieties have occurred in the Bombay Presidency, and the result of a careful study of these and of their capability by Prof. J. B. Knight has been recently published. The present bulletin is a study of a number of exotic varieties, obtained either from other parts of India or abroad, as grown on the Manjri Farm, the sugarcane research station of the Government of Bombay in the heart of the Bombay Deccan.

The varieties dealt with here represent a selection of exotic varieties introduced at various periods during the last twenty-five years, and all of those which showed any promise were multiplied and then tested on a large scale, and in many cases in general cultivation on the Deccan. The names given to the varieties are those under which they were received or which have been given to them since.

The origin of the varieties to be dealt with in the present bulletin is shown in the following list:—

1. *Pundia*.—The local favourite high yielding cane of the Deccan tract.
2. *Red Sports*.—This was obtained from the sugarcane station of the Madras Government at Samalkota in 1909 and has been grown at Manjri ever since.
3. *D. 109*.—This was obtained under this name as a sport cane from the West Indies in 1914.
4. *Java 100 (?)*.—This came from Hebbal in Mysore under the name given in 1914.
5. *White Transparent*.—This cane was received from the West Indies in 1914.
6. *Waxy Red*.—The origin of this cane is somewhat obscure, but it is said to have been received from Sind.

7. *B. 1528*.—This is also a West Indies cane, imported in 1914.

8. *B. 208*.—This is also a West Indies cane, imported in 1914.

9. *Manjav*.—This cane was received from the West Indies in 1914, and was supposed to be that named "B. 376". There was some doubt, however, about it, and hence the local name *Manjav* was given ("Man" from Manjri and "Jav" from Java).

10. *H. M. 544*.—This came from Hebbal in Mysore in 1920.

11. *H. M. 600*.—This also came from Hebbal in Mysore in 1920.

12. *S. 48*.—The origin of this cane cannot be traced. There is some probability that it is "J. 213," a well-known Java cane.*

13. *Cavangerie*.—This was introduced from Mauritius in 1898, and has become the usual cane of the Western India sea coast.

II. AIMS AND OBJECTS OF THE WORK.

(a) *Selection*.—The trial of these varieties commenced from the time they were brought. Preliminary selection for real comparative trials for a few of the varieties commenced earlier when only outturns were compared. But from the year 1923-24, a more detailed study of the varieties with three others on a large scale was made and the results obtained are recorded in the following pages.

(b) *Conditions under which the experiments were carried out*.—The methods of cultivation followed on the Manjri Farm in growing cane consist mainly in the following:—

The land is put under sann hemp (*Crotalaria juncea*) in the *kharif* season. The crop is ploughed in by the S. A. E. Gallows plough in October. The land is then disked and harrowed by December. Furrows are then opened five feet apart with a big ridger (R. N. R. L.). The land does not receive any farm yard manure. A top dressing of safflower cake (containing 75 lbs. of nitrogen) and sulphate of ammonia (containing 75 lbs. of nitrogen) is given to the crop in three doses. The

* This has been suggested by Rao Sahab Venkataraman, the Sugarcane Expert of the Government of India.

first dose is given when the crop is three weeks old, the second dose when the crop is about seven weeks old, and the last at the time of earthing, when the crop is about four or five months old.

Eight thousand sets, each having three eye buds, is the usual seed rate per acre. Planting is done in long rows without bunds. The crop generally gets irrigation every ten days. The total quantity of water including 20 inches rain comes to 100 acre inches.

The rotation consists of sann hemp as a green manure in the first year, sugarcane in the second year, and *Nilva jowar*, a form of *kharif jowar* followed by gram in the *rabi* season in the third year, thus completing the cycle of three years. No ratoon of cane is taken on this farm.

The soil of the Manjri Farm is medium black cotton soil having a sufficient amount of humus or organic matter. It is easy for tillage and is well drained. It has a porous sub-stratum of murum eighteen inches to two feet below the surface. The climate of the place is usually warm and moist with little excess of cold or heat. The range of shade temperature is from 60° F. to 106° F. in the hot weather, and from 49° F. to 85° F. in the cold weather. The average rainfall is not more than 20 inches (13 to 25 inches is the variation). The details for recent years are given in the Appendix B.

(c) *Objects*.—The object of the experiments was to find out what varieties of sugarcane are likely to give the best yield in point of weight of cane and *gul* (*jaggery*) in comparison with that given by *Pundia*, the local variety now usually grown, with a view to have on hand an equally good or better variety than *Pundia* in case the latter deteriorates. The trials were carried out under the ordinary working conditions of the Manjri Farm for several years under uniform conditions with a view to secure comparable outturns for each variety when tried on a field scale.

III. DESCRIPTION OF VARIETIES.

A.—GENERAL DESCRIPTION OF SUGARCANE.

Before giving an account of each of the varieties studied, it will not be out of place to give a general description of the cane plant.

General description of the cane plant.—Sugarcane is made up of (a) the root system, (b) the root stalk, (c) the stalk proper, (d) the leaf and (e) the inflorescence. The stalk of the cane is roughly cylindrical, and in some varieties is swollen between the joints, giving the internodes a shape somewhat like that of a barrel. The size of the stalk differs not only with the variety, but also with the conditions under which cane is grown. The diameter lies between a minimum of 0.5 and a maximum of 3 inches or from a reed like cane to the elephant type of cane. An average length of 12 feet is typical of a well-grown cane. The mean weight per cane in a well-grown crop is from 3 to 4 pounds. The growth of the cane is either erect or recumbent. The stalk is made up of a series of joints or internodes separated from each other by the nodes. These are either straight or zigzag. The node may be of larger or smaller diameter than the internode. The length of the node in a good cane is typically from 5 to 6 inches, though this is influenced by conditions such as drought, excessive cold, soil conditions and disease. The number of nodes may vary from twenty to thirty. At each node, and alternately on opposite sides, is an embryo cane known as the eye bud. This is generally bigger than a pea, and may be triangular, pointed, oval, or hemispherical in shape. In some varieties the eye is very swollen and prominent. From the eye and running upwards appears a channel along the stalk which may or may not be well marked. Above each joint appear from one to three rings of whitish spots, which is the zone from which adventitious roots may arise, each spot being an embryonic root. The eyes or buds serve to reproduce the cane by means of asexual-sexual propagation, that is to say, vegetative reproduction by sets. When the set is planted, simultaneously with the root system adventitious roots develop and serve to feed the plant. In some varieties the eyes have a tendency to sprout while on the parent plant.

Usually the canes are coloured, either green, yellow or some shade of red, varying from pink to deep purple. When exposed to the sun, they may get blotched or marbled in appearance. Striped or ribbon canes are formed by the absence of colouring matter in streaks running lengthwise with the stalk. From these striped canes, self-coloured sports frequently occur, many of which have been found to be of great economic interest.

The leaves are alternate and opposite one at each joint consisting of two parts, leaf sheath and the leaf blade. The

sheath is about twelve inches long, the blade is from three to four feet long and two to three inches wide. The colour is of varying shades of green, and may even be white. The leaves are serrated along the margin with hairs at the base in some cases.

The root system of sugarcane.—When germination takes place a single mother stalk is formed. The underground portion of the stalk forms itself into a rhizome, having at each node a dormant eye. As growth proceeds, new shoots form from this rhizome until a stool of cane is formed. The roots of the cane spring from the nodes of the set planted. They are fibrous, lateral and very delicate. They ramify in all directions from eighteen to thirty-six inches from the stem. The roots do not penetrate usually more than three feet depending upon the nature of the soil and the depth of sub-soil water level. The cane has no tap roots and its roots have comparatively little hold on the soil.

The flower.—The inflorescence of the sugarcane is a panicle of soft silky spikelets borne on the end of the elongated peduncle called the arrow, arising from the terminal vegetative point of the cane. Sugarcane rarely forms fertile seed. Some varieties never flower, and others do so only in the tropics. The age at which sugarcane flowers depends upon variety, climate and time of planting, varying generally from eight to fifteen months. Winter is the usual season for flowering in the Deccan, though the time of the year varies in the different cane-growing regions.

B.—GENERAL DESCRIPTION OF VARIETIES UNDER EXPERIMENT.

The following is the chart and synopsis which gives the names and description of the sugarcane varieties with which the experiments were made. The complete description with the structural details is given in a tabular form followed by the botanical description of individual varieties:—

Table for indentifying the Varieties of Sugarcane used.

I.—Red or purple canes.

(a) Slightly zigzag

(i) Arrowing.

(aa) Thick cane, with profuse wax.

Waxy Red.

(bb) Thin cane with wax present.

S. 48.

- (ii) Sparsely arrowing, thick and slightly waxy
(aa) Deep red in colour.

Red Sports.

- (bb) Light red in colour.

D. 109.

II.—Striped or ribbon canes.

- (a) Yellow, with red stripes, auricle present.

Kabirya.

- (b) Red, with dark green stripes, auricle absent.

Cavangerie.

III.—Green or Yellow canes.

- (a) Slightly zigzag.

- (i) Arrowing.

- (aa) Wax present, Greenish, yellow cane.

White Transparent.

- (bb) Wax absent, Bottle green cane
tumor opposite eyebud.

B. 208.

- (ii) Sparsely arrowing.

Manjav.

- (iii) Non-arrowing.

- (aa) Wax present, Barrel shaped inter-
nodes.

Pundia.

- (bb) Wax absent.

- (1) Auricle present.

Java 100.

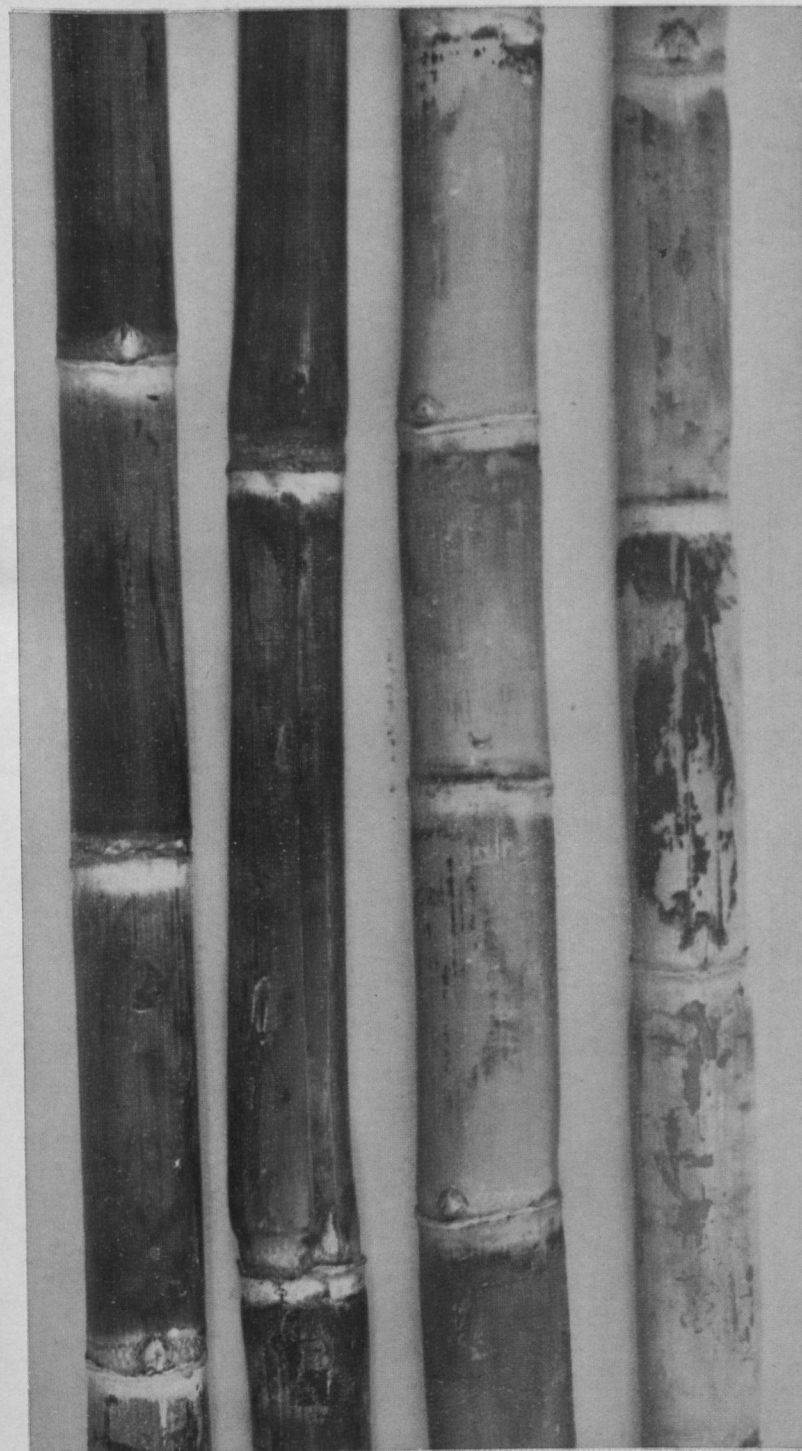
- (2) Auricle absent.

H. M. 544.

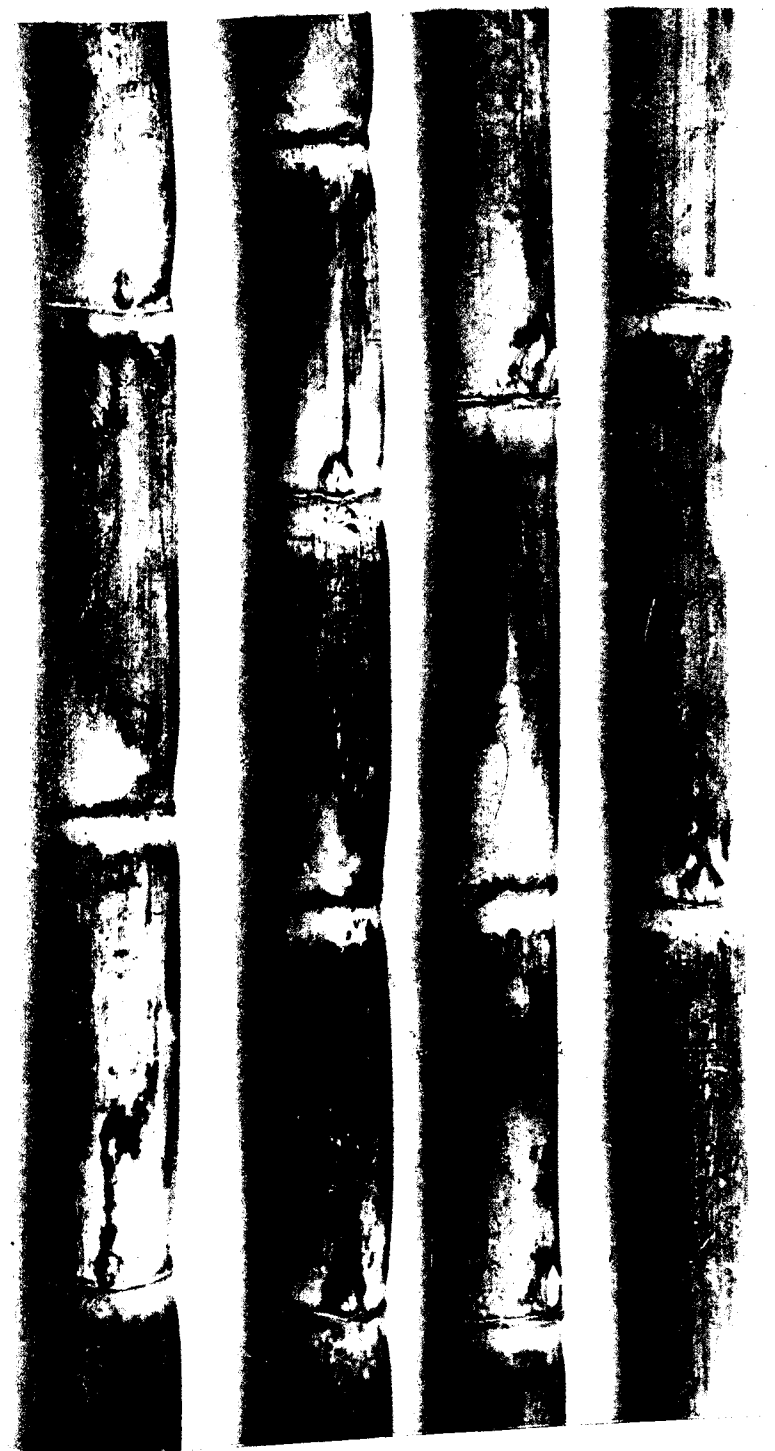
- (b) Distinctly zigzag.

- (i) Non-arrowing and thick.

H. M. 600.



1 2 3 4
Waxy Red. B. 1528. B. 208. Manjav.
($\frac{1}{2}$ Natural size.)



1 Pundia.

2 D. 109.

3 Java.

4 White
Transparent.

($\frac{1}{2}$ Natural size.)

The following table gives the description and structural details of each of the varieties of cane under study, including that of its stem, leaf, internodes and eye bud which is followed by the botanical description, the identifying characters and composition of the cane, &c., of the varieties dealt with in this bulletin : —

[See pp. 8 and 9 for Table.]

TABLE
Description of sugarcane varieties grown

Name of variety.	Field characters.						
	Habit of stem.	Height in	Size of cane, middle girth.	Average number of internodes.	Canes per stool.	Colour.	Arrowing.
Pundia	Erect to reclining.	56	4-2/8	16	4-5	Yellowish green colour, internodes have a tendency to split.	inches. 2-2/8 None
Red Sports.	Reclining or lodging.	82	4-3/8	20	4-5	Purplish red in varying shades with waxy coat (Medium).	2-5/8 Sparsely...
D. 109	Do.	63	4-3/8	19	4-5	Dirty yellowish red in varying shades faint purple with waxy encrustation.	2-3/4 Do.
Java	Erect	80	4-2/8	22	6-7	Yellow with bluish blend, in places red tinge where exposed.	2-3/8 None
White Transparent.	Do.	84	3-5/8	19	5-6	Glaucous or bluish green with pink shade.	2-2/8 Profuse
Waxy Red.	Erect to reclining.	82	4-1/8	18	4-6	Purple with waxy coat.	2-4/8 Do.
B. 1528	Slightly reclining.	85	3-6/8	21	5-6	Purplish red colour with waxy coat.	2-2/8 None
B. 208	Erect	66	4-2/8	16	4-5	Dirty peculiar green (bottle green).	2-5/8 Profuse
Manjav	Do.	89	4-4/8	23	4-5	Light green with pink and blue shade.	2-3/8 Sparsely...
Cavangerie	Do.	79	4	20	5-6	Purplish red or claret coloured with longitudinal black stripes.	2-4/8 None
H. M. 544	Erect to reclining.	80	3-7/8	19	5-6	Yellow with a shade of purple in covered internode, when exposed purplish or chocolate.	2-5/8 Do.
H. M. 600	Reclining to lodging.	78 to 79	3-6/8	21	4-5	Dirty blackish brown, greenish yellow sometimes with pink shade.	2-7/8 Very few...
S. 48	Erect to reclining.	88	2-4/8	18	9 to 11	Purplish red in the lower and purplish yellow in the upper internode. Black incrustation.	1-5 to 1-7 Profuse

No. 4.

on a field-scale as observed on Manjri Farm, 1923-24.

Internode characters.					Eye bud character.	
Shape.	Average length.	Average girth.	Channel.	Wax.	Size.	Shape.
Barrel shaped.	Inches. 4-5/8	Inches. 4-1/8	Slightly	Slightly	Medium	Semicircular at bottom and triangular at top.
Bulging at bottom.	5-1/8	4-4/8	Slight or none.	Medium waxy.	Do.	Flat round with hairy apex, extending beyond growth-band.
Broad at base than at top.	5-3/8	4-2/8	Slight	Waxy	Do.	Flat round with hairy apex.
Cylindrical	4-2/8	3-6/8	None	Very slight.	Medium and broad.	Round and bulging.
Nearly cylindrical.	5-5/8	3-7/8	Present	Slightly	Medium	Round at bottom and triangular at top.
Cylindrical	5-5/8	4-1/8	Slightly	Waxy	Small and broad.	Flat, round with an apex.
Zigzag	5-4/8	4	Present broad.	Do.	Large	Flat, rounded at bottom and triangular at the top hairs at the flanges.
Cylindrical with a bulge.	4-5/8	4-1/8	Slightly	None	Medium	Flat, medium broad apex extending beyond growth-band.
Cylindrical	5	4-2/8	Do.	Slightly	Do.	Rounded, hairy not prominent.
Opposite eye bud slightly zigzag.	4-1/2	4	None or very slightly.	None	Do.	Shape globoid.
Enlarged at base than at top.	3-4/8	4	None	Do.	Do.	Oval to ovate, prominent heavy patch at base and extending up to growth band.
Irregularly bulging.	5-7/8	3-7/8	Do.	Medium	Large	Hemispherical with blunt and flat apex, obtusely rounded, flanges prominent.
Cylindrical	5-2/8	2-6/8	Slight	Do.	Medium	Ovate, hairy at base and apex, flanges present.

C.—BOTANICAL DESCRIPTION OF THE VARIETIES TRIED.

The varieties described in the following pages are studied under the headings given below:—

1. Habit, comprising nature of growth, arrowing, tillering, ratooning, ripening, &c.
2. Colour.
3. Internode (region between two nodes or joints).
4. Growth ring (the region separating the node from the above internode).
5. Root-ring or root band (space between the growth ring and the point of attachment of the leaf sheath varying from 6 to 12 m.m. in width).
6. Leaf scar (remnant of base of sheath, remaining on stalk when the leaf falls off).
7. Wax ring or bloom band (region about 10 m.m. wide immediately below leaf scar, characterised by having deposit of wax).
8. Eye bud.
9. Channel or groove.
10. Leaf, comprising leaf sheath and leaf blade or lamina.
11. Distinguishing characters of the variety.
12. Composition, giving percentages of sucrose and fibre in cane and the Brix in the juice only.

(1) *Pundia*.

Habit.—It is a tall, slightly reclining, thick, soft, juicy cane. It ratoons freely, tillers profusely. It does not generally arrow in the Deccan, and ripens in about 12 months.

Colour.—The colour of exposed and ripe internodes is yellow to yellowish green or greenish yellow.

Internode.—This has a light bloom (wax) all over the surface of the internode and black incrustation of wax here and there. It is very slightly zigzag and medium in length. The shape is generally bulging giving the internode a barrel shape with constrictions at the nodes. It has corky longitudinal markings. The ring is soft, and it has got the splitting habit.

Growth ring.—Is about 2 m.m. wide, not very prominent or distinct, slightly elevated to the touch and is of a pale yellow colour.

Root ring.—It is 7 to 9 m.m. broad, having numerous root dots in three or four rows, the lower rows being well marked.

Leaf scar.—Is obliquely placed and recurved beneath the eye bud.

Wax ring.—Is depressed, having a coating of white wax. Colour underneath the wax coat is pale green or green.

Eye bud.—Is bulging and medium in size, semicircular and broad at the base, and triangular and acute at the top, or macronate, apex extending slightly beyond the growth ring. Apicobasal angle is half way between the base and the apex. The flanges are prominent.

Channel.—Is usually indistinct, and if distinct it is slightly above the eye bud, but not extending all the length of the internode.

Leaf.—Dry leaf sheaths, though detached at the leaf scar, keep on the cane and are covered with sharp stiff hairs (spicules). Leaf blade or lamina is about $2\frac{1}{2}$ inches wide and is coloured with varying shades of yellowish green to green. It is curved gracefully on the sides having serrated margins. It is hairy or lanate at the throat, with presence of ligule and ligular processes or auricles.

Distinguishing characters.—(1) Barrel shape of the internode. (2) Presence of corky longitudinal markings on the internodes. (3) Occasional splitting of the rind of the internode. (4) Presence of ligular processes or auricles.

Composition—

Cane.	Juice.	
	Sucrose, per cent.	Fibre, per cent.
14 to 15	10 to 11	Brix at 17.5 C. 18 to 20

(2) *Red Sports*.*

Habit.—It is a tall, reclining, thick, soft, juicy cane. Tillering is medium, arrowing is sparse, ratooning is good and ripening takes place in $11\frac{1}{2}$ to 12 months.

Colour.—Is red or purplish red, and is shining purplish red underneath the bloom.

Internode.—Has medium amount of wax all over the surface and black incrustations. It is enlarged or bulging at the base and narrows gradually towards the top, sometimes cylindrical also. Stalk is slightly zigzag.

Growth ring.—Is 3 to 5 m.m. wide, quite distinct and slightly elevated and much more prominent and broad when the cane lodges. Colour is dark purple where exposed and greenish pale yellow where covered.

* Identical with D. 109 botanically, though it differs in yield.

Root ring.—Is 5 to 7 m.m. broad, distinct, but rather depressed. Root dots are few and arranged in three rows.

Leaf scar.—Is prominent, squarrose and obliquely placed to the stalk.

Wax ring.—Is depressed, covered with wax of ashy black colour. Underneath the wax the colour is dirty yellow or green.

Eye bud.—Is ovate and subacute with narrow flanges. Apicobasal angle is half way between the base and apex. Hairy patches are present at the base.

Channel.—Is very narrow and shallow and extending over half to two-third the length of the internode and in very rare cases over the whole surface.

Leaf.—Sheaths are partially adhering, easy to strip and covered with sharp hairs or spicules; leaf blade is about 2 to 2½ inches broad and curves gracefully on the sides and is of green colour. It is hairy or lannate at the throat and serrated at the margin. Auricles or legular processes are absent.

Distinguishing characters.—(1) Presence of purplish red or reddish purple colour with medium bloom and black incrustations. (2) Internodes are bulging at the base. Growth ring is prominent and elevated.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Degree Brix at 17.5 C.
11.5 to 13	11 to 12	16.5 to 18

(3) *D. 109.*

Habit.—It is a tall, reclining, thick, soft, juicy cane. It tillers and arrows sparsely, and ripens in 11½ to 12 months. Ratooning is good.

Colour.—Is purplish red or reddish purple at the lower internodes; at the upper internodes purplish yellow in varying shades.

Internodes.—It has medium wax all over the surface and black incrustations. It is enlarged or bulging at base and narrows gradually towards the top. Stalk is slightly zigzag.

Growth ring.—It is about 3 to 5 m.m. wide, prominently elevated and broadened on account of the lodging character of cane, colour is dark purple where exposed and purplish yellow where covered.

Root ring.—It is 6 to 8 m.m. broad; very slightly depressed, root dots are not very numerous in number and arranged in two to three rows, being prominently tubercled.

Leaf scar.—It is squarrose, and obliquely placed to the stalk.

Wax ring.—It is broad and is rather depressed and has heavy deposit of wax.

Eye bud.—It is medium in size and varies from oval to ovate in shape, has acute apex and narrow flanges, apicobasal angle is half way between the base and apex. Patches are present at the base, point of germination is apical.

Channel.—It is indistinctly present and narrow and shallow if at all present. It extends over about half the length of the internode or so.

Leaf.—Sheaths remain partially adhering after drying and are easy to strip; they are covered with sharp stiff hairs and are covered with slight wax. Leaf blade is about 2 to 2½ inches broad, and curves gracefully on the sides. It is hairy at throat and serrated at the margins, has dark green colour. Auricles or ligular processes absent.

Distinguishing characters.—(1) The internodes are enlarged at the base than at the top. Its peculiar purplish red colour at the lower internode and purplish yellow in varying shades in the upper internodes is characteristic. (3) Prominently elevated growth band.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Degrees Brix at 17.5 C.
12.5 to 14	11 to 12.5	17.5 to 18

(4) *Java.*

Habit.—It is a tall, thick, soft, juicy cane; is erect in growth, has medium tillering capacity and does not arrow; it ripens in 11½ months to 12 months.

Colour.—Is greenish yellow to yellow; in exposed internodes, reddish or pink colour develops owing to the partial detaching of leaf sheaths.

Internodes.—Are nearly cylindrical in shape, and medium in size, and the stalk is very nearly straight or slightly zigzag.

Growth ring.—Is from 2 to 4 m.m. wide and slightly elevated, colour is whitish yellow or pale yellow.

Root ring.—Is from 9 to 11 m.m. wide and is very prominent; root dots are medium in number and arranged in three to four rows; colour is bright yellow.

Leaf scar.—Is prominent and smooth and nearly placed at right angle to the stalk.

Wax ring.—Is 10 to 12 m.m. broad and is slightly depressed; heavy deposit of wax.

Eye bud.—Is medium in size and oval in shape, has acute apex. It is as much broad as long and has hairy patches at base and hairs at the apex, apicobasal angle is at $\frac{1}{3}$ to $\frac{1}{2}$ the distance from the base of bud, fairly broad, sometimes of lightly purple shade, point of germination is apical.

Channel.—Is absent.

Leaf.—Sheath is covered with sharp stiff hairs or spicules and has light green colour with a shade of pink or purple; after drying, the sheath keep on adhering to the stalk; lamina $2\frac{1}{2}$ to 3 inches broad in the lower part of the cane the leaves spread sideways, and in the upper part they are erect with tips declined; auricle present on one shoulder.

Distinguishing characters.—(1) The internodes are medium in size and cylindrical in shape. (2) Presence of ligular process or auricle on one shoulder. (3) Prominent and broad root ring. (4) Striking yellow colour.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
14 to 15.5	12 to 13	18.5 to 19

(5) *White Transparent.*

Habit.—It is a medium, tall, thick cane, has medium tillering capacity, requires from $11\frac{1}{2}$ to 12 months for ripening and it arrows profusely.

Colour.—Is from pale yellow to greenish yellow in majority of cases, and in few cases light pink or blue shade is observed.

Internode.—It has light wax all over the surface and is nearly cylindrical in shape; black incrustations are also present.

Growth ring.—Is distinct and slightly elevated; it is from 2 to 3 m.m. broad and in colour is pale yellow to deep yellow.

Root ring.—Is distinct but not elevated, its colour varies from greenish yellow to light yellow or even dark green, is 7 to 9 m.m. broad having three to four rows of root dots, which are smaller in size and fairly numerous.

Leaf scar.—Is squarrose and obliquely placed to the stalk.

Wax ring.—Is depressed and covered with dense wax, colour underneath the wax is leaf green.

Eye bud.—Is fairly broad and is ovate, subacute to acute in shape, flanges and hairy patches are well marked, apicobasal angle is half way between base and apex, point of germination is apical.

Channel.—Is narrow and indistinct and extends over $\frac{2}{3}$ the surface of the internodes, is broad at base and is gradually narrowing upwards. In certain cases the channel is well pronounced.

Leaf.—Sheath is covered with sharp stiff hairs or spicules, after drying it keeps on partially attached to stalk but is easy to be stripped. Leaf blade is coloured green, lannate at the throat about $2\frac{1}{2}$ inches broad and spreading on the sides.

Distinguishing characters.—Colour of the internode greenish yellow and its shape is cylindrical. Stalk gradually narrows from the base to the top. Eye buds rather flat, ovate subacute.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5C.
15 to 17	11.5 to 13	20 to 21

(6) *Waxy Red.*

Habit.—It is an erect (sometimes slightly reclining), tall, medium, thick cane. It does not tiller profusely, arrows freely and ripens in $11\frac{1}{2}$ to 12 months.

Colour.—Is reddish purple, covered with dense bloom or wax all over the surface of the internode giving waxy red colour. In the covered part of the internode the colour is purplish green.

Internode.—Is very nearly cylindrical in shape, and the stalk is continuous and not zigzag. Black incrustations present.

Growth ring.—Is distinct and slightly elevated, when covered it has pale yellow colour and where exposed purple. It is 2 to 3 m.m. broad.

Root ring.—Is 6 to 7 m.m. broad, prominent but not elevated. When covered it is pale yellow with a shade of purple and when exposed, dark purple; numerous root dots are present in three to four rows.

Leaf scar.—Is obliquely placed to the stalk having presence of rough processes.

Wax ring.—Is slightly depressed and is covered with dense wax.

Eye bud.—Is ovate, subacute to acute, has prominent flanges with hairy patches present. Apicobasal angle is half way between the base and the apex, but is longer than broad.

Channel.—Is not marked, and when seen it extends to about half the length of the internode.

Leaf.—Sheath has spicules on the entire surface, is partially attached to stalk, but easy to be stripped. The leaf blade is about $2\frac{1}{2}$ inches broad and densely lannate at the throat, the colour is green.

Distinguishing characters.—(1) Presence of waxy coat on the entire surface of the internode. (2) Shape of the internode cylindrical. (3) Presence of black incrustations.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
13.5 to 15	11 to 12	19 to 19.5

(7) *B. 1523.*

Habit.—It is an erect (sometimes reclining), tall, thick cane. It does not arrow usually, has got medium tillering capacity. It ripens at $11\frac{1}{2}$ to 12 months.

Colour.—Is purple in varying intensities.

Internodes.—Is nearly cylindrical in shape, has light coating of wax, with black incrustations on the upper part near the wax ring. It is bulging at the upper part in some cases, but is constricted at the node. The stalk is strongly zigzag.

Growth ring.—Is slightly elevated on the opposite side of the bud, 2 to 4 m.m. wide.

Root ring.—Is dark brown in colour and 6 to 8 m.m. broad, dirty yellow coloured root dots, medium in number, are present in three rows.

Leaf scar.—Is prominent, obliquely placed to the stalk, and slightly squarrose.

Wax ring.—Is coated with dense wax giving blackish appearance.

Eye bud.—Is broad, triangular, ovate and big in size. Flanges present with prominent hairy patches. Apicobasal angle is $\frac{1}{4}$ th the distance between the base and the apex. The apex extends beyond the growth ring.

Channel.—Is prominent, broad, but shallow and extends all over the internode.

Leaf.—Sheath does not completely envelope the internode, and remains adhering partially. Spicules are present with coating of slight wax. Sheath is pinkish green in colour, leaf blade is about 2 inches broad, light green in colour and has serrated margin.

Distinguishing characters.—(1) Zigzag nature of the stalk. (2) Broad and shallow channel extending throughout the length of the internode. (3) Fairly big sized bud which is triangular and ovate.

Composition —

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
13 to 15	11.5 to 12.5	18 to 19.

(8) *B. 208.*

Habit.—It is an erect, medium in height (5 to 7 feet), thick cane (1.2" to 1.6" in diameter). It has medium tillering and ripens in $11\frac{1}{2}$ to 12 months.

Colour.—Is dirty green or bottle green. It may even be described as mango green.

Internodes.—Have sides constricted at nodes, are bulging evenly, and are cylindrical in shape, ivory or corky markings near the wax ring are present in rare cases, in exposed internodes colour is dirty green, and where covered, yellowish green. Very light wax on the surface of internodes.

Growth ring.—Is prominent and elevated, in exposed internodes, colour is purplish with shade of light green and in covered internodes greenish yellow with shade of purple.

Root ring.—Is distinct, having the back ground colour of internodes slightly yellowish purple, root dots in three rows, relatively numerous and large in size.

Leaf scar.—Is distinct, obliquely placed and depressed below the eye bud, with promiscuous hairy fringe. It does not touch the eye bud.

Wax ring.—Has profuse wax; underneath the wax the colour is the same as the internode.

Eye bud.—Sub-hemispherical, ovate, medium in size; has prominent flanges; basal patches present; hairiness at apex; edges sparingly hairy. It is very slightly longer than broad; apicobasal angle at about half way from the base or is slightly beyond it.

Channel.—Is nearly absent; if present it is indistinctly marked, slight depression near the eye-bud is noticed.

Leaf.—Has serrations going in upwards direction; sheath is profusely covered with bristles. Semi-adherent to the stalk, and not completely dropping.

Distinguishing characters.—Distinct tumorous appearance on the opposite side of the bud. Soft hairy fringes or circle of hairs at the leaf scar.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
14 to 16	11.5 to 13.5	19.5 to 20.5

(9) *Manjav.*

Habit.—It is erect, thick cane and not very tall. Tillering is medium and arrowing is sparse to medium, ripening takes place at 11 to 11½ months.

Colour.—Is greenish yellow to yellowish green with an admixture of light shades of blue and pink.

Internode.—Has light wax over the surface of internode; black incrustations are present; stalk is very slightly zigzag; internodes have a slight uniform bulge and are nearly cylindrical in shape.

Growth ring.—Is distinct and very slightly elevated, 2 to 3 m.m. broad, colour varies from green to greenish yellow.

Root ring.—Is from 6 to 8 m.m. broad and in colour is pale yellow to greenish yellow; has three to four rows of root dots fairly numerous.

Leaf scar.—Is obliquely placed with a depression below the eye bud and is protruding out prominently.

Wax ring.—Is prominent, with a slight depression, colour underneath the wax is pale green to green.

Eye bud.—Is medium in size, ovate and subacute in shape, having broad and prominent flanges, hairy patches at the base are present, also it is hairy at the apex, apicobasal angle is half way between base and apex.

Channel.—Varies according to the character of the eye bud, is distinctly marked to nearly absent.

Leaf.—Leaf sheath is partially adhering on drying, sheath is covered with sharp, stiff hairs, breadth of lamina is 1½" to 2" broad. It is hairy or lannate at the throat, and has a short auricle or ligular process on one shoulder only.

Distinguishing characters.—(1) Its characteristic is yellowish green colour with shades of blue and pink. (2) Juicy appearance of stalk. (3) Presence of short auricle on one shoulder. (4) Leafsheath partially adhering and easy to strip.

Composition of cane—

Cane.	Juice.
Sucrose, per cent.	Degrees Brix 17.5 C.
13.5 to 14.5	19 to 20.
Fibre, per cent.	
11 to 11.5	

(10) *H. M. 544.*

Habit.—It is tall, thick, erect cane, has medium tillering capacity, does not arrow and requires from 12 to 12½ months to ripen.

Colour.—Is yellow or greenish yellow; where exposed pink or purplish colour develops due to exposure or partial removal of sheaths.

Internode.—Is slightly enlarged at the base than at the top, nearly cylindrical in shape, wax on the surface of internode is absent, stalk is slightly zigzag, black incrustations are present.

Growth ring.—Is 4 to 5 m.m. broad and distinctly elevated, colour is greenish yellow and some times blended with pink or light red.

Root ring.—Is 9 to 10 m.m. broad and distinct; colour varies from light yellow to yellow with a shade of purplish red in some cases. It has three to four rows of root dots, fairly large in size but not very numerous.

Leaf scar.—Is placed rather obliquely to the stalk.

Wax ring.—Is slightly depressed and covered with dense wax; colour underneath the wax is dirty green or purplish green.

Eye bud.—Is medium in size, oval to ovate in shape, has prominent hairy patches at the base and hairs at the apex, flanges are not big in size, but are slightly pink in colour. Apicobasal angle is half way between the base and the apex and extends up to or a little beyond the growth ring.

Channel.—Is mostly absent and in exceptionally rare cases it extends over half the surface of the internode.

Leaf.—Leaf sheath is covered with sharp stiff hairs or spicules and is indifferently or partially adherent in such a way that the triangular patches in the internodes are exposed where a sort of pink colour is developed; vestige of ligular process present; lamina is hairy at the throat, is thick and broad, light green in colour; top leaves are sub-erect, and bottom ones curving sideways.

Distinguishing characters.—(1) Internode is slightly enlarged at the base than at the top. (2) Distinctly elevated growth ring. (3) Absence of wax on the surface of the internode. (4) Yellow colour of internode with pink colour developed at the exposed surface.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix of juice at 17.5 C.
12 to 13	12.5 to 13	17.5 to 18.

(11) *H. M. 600.*

Habit.—Is erect in earlier stages; reclining at full maturity, is a tall thick cane having excellent vigour in mother canes; it tillers rather less than the average, and requires 11½ months to 12 months to ripen.

Colour.—Varies from dirty greenish yellow with a shade of dirty black to purplish or crimson. In general it is dirty greenish yellow with blackish brown shade.

Internodes.—Are longer, sides of the internodes are not in a straight line and are bulging irregularly, stalk is zigzag and has light wax on the surface of the internodes and black incrustations.

Growth ring.—Is very distinct and elevated 3 to 5 m.m. broad, colour is light dark brown where exposed and greenish yellow with a shade of purple where covered by the sheaths.

Root ring.—Is distinct, broad, depressed and has three to four rows of root dots; colour of root ring is pale yellow or light reddish purple, and that of root dots is whitish, root dots are bigger in size and medium in number.

Leaf scar.—Is placed obliquely to the stalk having rough spreading processes.

Wax ring.—Is slightly depressed, and covered with dense wax, colour underneath the wax is light green or yellowish green.

Eye bud.—Is from medium to large size, hemispherical in shape having a blunt and flat apex, being obtusely rounded, and has a slight bulge, hairy patches, i.e., flanges towards the upper flattened portion of the eye bud present, having a light purple shade.

Channel.—Is absent.

Leaf.—Leaf sheaths are covered with sharp hairs or spicules and light wax, they are partially adhering; the partial adherence develops a sort of light purplish colour in the internodes; lamina is 2" to 2¼" broad, being sub-erect in the top portion and curving sideways in the bottom portion.

Distinguishing characters.—(1) Prominently zigzag nature of the stalk. (2) Distinctly elevated growth ring. (3) Striking form of eye bud being hemispherical with flattened top and light purplish shade in the flanges. (4) Longer type of internode with irregular bulging.

Composition—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
12 to 12.75	12.5 to 13	17 to 17.5

(12) *S. 48.*

Habit.—Is erect and slightly reclining at full maturity, it is a tall, thin, hard cane, having profuse tillering and arrowing. It ripens in 11 to 11½ months.

Colour.—In the bottom internode is purplish red and passes on to purplish yellow in the upper internodes in streaks.

Internodes.—Shape is bi-concave to nearly cylindrical, bottom internodes being longer than the top ones, are covered with light bloom all over the surface, black incrustations are present below the wax ring here and there. Internodes have a tendency to split.

Growth ring.—Has yellow colour, and is 3 to 5 m.m. broad.

Root ring.—Is 7 to 9 m.m. broad, presenting an elevated appearance due to tubercled nature of root dots, has two to three rows of root dots of whitish colour, are fairly large in size, but are not very numerous, colour of the root ring is very light purple.

Leaf scar.—Is placed obliquely to stalk and slightly squarrose.

Wax ring.—Is broad and very slightly depressed, colour underneath wax is light purple or greenish purple.

Eye bud.—Is medium size, ovate and acute in shape, hairy patches present, flanges prominent. It extends up to the growth band or slightly beyond it, apicobasal angle at $\frac{1}{4}$ to $\frac{1}{3}$ the distance from the base of the bud. Point of germination is apical.

Channel.—Is distinctly marked and shallow and sometimes broad.

Leaf.—Leaf sheaths are covered with sharp stiff hairs, keeping partially adherent, and are easy to strip, covered with light wax, lamina is sub-erect to erect in top portion and curving sideways in the bottom portion $1\frac{1}{2}$ to $1\frac{3}{4}$ inches broad.

Distinguishing characters.—(1) Fairly long basal internodes. (2) Its purplish red colour. (3) Splitting tendency of internodes. (4) Ovate and acute shape of the bud. (5) Tubercled appearance of root dots in the root ring.

Composition —

Cane		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
13 to 13.5	18 to 19	19 to 19.5

(13) *Cavangerie*.

Habit.—It is an erect, tall, thick, moderately soft cane, has medium tillering capacity, requires 14 to 16 months to fully ripen, when grown as a 12 months' crop it is seldom or never arrows, but arrows when kept late in the season.

Colour.—Is of dark wine or greenish red and has longitudinal greenish black stripes.

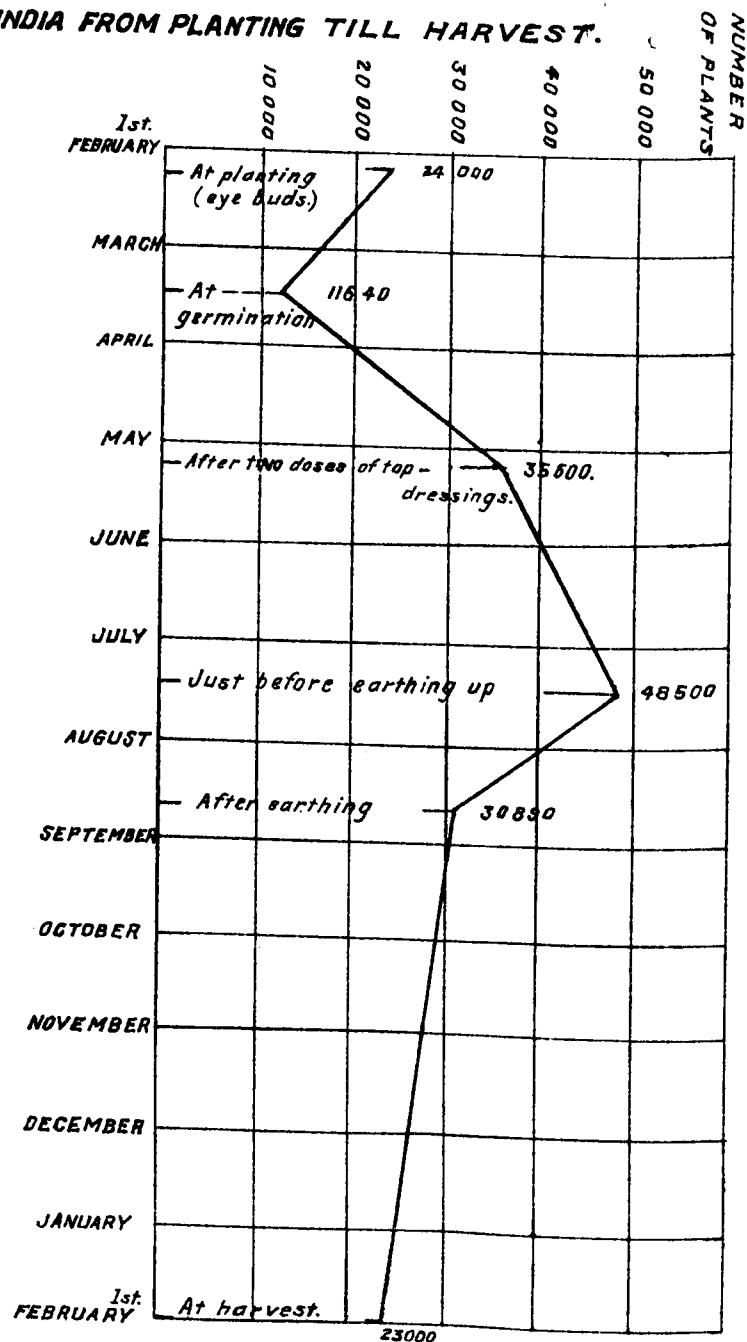
Internodes.—Are nearly cylindrical in shape and of medium length, stalk is nearly cylindrical, corky longitudinal markings near wax ring are present.

Growth ring.—Colour is yellow with a shade of red and is elevated, is 2 to 4 m.m. broad.

Root ring.—5 to 7 m.m. broad, rather depressed, colour is light yellow with a shade of red, has whitish yellow root dots, which are numerous, but of small size. These are arranged in three to four rows.

Leaf scar.—Is obliquely placed to the stalk and is slightly squarrose.

GRAPH SHOWING THE TILLERING OF
PUNDIA FROM PLANTING TILL HARVEST.



This graph shows the tillering habit of Pundia cane from the date of planting till harvest. The figure at planting shows the number of eye buds planted.

Eye bud.—Is ovoid to ovate and sub-acute in shape, set in a depression in the root ring and extends up to the growth band or below it, hairy patches are present, flanges or margins are scarcely perceptible, in the lower internodes the buds are bit darker in colour and in the upper internodes they have margin of light red colour.

Channel.—Is absent.

Leaf.—Leaf sheaths are covered with stiff hairs or spicules, keep on partially adhering to stalk and are easy to strip, colour of sheath is reddish green and has whitish longitudinal stripes, lamina is broad and has the tips growing erect.

Distinguishing characters.—(1) Red colour of cane with longitudinal green black stripes on the leaf sheaths, with white streaks in the lamina. (2) Typically plump and short bud set in a depression in the root ring.

Composition.—

Cane.		Juice.
Sucrose, per cent.	Fibre, per cent.	Brix at 17.5 C.
11 to 13	13 to 15	16.5 to 18.

IV. EXPERIMENTS WITH TILLERING, ROOT SYSTEM AND ARROWING.

(a) *Tillering.*—Though tillering, of any variety of cane, is affected by environmental conditions, varieties show different capacities in tillering when raised under the same conditions. Apart from the effect of tillering on the total yield of cane, a variety which has a sufficient number of tillers on all sides does not lodge and is found to stand storms better. Comparative study of the tillering capacities of the varieties under trial for the year 1924-25 is presented in the following table No. 5.

TABLE No. 5.

Table giving actual counts of the number of canes at different periods of growth.

Name of variety.	1st counting, 1½ month after germina- tion. No. per acre.	2nd counting, 3 months after, before earthing up. No. per acre.	3rd counting, 7 months after earthing up. No. per acre.	4th counting, 11½ months after, at harvest. No. per acre.
Pundia ...	7,686	26,020	27,270	20,160
Red Sport ...	12,620	36,980	36,660	28,430
D. 109 ...	14,180	43,400	40,440	26,620
Java ...	10,630	36,810	33,060	24,030
White Transparent ...	16,590	49,480	35,500	23,430
Waxy Red ...	14,710	45,020	37,990	25,270
B. 1528 ...	12,770	41,640	39,400	24,030
B. 208 ...	11,310	43,660	41,640	22,300
Manjav ...	11,340	39,750	29,520	21,680
H. M. 544 ...	5,980	33,970	37,610	22,350
H. M. 600 ...	6,186	21,280	28,910	18,310
S. 48 ...	14,080	78,810	59,130	47,880

Per acre figures have been calculated on the counts taken from two representative rows (1/20 acre) of each of the plots.

The above figures show that the stand of cane varies very much from the time of germination to harvest, *i.e.*, at different periods of growth. It can be better seen from the Table No. 6, which gives the ratios of the counts to the number of eye-buds planted; in other words the percentages of living plants in each case and their proportion is found out from the actual number of plants during the different periods of growth in percentages.

TABLE No. 6.

The ratios of counts to the number of eye buds.

Name of variety.	Buds planted.	1st counting, 1½ months after planting, <i>i.e.</i> , germina- tion.	2nd counting, 3 months after planting (before earth- ing up).	3rd counting, 7 months after planting (after earthing up).	4th counting, 11½ months after planting at harvest.
		per cent.	per cent.	per cent.	per cent.
Pundia ...	100	31.7	108.5	113.6	84.0
Red Sports...	100	53.8	154.1	152.7	118.4
D. 109 ...	100	54.4	180.8	168.5	110.9
Java ...	100	45.8	153.4	137.7	100.16
White Trans- parent ...	100	67.8	206.2	147.9	97.6
Waxy Red ...	100	58.1	187.6	158.3	105.3
B. 1528 ...	100	47.0	173.5	164.1	100.1
B. 203 ...	100	43.9	181.9	173.5	92.9
Manjav ...	100	48.4	165.6	123.0	90.3
H. M. 544 ...	100	24.6	141.5	150.6	93.1
H. M. 600 ...	100	24.8	101.1	120.5	76.3
S. 48 ...	100	54.6	328.3	246.4	199.3
Cavangerie...	100	...	...	...	106.2

Though there is a great variation in the counts at germination, before earthing up and after earthing up, the total number at harvest is nearly the same except in the case of H.M. 600 and S. 48. In the case of H.M. 600 tillering is low, while in that of S. 48 it is very high.

In the case of H.M. 600 and S. 48 the total weights of cane per acre are nearly the same. It is accounted for by the thickness and the higher growth of cane in the case of H.M. 600, and by the thinness and higher number of canes in that of S. 48. This will be clear from the ratio of the buds planted to plants at harvest, for the last two varieties in Table No. 7 which gives the relation of number to weight.

J311-221
6125

TABLE No. 7.

The relation of the number of plants to weight.

Name of variety.	Number of canes at harvest per acre.	Weight of stripped canes per acre in lbs.	Ratio of the number of plants at harvest to weight of stripped canes.
Pundia	20,160	58,539	100:290.4
Red Sports	28,430	79,492	100:279.6
D. 109	26,620	83,760	100:303.3
Java	24,030	67,119	100:279.3
White Transparent	23,430	66,422	100:283.4
Waxy Red	25,270	62,037	100:245.4
B. 1528	24,030	75,825	100:315.5
B. 208	22,300	63,979	100:286.9
Manjav	21,680	56,794	100:261.9
H. M. 544	22,350	90,086	100:403.0
H. M. 600	18,310	71,053	100:388.0
S. 48	47,880	75,365	100:157.4

This shows that the weight of individual canes in the case of S. 48 is low and that it tillers and makes up the defect in weight, while in the case of H. M. 600, since the weight of the cane is high, the low tillering is compensated by the high weight of the cane.

The comparison of the ratio of the mother plants to tillers will give an idea of the variation that exists in different varieties. In the following Table (No. 8) are given the ratios of the mother canes to tillers. The mother canes are taken as the number which is obtained at the germination count and the borer attack, &c., is not taken into consideration.

TABLE No. 8.

The ratios of the mother canes to tillers.

Name of variety.	Total number of canes at germination per acre.	Total number of canes at harvest per acre.	Total number of growing tillers per acre.	Ratio of mother canes to tillers.	Number giving grade of tillering.
Pundia	7,636	20,160	12,474	100:162.2	4
Red Sports	12,620	28,430	15,810	100:125.3	6
D. 109	14,180	26,620	12,440	100:87.74	10
Java	10,630	24,030	13,400	100:126.1	5
White Transparent	16,590	23,430	6,840	100:41.25	12
Waxy Red	14,710	25,270	10,560	100:71.78	11
B. 1528	12,770	24,030	11,260	100:88.22	8
B. 208	11,310	22,300	10,990	100:97.25	7
Manjav	11,340	21,680	10,340	100:89.8	9
H. M. 544	5,980	22,350	16,370	100:273.7	1
H. M. 600	6,186	18,310	12,124	100:195.9	3
S. 48	14,080	47,880	33,800	100:240.1	2

The ratio of mother canes to tillers at harvest is an important factor as the weight of cane depends upon the number of tillers and their development. Except in the case of thin varieties like S. 48, the ratio of mother cane to tillers can be said to be better when it lies between 100 to 150 or 200.

These tables suggest that in the case of varieties with low tillering, the planting will have to be made closer than in the case with varieties tillering freely. This was tried with Manjav, and thick planting has given better results, when tried at Kopargaon. Some of the varieties have given a lower number of canes per acre or a lower ratio of tillers to mother canes and yet their outturns are comparatively high. This is explained by the thickness and length of the cane.

(b) *Root system*.—In course of these experiments, once on the 17th October 1924 a hail storm accompanied with strong and beating showers (with 1.83 inches of rain in three-quarters of an hour) occurred. At this time all the exotic varieties except B. 208 and Manjav lodged. B. 208 withstood the storm as well as the local Pundia, and Manjav partially.

An attempt was, therefore, made to study the causes. Red Sports, D. 109 and S. 48 being tall and reclining, and perhaps with a comparatively weaker root system, suffered most. Java, Waxy Red and B. 1528, though erect, are tall and the effect of the storm on these was slightly less disastrous. Manjav is not very tall, any how it did not suffer much; it was only partially lodged. B. 208 is thick, erect, and not very tall and has deep spreading roots. It did not suffer at all. Pundia, though thick and tall and slightly reclining, and has not a stronger root system; it has well balanced tillering, and hence it could withstand the storm admirably.

To get some idea of the root system of these varieties, the following procedure was adopted. After the crop was harvested by cutting canes flush to the ground, the stools were cut out by digging a pit four feet long by four feet wide and three feet deep around the stool (formed of a set having three eye buds). The soil was washed away carefully removing the earth and measurements were taken. The measurement* of the roots and the observation of their behaviour made us believe that the root system has much to do with the lodging tendency of sugarcane, and therefore, a more elaborate study of the root system of cane has been undertaken since this year (1925), on lines similar to those suggested in the *Agricultural Journal of India*, Vol. XIX, Part V, pages 514 to 519, by Rao Saheb T. S. Venkatraman. This study is expected to throw more light on the subject.

(c) *Arrowing*.—The flowering or arrowing as it is called in the case of sugarcane is an indication of maturity of the plant. It may be remembered at the same time that the cane plant being propagated by sets (and not from seed) except for breeding work, it has largely lost its power of propagation by seed and some varieties do not flower at all, or flower very rarely. In the Deccan, out of 343 varieties grown, 101 are

* The measurements are not given since the work was for one year, and the separation of roots could not be effected satisfactorily as such work was not contemplated beforehand.

found to flower. A very much larger number of the varieties flower in the more tropical parts of India.

The season of the year seems to have an effect on the flowering; the cold weather being the most favourable time. It is possible to get maximum growth before flowering by changing the planting time, *i.e.*, by planting early and giving more time for the plant to grow. Those varieties which flower early can be said to be early varieties. With flowering, vegetative growth stops; but for some time the sugar contents increase. If sugarcane is kept too long after it is arrowed, not only the sucrose but even the total solids fall and the cane becomes too dry to yield its maximum quantity of juice.

It is observed that the period, from the commencement of arrowing till its completion, varies from 3 to 5 weeks. When this stage (fully arrowed condition) arrives, the cane begins to ripen. To ascertain the development of ripeness in the arrowing varieties, after they are fully arrowed, these were harvested in two lots, the first test was made when the arrowing was complete, and the second when the chemical tests showed the maximum purity. The laboratory tests were taken continuously every week.

Since the condition of cane after arrowing influences the outturn of *gul*, an attempt was made to note the effects of arrowing upon the yield.

Of the twelve varieties under trial, eight, namely, Red Sports, D. 109, White Transparent, Waxy Red, B. 208, Manjav, H. M. 600 and S. 48 arrow. Out of these seven arrowing varieties the results of six have been given below.

The following table gives the results of the tests in the year 1923-24 only:—

TABLE No. 10.

The effect of arrowing on the ripening of cane in point of yield.

Name of variety.	Weight of cane.	Weight of juice.	Weight of <i>gul</i> .	Extraction. P. C.	<i>Gul</i> to juice.	Brix corrected
	lbs.	lbs.	lbs.			
Red Sports—						
Date of harvesting—						
27-12-1923	80,323	55,457	8,124	69	14.6	15.36
31-1-1924	69,360	47,872	8,132	69	17.0	16.86
D. 109—						
Date of harvesting—						
28-12-1923	70,513	49,429	7,350	70	14.8	15.01
30-1-1924	72,613	49,667	8,547	63.5	17.2	17.29
White Transparent—						
Date of harvesting—						
28-12-1923	64,581	45,210	8,014	70	17.7	18.46
23-1-1924	58,922	39,494	8,034	67	20.3	20.44
Waxy Red—						
Date of harvesting—						
28-12-1923	56,813	39,884	7,356	70	18.4	18.5
22-1-1924	56,372	38,896	7,857	69	20.1	19.78
B. 208—						
Date of harvesting—						
28-12-1923	47,539	32,557	5,671	68.5	17.4	18.34
30-1-1924	50,014	33,514	6,383	67	19.0	18.89
Manjav —						
Date of harvesting—						
26-12-1923	37,421	25,448	4,184	68	16.4	16.96
22-1-1924	46,368	30,006	5,512	66	17.2	18.26

The above figures are quite in agreement with those of this year 1924-25. The results of S. 48 for the year 1924-25 are also exactly similar.

The above results show definitely that even when the cane is harvested at the fully arrowed condition it is not ripe as the yield of *gul* goes on increasing for some period longer. The purity has been found to increase from 5 to 10 per cent. In all cases the concentration of the juice (Brix)

and consequently the quantity of *gul* is increased. The figures of *gul* were quite in accordance with the results of the chemical tests which were taken every week.

In short the results go to indicate clearly that the richness of juice (purity) does not cease when a cane field completely arrows, but it goes on increasing for a definite period which comes to about one month.

If, however, the early flowering varieties are kept too long in the field they become hard and yield of *gul* suffers.

V. CHEMICAL COMPOSITION OF CANE AND JUICE OF THE VARIETIES.

The nature of the juice of sugarcane depends upon various factors out of which the variety of cane is an important one. The juice, in different varieties, varies in purity, sucrose contents as well as in brix or total solids.

Extraction depends upon the variety of cane, its development and the nature of the rind. In the present trials cane was milled on a power plant (Manlove Alliot Make) and the figures of extraction are taken from the average for two years 1923-24 and 1924-25 from the actual quantity of juice obtained by milling the cane under field scale and usual working conditions. It is not likely that the extraction would remain constant and uniform during the whole of the working season as it is liable to change owing to variation in the adjustment of the mill, the way of feeding cane into the mill, the age at which the cane is harvested, thickness and development of the cane, condition of cane (diseased or dry condition) and the time the cane lies from cutting to milling. Even though extraction is thus liable to variation the following figures may safely be taken as fairly good average figures.

The following table gives the composition of cane and juice. The figures are the averages of two years (namely, 1923-24 and 1924-25) in the case of the first nine varieties and Cavangerie, while those of H. M. 544, H. M. 600 and S. 48 are of only one year (1924-25):—

[See next page for table.]

TABLE No. 11.

Chemical composition of cane and juice.

Name of variety.	Extraction per-centage.	Composition of cane.		Composition of juice.					Number in order of merit of purity.
		Percentage of sucrose.	Percentage of fibre.	Brix.	Percentage of sucrose.	Percentage of reducing sugar.	Glucose ratio.	Purity.	
Year 1923-24.									
Pundia	71.6	13.52	10.10	19.53*	17.43	1.36	7.82	89.20	
Red Sports	68.9	11.55	11.8	18.08	15.63	1.77	11.32	86.41	10
D. 109	68.4	11.36	11.33	16.30	13.37	2.04	16.04	81.98	12
Java	64.4	13.83	12.79	16.3	13.38	2.02	15.10	82.10	13
White Transparent	67.7	14.78	11.65	18.02	16.30	1.21	7.42	90.44	6
Waxy Red	67.8	14.24	11.24	19.08	17.36	1.04	5.98	91.11	4
B. 1528	65.4	12.54	15.13	18.82	16.63	1.36	8.18	88.35	
B. 208	64.9	14.02	13.15	17.05	15.31	1.17	7.64	89.82	8
Manjav	69.6	14.29	9.61	18.89	17.33	0.88	5.08	91.70	2
Cavangerie	66.6	11.29	12.64	18.23	16.59	1.23	7.41	91.01	3
				16.69	13.86	1.59	11.48	83.05	11
Year 1924-25.									
H. M. 544	62.4	12.91	13.74	17.49	15.8	1.23	7.78	90.33	5
H. M. 600	62.6	12.65	12.90	17.38	15.21	1.43	9.40	87.5	9
S. 48	55.7	13.28	19.78	19.24	18.02	0.51	2.82	93.68	1

* The first figures given for Pundia are the right ones for the composition of juice, since Pundia is harvested at its ripening time, i.e., 12 months, while the figures in the next line have been arrived at when Pundia was harvested along with other varieties under trial, i.e., at 11½ months.

From the above figures it will be seen that the lower the fibre contents the higher is the extraction percentage from sugarcane. Even while comparing the composition of several varieties it can be said that where the fibre is low, the extraction is usually high. For example, Manjav and Pundia which have the least percentage of fibre have given highest percentage of extraction, while S. 48 having highest percentage of fibre has given the lowest percentage of extraction.

In the composition of the juice a higher Brix reading (total solids) shows a higher concentration of juice which is a great advantage from the point of *gul* making. When the total solids present contain a greater amount of sucrose (crystallisable sugar) the purity (ratio of sucrose to total solids) is high, which is the criterion for judging the quality

and richness of juice. In the order of merit of purity they stand with S. 48, leading, as will be seen from the gradation number given in the last column. The higher is the amount of reducing sugars or glucose (uncrystallisable sugar) present lower is the quality of juice. The higher amount of reducing sugars yield soft *gul* and hence the least percentage of these sugars is most favourable for getting a better quality of *gul*. The percentage of reducing sugars should not exceed more than 1.5 generally and therefore the two varieties, namely D. 109 and Red Sports, are much below the mark. From the above figures it will be seen that Pundia has got all the good qualities, while some of the others possess one or more of the advantageous points. Most of the red types (except Waxy Red) yield juice of low Brix, higher percentage of reducing sugars, low purity and hence the quality of the juice of coloured canes on the whole is poor when compared with that of thick greenish yellow canes.

Since *gul* is the final object with almost all the cane growers in the Bombay Presidency, the amount and quality of *gul* is the important factor from the economic point of view. To get higher amount of *gul*, the richness and purity of the juice, as also the ratio of *gul* to juice, must be high. To obtain both highest amount and best quality of *gul* the juice must necessarily be of higher Brix and higher purity.

There is generally a fixed proportion between the Brix reading of the juice and the quantity of *gul* obtained from it (the quantity of *gul* is slightly less, about 1 per cent. than the Brix).

Brix is therefore always taken as a basis for finding the *gul* contents. However, it may be noted that there are other factors (such as the presence of albuminoids, suspended impurities, &c., in variable quantities) which may affect the relation or the proportion between the Brix reading and the quantity of *gul*. If we take two juices of the same Brix but of different composition, one with less albuminoids and higher purity, it will invariably yield more *gul* since the quantity of scum removed in such a case is less.

The following table gives the ratio of *gul* to juice with the description of the quality of *gul*.

Average figures of two years (1923-24 and 1924-25) in the case of first nine varieties and Cavangerie, and of one year

(1924-25) only in the case of H. M. 544, H. M. 600 and S. 48 are taken in the preparation of the following table:—

TABLE No. 12.

Ratio of *gul* to juice and quality of *gul*.

Name of variety.	Weight of cane in lbs. per acre.	Weight of juice in lbs. per acre.	Corrected Brix reading (at 17.5 C.).	<i>Gul</i> in lbs. per acre.	Ratio of <i>gul</i> to cane per cent.	Ratio of <i>gul</i> to juice per cent.	Quality of <i>gul</i> (giving Poona Market grades).
(1923-24 and 1924-25)							
Pundia	53,232	38,154	18.03	6,518	12.24	16.9	No. I Hard, golden yellow and crystalline.
Red Sports	77,171	53,190	16.63	8,551	11.08	16.6	No. II Reddish, slightly soft, semi-crystalline.
D. 109	76,162	52,143	16.30	8,331	10.94	16.0	No. II Do.
Java	65,393	42,195	18.03	7,334	11.21	17.3	No. I Yellowish, hard, crystalline.
White Transparent.	64,092	43,458	19.08	8,105	12.64	18.7	No. I Yellow, hard and crystalline.
Waxy Red	61,045	41,680	18.82	7,760	12.71	18.6	No. I ₂ Reddish, hard and highly crystalline.
B. 1528	67,649	44,806	17.05	7,788	11.51	17.4	No. I ₂ Do.
B. 208	55,302	36,211	18.68	6,696	12.08	18.3	No. I ₂ Yellowish Do.
Manjav	49,344	34,464	18.23	6,223	12.62	17.7	No. II Yellowish slightly soft and semi-crystalline.
(1924-25)							
H. M. 544	50,086	56,273	17.49	9,003	10.10	16.1	No. II Yellowish, soft and semi-crystalline.
H. M. 600	71,053	44,523	17.38	7,629	10.85	17.0	No. II Do.
S. 48	75,365	41,901	19.21	7,805	19.18	18.8	No. I Reddish yellow, hard and highly crystalline.
(1923-24 & 1924-25)							
Cavangerie	62,822	41,883	16.51	6,674	10.62	15.9	No. III Reddish black, soft and semi-crystalline.

Judging from the percentages of *gul* to juice, and the quality of *gul*, it can be seen that D. 109, Red Sports, H. M. 544, H. M. 600 and Cavangerie rank below Pundia; S. 48, White Transparent and Waxy Red rank above Pundia; while others, namely, Manjav, B. 1528 and Java, approach Pundia in quality.

There is no doubt that quality of *gul* makes a difference in the market prices. Yet the total yield per acre makes considerably more difference in the gross value. The yield of *gul* of D. 109 and others are much higher than that of Pundia (as is seen from the above table) and consequently their defects in quality are more than compensated by the higher yields per acre. This will be more clearly seen from the figures of performances given in the next chapter.

The complete data regarding chemical composition is given in Appendix A.

VI. PERFORMANCES.

(a) *Comparison of yields.*—The main idea of the whole series of comparative trials was to try to find varieties equal to or better than Pundia. In all 13 varieties were tried. Out of the thirteen, ten, namely Pundia, Red Sports, D. 109, Java, Waxy Red, White Transparent, B. 208, B. 1528, Manjav and Cavangerie, were tried for five years, while H. M. 544, H. M. 600 and S. 48, being introduced later in the series, were tried only for one year. The first table gives the performances of the ten varieties taking the average of the results of five years, while the second gives the performances of the three varieties tried for one year only.

The following tables give the actual produce of cane and *gul* per acre, with points for the weight of cane and *gul* taking Pundia as 100 for comparison.

TABLE No. 13.

Comparative value of the outturn (Pundia 100).

Name of variety.	Weight of cane in lbs. per acre.	Weight of <i>gul</i> in lbs. per acre.	Points taking Pundia 100.		Number in order of merit when weight of cane is considered.	Number in order of merit when weight of <i>gul</i> is considered.
			When weight of cane is considered.	When weight of <i>gul</i> is considered.		
Pundia	57,942	6,475	100	100	8	9
Red Sports	86,696	8,028	149.6	137.9	1	2
Java	65,802	6,526	113.6	100.8	5	8
D. 109	84,450	9,025	145.9	139.4	2	1
White Transparent	59,012	6,724	101.8	103.8	7	6
Waxy Red	63,250	6,970	109.2	107.6	6	5
B. 1528	68,220	7,761	117.7	119.9	4	4
B. 208	54,329	5,928	93.7	91.6	10	10
Manjav	56,040	6,628	96.7	102.4	9	7
*Cavangerie	74,883	7,965	129.2	123.0	3	3

*Plot was smaller as compared to others throughout the experiment.

The above figures show clearly that D. 109, Red Sports, B. 1528, Waxy Red and Cavangerie are decidedly better in outturn of cane and *gul* to Pundia (the standard which is taken for comparison). The numbers of the order of merit

for cane and *gul* show how these and others stand in comparison.

TABLE No. 14.

Comparative value of outturn (Pundia 100).

Name of variety.	Weight of cane in lbs. per acre.	Weight of <i>gul</i> in lbs. per acre.	Points taking Pundia as 100.		Number in order of merit when weight of cane is considered.	Number in order of merit when weight of <i>gul</i> is considered.
			When weight of cane is considered.	When weight of <i>gul</i> is considered.		
Pundia	58,539	7,451	100	100	4	4
H. M. 544	90,086	9,098	153.8	121.5	1	1
H. M. 600	71,058	7,609	121.8	102.1	3	3
S. 48	75,365	7,895	128.7	105.9	2	2

The figures of Pundia are of the same year as those of others.

The three varieties given in the above table show great promise. In the first year of their comparison, all of them beat Pundia while H. M. 544 takes the first place when compared with the others in Table No. 1. These varieties are not included in the first table since for such comparison further trial is necessary.

The results in the above tables can be seen better illustrated from the graph given below:—

PLATE VI

COMPARATIVE VALUE OF THE VARIETIES
IN POINT OF WEIGHT OF CANE.

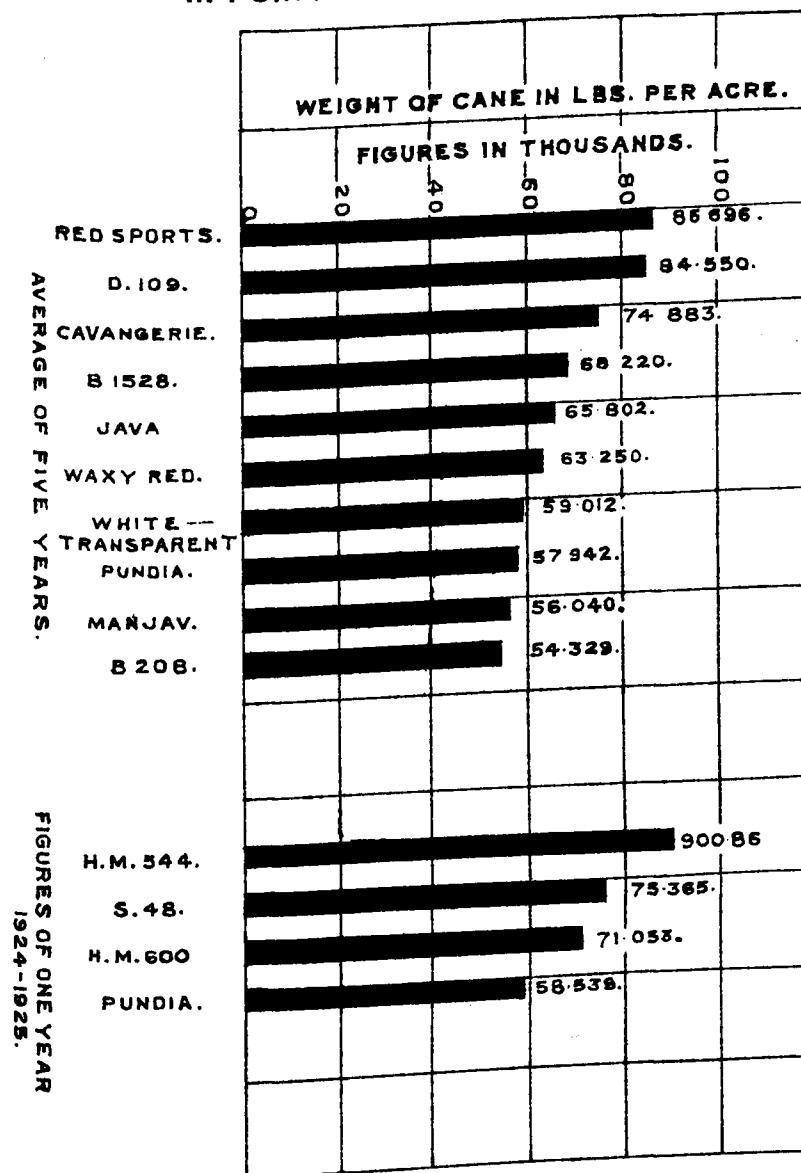
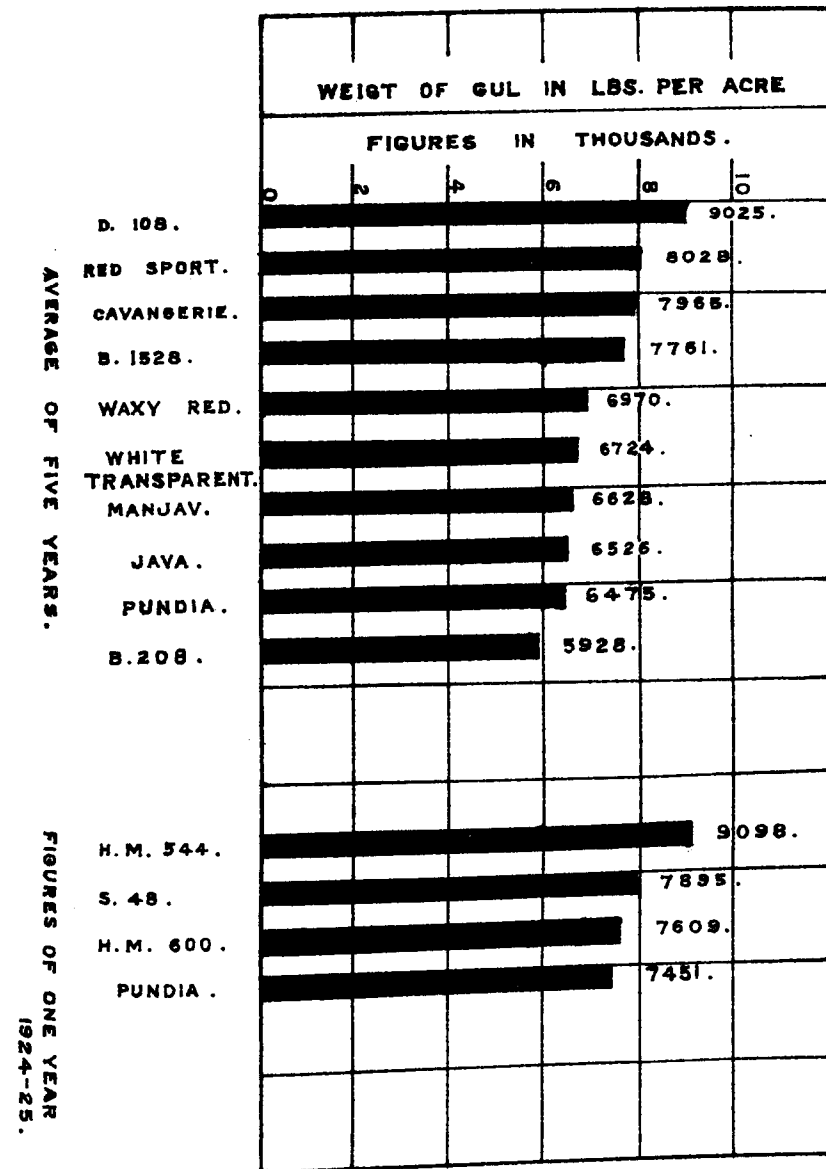


PLATE VII

COMPARATIVE VALUE OF THE VARIETIES IN POINT OF WEIGHT OF GUL.



So far we have considered the varieties on the following points, such as their root system, tillering habit, arrowing, composition (both of cane and juice), outturn (of cane and *gul*) and quality of *gul*, &c. From the cane growers' point, however, the crucial test is the money value of the *gul* yielded by the different varieties. This is necessary because the money value is influenced by the amount as well as by the quality of *gul*. Quality of *gul* is judged mostly by its colour, hardness and crystalline nature. Before attempting to visualize the comparative money value, it is necessary to give a short explanation of the grades of *gul* and the unit at which *gul* is sold in the Poona market.

Grade.—*Gul* of No. 1 grade should have golden yellow colour, must be hard and quite crystalline. If only the colour is not golden yellow the grade gets No. 1½. Prominent defect in any of the three principal characters reduces the grade by one. Generally *gul* is graded into Nos. 1, 1½, 2 and 3. No. 1½ many times merges into No. 2. *Gul* made from the second scum or any black coloured *gul* of that nature may be graded as No. 4 or even 5. The price of *gul* varies with the grade. If No. 1 *gul* is valued at Rs. 30 per *palla* No. 1½ gets Rs. 29-8-0, No. 2, Rs. 28-8-0 and No. 3, Rs. 27 and so on. Slight differences are not unusual.

Unit.—*Gul* is sold by the weight of a *palla* or *atki*. The weights of the *palla* and *atki* vary in different markets. At Poona the weight of the *palla* can be taken as 252 lbs. (really speaking the weight of the *palla* is 240 lbs., but since the deductions named *kadta**, *soot*†, &c., come to 12 lbs. the net weight comes to 252 lbs.). Of late the prices of *gul*, from year to year and also in different seasons of the year, fluctuate violently. In arriving at the money value of *gul* of different varieties Rs. 30 per *palla* for first grade (number one) is taken as the basis for calculating the money returns.

* *Kadta*—Usual excess weight allowed.

† *Soot*—Deduction allowed for inferior quality, breakage, &c.

TABLE No. 15.

Money value of the yield of gul per acre of the different varieties.

Name of variety.	Weight of gul in lbs. per acre.	Grade of gul.	Average rate per <i>pullu</i> of 252 lbs. in rupee.	Money value of gul in rupees per acre.	Number in order of merit of money value.
Pundia	6,475	1	Rs. a. p. 30 0 0	Rs. a. p. 770 13 0	9
Red Sports	8,928	2	28 8 0	1,091 11 0	2
D. 109	9,025	3	28 8 0	1,020 11 0	1
Java	6,526	1	30 0 0	776 14 0	7
White Transparent.	6,970	1	30 0 0	829 12 0	5
Waxy Red	6,724	1½	29 8 0	787 2 0	6
B. 1528	7,761	1½	29 8 0	903 8 0	3
B. 208	5,923	1½	29 8 0	693 15 0	10
Manjav	6,628	1½	29 8 0	775 14 0	8
Cavangerie	7,935	3	27 0 0	853 6 0	4

TABLE No. 16.

<i>Of one year only.</i>					
H. M. 544	9,093	2	28 8 0	1,028 15 0	1
H. M. 600	7,609	2	28 8 0	860 8 0	3
S. 48	7,895	1	30 0 0	939 14 0	2

(Figures of weight of gul are average for five years.)

The numbers in order of merit as regards receipts in the above table do not remain the same as those of outturns of gul given in table No. 13. In the case of White Transparent and B. 1528, the number rises by one, in the case of Manjav, Waxy Red, Java and Cavangerie, the number loses by one while others keep their own numbers. This change is brought about by the influence of the quality of gul. D. 109 and Red Sports have maintained their ranks owing to their higher yields.

VII. GENERAL OBSERVATIONS.

A.—IS PUNDIA DETERIORATED?

From the preceding tables it is seen that on the average Deccan Canal Soils (either heavy or tending to heavy black soils on which sugarcane finds its place) varieties like D. 109 and Red Sports far surpass Pundia. It may, however, be noted that on light soils (especially those on which cane is not grown previously) Pundia beats these varieties. The following table suggests very interesting inferences:—

TABLE No. 17.

Outturns in old and new light soils of cane.

Name of variety.	New and light soil.		Black soil and usual cane soil.		Conditions under which these are grown and remarks.
	Weight of cane in lbs. per acre.	Weight of gul in lbs. per acre.	Weight of cane in lbs. per acre.	Weight of gul in lbs. per acre.	
Pundia	106,944	13,407	58,539	7,451	All conditions were the same except that the light soil was given farm yard manure while the other had sangreen manuring. Top dressing of 150 lbs. nitrogen was equal in both cases.
Red Sports...	99,159	10,839	79,295	8,950	
D. 109	89,886	10,275	82,258	8,885	

The outturn of Red Sports and D. 109 on average heavy soils (on which the cropping of sugarcane finds its place in rotation) is more. Whereas on light soils (on which cane is newly grown) the figures of outturn disclose quite a different turn. Pundia gives more outturn than D. 109 and Red Sports.

(1) It therefore suggests that Pundia generally does better on lighter soils than on heavier soils if proper care is taken such as regularity in watering, &c.

(2) It is likely that most canal soils which are cropped with Pundia (along with the rotation crops) may be sick of the Pundia variety, since in the same soils other varieties do better.

(3) Change of variety is likely to be of advantage both on light and average (canal) soils.

Inquiries in the canal tract in the Deccan show that when a canal is newly opened, the outturn of *gul* is high, and the keeping of ratoons is generally more profitable. Steadily the yield of plant cane falls and the ratooning ceases to be profitable at all. Yields of 40 *pallas* of *gul* per acre on the Nira canals were not uncommon about twenty years ago. During recent years the average has come down to about 25 to 30 *pallas*. In the year 1923-24, which was not a bad year for sugarcane, the average of about 800 acres near Baramati came only to 27 *pallas*.

This is borne out by the fact that the Saswad Mali, who is a very keen business man, never sticks to any canal. He takes land on lease and continues there for about ten years and then shifts to another tract where a canal is newly opened.

In the Bombay Deccan, and especially on the canals; change of land is practically impossible. The most, the farmer can do, is to prevent its deterioration. If the cane is to continue (and with the high prices of land and water, he cannot find any competing crop) the only possible remedy for him is to cultivate other varieties of sugarcane. The present study is intended to find varieties to solve the difficulty. It can be said that the trials have, so far, given us at least some varieties which we can grow profitably on the land where Pundia is not yielding well.

B.—POSSIBILITIES OF EXTENSION OF THESE VARIETIES.

It has been observed that most of the selected varieties withstand drought conditions and irregularities in watering, both in quantity and interval, better than Pundia. Such irregularities are not uncommon under canal conditions. It has been found that most of the varieties ratoon well on the Deccan canals. On the Kopargaon Farm, they have ratooned better than Pundia. Several farmers on the Godavari and Nira canals have seen the varieties at Manjri and have tested these and they are extending fast. Of these varieties Cavangerie stands heavy rains better, and has already become the most popular variety of the Konkan and Kanara. Manjav, which is an early variety, is found to be very suitable for filling gaps (in Pundia) as the new canes of Manjav mature at the same time as Pundia, planted as a field crop. It is further observed that Manjav stands water logged conditions better than Pundia. Cavangerie is found to withstand salt conditions better than others.

Almost all the varieties have been found to be susceptible to the attack of mealy bugs, when such attack occurs. The ravages are not, however, so bad as to damage the crop seriously except in the case of Manjav.

Presence of smut is seen prominently in B. 208 though it has not developed into a pest. Pundia is more susceptible to red rot though of late, selection of sets has brought it under control. During recent years red rot is not much seen even in Pundia.

The attack of the borer (*Diatrea oricilia*) is common in all varieties. Observations from the experimental plots (in the seasonal planting series) indicate that the crop suffers least if the planting is done early in the season (in January and February). The crop planted late (March and April) when the conditions for the borer are more favourable, suffers most.

C.—MERITS AND DEMERITS OF THE VARIETIES.

Merits of the new varieties.—(1) All the 12 selected varieties are better yielders except two, namely, B. 208 and Manjav, which yield less weight of cane than that of Pundia, and only one, namely, B. 208, yields less weight of *gul* under the conditions of Manjri. Higher yield of produce means higher money return.

(2) Six out of twelve, namely, Waxy Red, B. 1528, White Transparent, Java, S. 48 and Manjav are higher in sucrose contents than Pundia, and hence their *gul* is quite crystalline.

(3) Seven of the selected varieties, namely, Waxy Red, S. 48, Java, White Transparent, B. 1528, B. 208, and Manjav, are higher in Brix reading and in the percentage of *gul* in juice. This means that in these cases a greater amount of *gul* is obtained from the same quantity of juice as compared with Pundia.

(4) Most of the exotic varieties withstand drought conditions, which might be caused by irregularities of watering, either in the quantity of water or interval of waterings. The effect of sudden change in climate, such as excesses of heat and cold, is not so great in the other varieties as in the case of Pundia. Thereby the growth of the crop remains continuous throughout the year.

(5) Two varieties, namely, Cavangerie and Manjav, can be grown under waterlogged conditions, while Cavangerie

flourishes under both waterlogged and salty conditions. Cavangerie has already established itself in Konkan and Karwar.

(6) One variety (Manjav) flowers early and so matures early, in $10\frac{1}{2}$ to 11 months; thereby becoming useful for filling the gaps in other varieties and for early harvesting.

(7) The arrowing varieties being early can be harvested earlier when the produce brings higher prices.

Demerits of new varieties.

(1) Eight out of twelve selected varieties, namely, Red Sports, D.109, Manjav, Waxy Red, White Transparent, B.208, H.M.600 and S.48, are arrowing. This habit makes it impossible to keep these as "*adsalya*" that is to say for a period of one and half year.

(2) In the case of eight varieties, namely, D.109, Red Sports, S.48, White Transperant, Waxy Red, B.208, Manjav and S.48, the eye buds from the top portion begin to sprout before maturity of the cane and hence the top portion of the crop is not useful for seed purposes as non arrowing canes.

(3) Six varieties, namely, Red Sports, D.109, Waxy Red, Cavangerie, S. 48 and B. 1528, which are either red or purple coloured, yield generally *gul* of reddish or reddish brown colour. This affects the quality of *gul* which fetches lower price in the market. Colour is defect from the point of *gul* making, but for sugar factories it does not affect the produce.

(4) All the varieties, except B. 208, get lodged by hail storm and high wind, while Pundia having balanced tillering does not lodge at all. Lodging affects the growth and thereby the yield. Occurrence of hail storm is, however, rare in the Deccan.

(5) Among the selected varieties, there are two varieties which are sports, namely, D. 109, and Red Sports. Since sports are supposed to be liable to go back, introduction of these should be done with caution.

(6) Two varieties, namely, Cavangerie and B.208, are thick and hard and S.48 is thin and hard. These are not easy to be milled, contain a higher amount of fibre, and give low extraction of juice.

(7) One variety, namely, Manjav, is susceptible to the attack of mealy bugs, and another, namely, B.208, to smut when compared to Pundia.

VIII. CONCLUSIONS.

Taking into consideration the outturn of *gul* and the gross money return, it can be seen that the scale of advantages in some of the varieties as Red Sports, D. 109, White Transparent, Waxy Red, B. 1528 and S. 48 is heavy enough to compensate the disadvantages when compared with Pundia. It cannot be definitely said as yet whether these varieties would be an unmixed blessing to the cultivators since the Pundia variety, that they grow, is by no means inferior when all the good qualities which are required to be present in cane are taken into consideration. Of course where the conditions of growth are unfavourable to Pundia (as is the case on many old canals) such as deficiency of water supply, waterlogged condition of the soil, &c., the introduction of some of these varieties is sure to be more profitable to the cultivators.

It is evident that to depend upon one variety is dangerous; since growing of one variety all the time is likely to result in the deterioration of that variety or in the formation of unsuitable condition of the soil for that variety. The exotic varieties here discussed are now grown under the supervision of the farms of selected cultivators on different canals of the Deccan and their results are awaited. When these are obtained it will be possible to distribute several of them on a very large scale.

The Authors would acknowledge with their best thanks the very valuable assistance they have received in accumulating the Data given in the present Bulletin, from Messrs. B. N. Bhandarkar, B.Ag. and N. B. Patwardhan, B.Ag., Assistants on the Manjri Farm.

APPENDIX A.

Performances of cane varieties in 1923-24 and 1924-25.

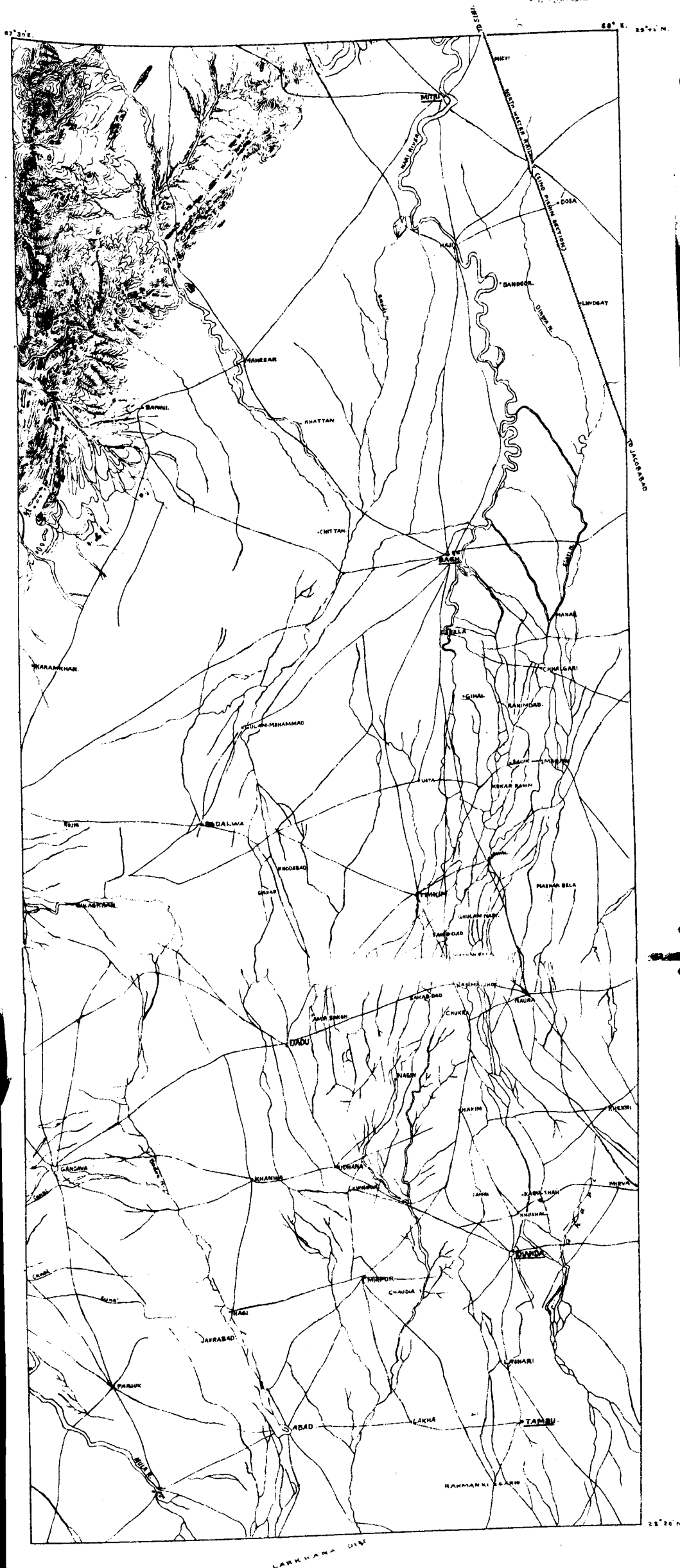
Variety. 1923-1924 and 1924-25.	Number of cane per acre.	Weight of cane in lbs. per acre.	Percentage of extraction.	Weight of gull in lbs. per acre.	Percentage of gull to cane.	Percentage of gull to juice.	Composition of cane.		Composition of megasse.		Composition of juice.			Glucose, ratio.	Purity.	Composition of gull.				
							Percentage of sucrose.	Percentage of fibre.	Percentage of sucrose.	Percentage of fibre.	Brix.	Percentage of reducing sugar.				Sucrose %.	Reducing sugar %.	Ash.	Purity.	
Red Sports	24,634	77,171	68.9	8,551	11.08	16.6	11.55	11.8	37.82	7.57	16.30	2.04	13.37	15.25	82.04	70.72	14.0	4.5	1.48	74.15
Waxy Red	23,675	61,045	67.8	7,760	12.71	18.6	14.24	11.24	34.8	9.64	16.82	1.36	16.63	8.18	88.35	74.5	12.57	5.55	1.34	78.98
White Transparent	22,167	64,092	67.7	8,105	12.64	18.7	11.78	11.65	36.22	9.41	19.08	1.04	17.36	5.98	91.11	82.81	11.11	4.55	1.24	88.75
D.D.109	25,061	76,161	68.4	8,331	10.93	16.0	11.36	11.33	35.97	7.1	16.3	2.02	13.38	15.10	83.10	69.74	12.95	3.0	1.26	71.88
B.B.1588	22,963	67,649	65.4	7,758	11.51	17.4	12.54	13.13	37.71	7.41	17.05	1.17	15.31	7.64	89.82	70.17	13.8	6.05	0.88	74.67
Java	23,276	65,393	64.4	7,334	11.21	17.3	13.83	12.79	37.51	9.03	18.02	1.21	16.30	7.42	90.44	71.27	13.19	5.75	0.88	75.61
Pundia	20,968	53,232	71.6	6,518	12.24	16.9	13.52	10.10	35.67	8.23	18.08	1.77	15.63	11.32	86.44	76.11	11.8	5.3	1.58	80.91
B.208	21,880	55,362	64.9	6,686	12.07	18.3	14.02	13.15	39.69	7.37	18.89	0.88	17.33	5.08	91.70	80.48	10.5	5.5	1.36	85.17
Manjav	21,100	49,344	69.6	6,229	12.62	17.7	14.29	9.61	31.62	8.97	18.23	1.23	16.59	7.41	91.01	71.14	18.05	4.95	1.21	74.35
Caravangerie	22,441	62,822	66.6	6,674	10.63	15.9	11.29	12.64	37.6	5.95	16.69	1.59	13.66	11.48	83.05	70.0	16.6	6.15	1.97	74.59
B. M. 544	22,350	90,066	62.4	9,098	10.01	16.1	12.91	13.74	36.55	8.12	17.49	1.28	15.8	7.78	90.33	...	...	...	...	...
B. M. 600	18,310	71,053	62.6	7,609	10.71	17.0	12.65	12.90	34.5	8.36	17.38	1.43	15.21	9.40	87.5	...	...	...	...	...
S. 48	47,765	75,365	55.7	7,985	10.59	18.8	13.98	19.78	43.27	7.84	19.24	0.51	18.02	2.82	93.68	79.16	9.45	4.7	1.67	83.08

APPENDIX B.

Temperature Record (Fortnightly Averages for 10 Years).

	April.		May.		June.		July.		August.		September.		October.		November.		December.		January.		February.		March.		Total.
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Maximum ...	102.47	104.6	103.14	101.01	98.54	88.54	84.51	82.23	81.81	82.62	87.30	88.11	90.98	91.68	89.87	87.47	87.91	86.77	88.33	88.44	90.67	93.68	96.39	100.73	...
Minimum ...	63.42	66.5	69.31	70.88	73.21	71.56	70.27	69.42	69.19	69.15	69.67	68.33	66.71	62.78	59.44	56.98	51.46	49.45	51.46	51.25	52.71	52.4	56.7	60.46	...
Humidity ...	50.53	51.2	55.34	64.7	72.65	74.9	70.7	83.15	84.05	83.31	82.65	83.42	79.15	75.05	71.84	69.50	69.02	70.02	69.32	73.64	68.81	61.33	60.42	55.2	...
Rainfall (Fortnightly averages for 21 years).	0.17".	0.35"	0.45"	0.93"	2.18"	1.84"	1.63"	2.60"	1.40"	0.84"	0.95"	3.15"	1.66"	0.97"	0.87"	0.58"	0.01"	0.02"	0.02"	0.04"	0.07"	0.06"	0.02"	0.07"	20.73"

XXV-A
208



THE BHAGNARI BREED OF CATTLE IN SIND AND BALUCHISTAN.

There is a well known breed of cattle, large and exceedingly strong, found in Upper Sind and much sought after by dealers from the Punjab, under the name *Bhagnari*. They have extended their range as a result of their suitability for agricultural, siege-train, and army transport purposes. Detailed information as to the character of this breed in its home in Baluchistan seems to be lacking, and the present account is the result of an investigation by the Government of Bombay Agricultural Department to see and study it in its place of origin. The question really before us was, in fact, how far it is possible or advisable to attempt regular breeding of this fine type of animal in Sind, and how far, if this could be done, it would be suitable for general agricultural purposes in that province.

THE HOME OF THE BREED.

The *Bhagnari* breed of cattle finds its home in the Kachhi district of the territory of Baluchistan. This district consists of a flat triangular plain with its base on the Upper Sind Frontier Districts of Sind, and is enclosed by the Marri and Bugti Hills to the east, and by the Kirthar and other mountain ranges to the west. To the north-east of its apex lies the British tract known as Sibi. The *Bhagnari illaqua* or area starts south from the village Mithri, which is twelve miles south of Sibi station and stretches along the tortuous course of the Nari river towards Kanda and Tamboo. It terminates a few miles from the border of the Upper Sind Frontier District of Sind. The line of the North Western Railway proceeding towards Quetta forms its eastern boundary, from which it stretches west to the Jhalawan hills. The town of Bhag, formerly the winter home of the Khan of Kalat and now the head quarters of the *tahsil* of that name, is situated on the Nari river and is the centre of the tract. It divides the area into two parts, the Upper or Bala Nari and the lower or Zerim Nari, and stands about 5,000 feet above sea level.

The physical characters of this area, forming the centre of the breeding of *Bhagnari* cattle are striking. It forms an

alluvial plain of recent origin, and the present alluvium has been deposited chiefly by hill torrents, and thus the soil throughout is a light loam known as *Math*, moderately mixed with sand, light, medium, and heavy stiff clay (*Khauri*) which cracks heavily on drying. The organic contents of the soil are low, as is usual in that of such an arid country. All the hill torrents run into the Nari river, and this river is dammed by a series of large earthen embankments constructed in the bed of the rivers by the co-operation of the cultivators. The most important of these dams is at Gadi twelve miles north of Bhag. It is by means of these dams that the whole tract is irrigated by heavy flood irrigation, by means of canals taken from the river. Hence the upper or Bala Nari area has the first call on the water which may be in the river.

The rainfall of the Kachhi district varies from two to five inches. The temperature in the hot weather runs up to 120° F. and sinks in winter to below 40° F. Sometimes frost occurs. In the hot weather, the country is subject to the hot wind storms known as *luk* or *jhola*, and even drinking water is scarce from March to the middle of June. Hence the climate will be seen to be very hot, dry, and scorching in the hot weather, and very cold and almost equally dry in the winter.

Except along the foot of the western hills, that is to say, over an area of a few thousand acres, the whole aspect of the country is desolate and bare. The trees and shrubs are scanty and thorny. The chief large shrubs and trees are the *kandi* (*Prosopis spicigera*), *kirar* (*Capparis aphylla*), *khahar* (*Salvadora oleoides*) and few *ber* (*Zizyphus jujuba*) trees specially in irrigated tracts, and *lai* (*Tamarix*) in river beds. *Ak* (*Calotropis gigantea*) is very common. After the first flood or rains in June, many good grasses are found, and form excellent pasture. The most common ones are *gamh* (*Panicum antidotale*) which is excellent fodder, and grows to a height of four to five feet. This grass tillers profusely, and even forms a grain useful in times of famine for the starving people. Other common grasses are *khiv* (*sporobolus Indicus*), *chhabbar* or *hariali* (*Cynodon Dactylon*), *ghander* (*Andropogon Foveolatus*), *drab* (*Eragrostis Cynosurides*), *kabak* (*Cyprus rotundus*) and others. *Gamh*, *khiv* and *ghander* are considered to be the best and most nutritious grasses, and they grow abundantly on the plains.

The cultivated area in Kachhi, in a normal year, varies from 60,000 to 80,000 acres, and is limited to 95 to 100 villages with a population varying from ten to over two thousand. The chief staple crop is *jowar* (*Andropogon sorghum*) with an admixture of *mug* (*Phaseolus mungo*) and *til* or sesamum (*Sesamum indicum*). The *jowar* crop will give two ratoon crops if it gets a shower or flood in October and in February. This is peculiar to Kachhi. *Jowar* stalks remain in a green condition even when the crop is ready for harvest. If there are showers in September two varieties of oilseeds are grown, *sireh* (*Brassica campestris*) and *jimba* (*Eruca sativa*). *Bajri* (*Pennisetum typhoideum*) is rare except in sandy places. Special fodder crops are not grown except when early showers come in May, when *kiring* (*Setaria italica*) is grown. This gives a first cutting in June, and a second and third in July. It is succulent and very nutritious.

THE HISTORY OF THE BREED.

Very little is known about the Bhagnari breed till the beginning of the fifteenth century when the Baluchie people are said to have taken possession of the tract. Since that time this breed has been a prime favourite with the people, the cattle are only second in importance to their horses. The present name Bhagnari is derived from that of the town Bhag, which forms the centre of the area, and Nari, that of the river which runs through the valley. It is the Bala Nari or Upper part of the Bhag *tahsil* which produces the cream of the stock at present. The chief centres are Mithri, the Jaghir Inam of Nawab Bahadur Raisanis Baluchies, the Haji, Dandore and Gadi areas twelve miles above Bhag town. Outside these areas and specially when going down the lower (Zerin) Nari valley towards the Sind boundary, there is a gradual admixture of cattle of other breeds or of *Bhagnari* animals of a lower grade. The Nasirabad *tahsil*, a buffer area between Sind and the Baluchistan territory has, almost entirely, a very mixed breed of cattle (*khari*) between the Sind and Bala Nari breeds.

The total number of animals in the area producing pure Bhagnari cattle is not exactly known, but an approximate estimate for a village of good size such as that of Haji, Gadi, Mithri, &c., with a human population of 1,500 to 2,000, would be 250 to 300 head of *Bhagnari* cattle. Fifty per cent. of these would be cows of breeding age, and the remainder

bullocks and bulls (30 per cent.) and young stock (20 per cent.). The total number of plough cattle would not exceed 5,000 to 7,000 in the Bala Nari, and 6,000 to 8,000 in the Zerim Nari.

In the Jacobabad District of Sind (Upper Sind Frontier) a few herds of good *Bhagnari* cattle, but not many, were seen. In the area of Khan Bahadur Bahadur Khan Khoso and in that of his son, Khan Bahadur Dilmurad Khan, there were good *Bhagnari* cattle. In the former estate forty head of true *Bhagnari* cattle were observed, out of which nineteen were breeding cows, and the rest young stock, two bulls and nine bullocks; in the latter estate there were seven cows, one bull, thirteen young stock and five bullocks. In Khan Saheb Sher Mohomad Khan Bijarani's area and three other places, there were also good specimens of cows, bulls, young stock and bullocks, but not many.

DESCRIPTION OF THE BREED.

A fair description of these cattle has been given by Pease and Baldrey in their book on Punjab Cattle,* but it was apparently based on specimens which had been imported into the Punjab. There does not seem to be any other careful and detailed description of the *Bhagnari* cattle published hitherto, though several officers of the Veterinary Department in Sind have made notes upon them. The description, which follows, is based on the present investigations in Kachhi in 1923, but use of unpublished notes by Major Trydell (1909) and M. Abdullah (1917) referred to above has been made.

There are two distinct types of *Bhagnari* cattle :—

(1) The first of these is heavier than the other, and has a little fawn coloured hair on the upper frontal region of the head, specially over the frontal ridge. Generally, however, it has a white colour tending to iron grey. This type stands to a height of 56 to 58 inches at the shoulder with a girth of 80 to 90 inches. One exceptional animal seen was much more massive than this average, standing 63 inches in height at the shoulder with a girth of 95 inches.

(2) The second type is a little lighter, and never has any fawn coloured hair on the frontal region.

* H. T. Pease and Baldrey—Breeds of Indian Cattle, Punjab Notes on Indigenous Breeds of Cattle in the Punjab (1908).

There is, however, very little real difference between the two recognised types, and one general description will apply to both, with the exceptional points already noted.

BULLS AND BULLOCKS.

(a) *General Appearance*.—They are very handsome, well proportioned and symmetrical.

(b) *Temperament*.—The animals are very domesticated, the bullocks are very docile, not fiery or timid.

(c) *Weight*.—When full grown the bulls and bullocks weigh from 1,250 to 1,450 lbs.

(d) *Colour*.—They are invariably white, with iron grey or blackish colour at the shoulders, neck and hump with a slight fawn colour on the frontal ridge in the heavier section of the breed.

(e) *Skin and Coat*.—The skin is thin, pliable, waxy and with a black colour, with a coat of white silky hair, except on the shoulder and neck in bulls. Some are darker than others, but the white colour generally predominates.

(f) *Bones*.—These are fairly clean and firm.

(g) *Head*.—The frontal and parietal regions are broad, and massive. The frontals are specially broad, thus placing the set of the horn cores very far apart. The general look is very bovine, but well carried.

The horns are black, short, stumpy and thick, set widely apart, and directed in general outward and upward, ending in broad and blunt tips. The line midway between the horns is usually depressed very broad at the frontals which seem raised slightly. A prominent linear ridge runs as a groove from *nimburi* to muzzle; it starts arching from the lower part of the frontal dipping at a level with the superior commeasure of the eyes, and recurves slightly forward just above the muzzle. The jaws are light. The muzzle is small and black, the nasal opening is round and slightly raised sloping slightly on both sides. The eyes are large, full, mild and slightly bright. The eyebrows are prominent, slightly raised at the upper process and covered with thick overhanging rough skin. The ears are medium sized, half carried, with orange colour inside with a black spot on the inner middle line.

(h) *Neck*.—This is straight, comparatively short and thick. The dewlap is well developed, but not massive and pendulous; it folds down when the neck is raised erect.

The dewlap is fairly fine, beginning a few inches behind the chin and ending at the sternum; it may in exceptional cases extend as far as the naval, and is well pouched at the armpit.

(i) *Hump*.—The hump is well developed, slightly inclined backward.

(j) *Body or Trunk*.—The body is large and long in proportion to the neck, and the legs deep and long, with large girth. The barrel is long and deep, with well sprung ribs, indicating capacity, and endurance for draught. The chest and sternum are broad, deep and strong.

The back is level, fairly straight, dipping very slightly immediately behind the hump, and rising again very slightly to the croup.

The loins are broad and powerful. The croup is large, wide at the hips, medium at the pin bones, higher up than withers and not as sloping as is found in Sindhi cattle.

(k) *Tail*.—The tail is fine, tapering to a well bunched tuft of black hair, fairly high set and carried, reaching much below the hocks or even the fetlocks.

(l) *Limbs*.—The limbs are strong and of medium length, well proportioned to the trunk.

As regards the forequarters, the shoulder is strong, muscular and broad, sloping slightly, somewhat light but with good draught qualities. The forelegs are fine and straight with clean, strong bones; the arms are muscular, coned down with muscles and powerful; the cannon is clean and strong; and the pastern is strong with a band of blackish hair in bulls. The forefeet are medium in size, with strong black horn, and well set for hard work.

As regards the hindquarters, the hip bones are prominent and set wide apart. The hind legs are more or less straight, well muscled, but not massive. The thigh is broad and well muscled for draught.

(m) *Sheath*.—The sheath is large, but not pendulous and more or less triangular, well furnished at prepuce. Breeders prefer for breeding purposes a sheath more or less buttoned up.

(n) *General*.—The bulls become active for service after the age of $2\frac{1}{2}$ years at the earliest, and serve for eleven years. The bullocks are powerful, fairly quick, very enduring, and easily managed. They stand well changes of climate from

the scorching heat of the Sind plains to the piercing cold of the frontier winters. They feed easily and well. The price of a good bull is about Rs. 250, but the best specimens fetch from Rs. 550 to Rs. 750.

Cows.

The general characters are similar to those of the bulls and bullocks. The special points deserving of remark are as follows:—

(a) *General Appearance*.—They are very handsome, attractive and docile.

(b) *Temperament*.—The animals are very docile and would be fit for dairy purposes if developed in this end.

(c) *Weight*.—When full grown the cows weigh from 850 to 1,000 pounds.

(d) *Head*.—The face of the cows is fine, long and tapering much more so than with the bulls and bullocks.

The forehead is not so prominent as in male animals nor so wide. The facial groove is prominent.

The nasal bone is long, prominent and round with prominent clear facial veins.

The horns are of medium size, but some specimens have long finer horns, growing outward and upward, and slightly inclined inward at the top.

(e) *Udders*.—The udders are fairly capacious, but fleshy. The average milk yield during the lactation is 12 pounds per day.

(f) *General*.—The cows start breeding at the age of $3\frac{1}{2}$ years, and usually throw calves regularly up to the fifteenth year, though they may continue up to the age of eighteen. They usually drop a calf every sixteenth month.

CALVES.

The calves are white in colour at birth, with a marked fawn colour on the head, hump, shoulder and upper part of the neck, which with advancing age disappears gradually. Calves range in weight at birth from 50 to 60 pounds.

Measurements taken on a number of typical animals in their own country in Kachhi are recorded in the appendix.

BREEDING CONDITIONS IN THE HOME OF THE BREED.

As already explained, the tract where these cattle are bred is a rich alluvial plain, which has a sufficient supply of drinking water in the Nari River from July to February, but distinct scarcity from March to June. This difficulty of water supply is overcome by digging temporary wells in the lowest part of the river bed. Almost every cultivator family has its own well, and the amount of water which soaks into these wells is sufficient for his family and animals. Further in this tract there is very little natural growth of fodder on the open land throughout the year, so that the cattle cannot be bred or kept on the open ranching system. The insufficiency of shade is a vital factor in a country with such extremes of climate, which would make an open ranching system almost impossible, and in any case it is a distinct difficulty with breeding in this tract. The people partially avoid this difficulty by sending the animals out for grazing, in the hot weather, only in the early morning before 10 a.m. From that time they are kept under temporary shades (*chappers*) in their house compounds, fed and attended there. When the *jowar* crop is four feet high the animals are tethered along the bunds and the sides of the fields and the feed they get is supplemented by weeds, grass and *jowar* leaves brought from the fields. In any case, and in every season, the cattle must be back in the village before dusk, for safety.

In the rainy season, when rain occurs grasses grow luxuriantly throughout the country, and the whole tract forms a rich pasture, which in a favourable year remains green until the end of November. As already described the *jowar* grown here remains green even after harvesting, and forms a very good hay. By stocking this hay, and with a certain amount of grazing up to the end of March, the animals are kept going during the period of stress from April to June, with a small supplement of *jowar* grain, and occasionally of oil seed cake.

BREEDING PRACTICE.

The original breeders of Bhagnari cattle were the Baluchi tribes, and a great deal of the breeding is still in their hands. They understand well the management of breeding cattle, and from this point of view the *Bhagnari* tract is divided into zones. Each zone consists of a central village

owned by a *jagirdar* or by *zemindars*, and stretches from this centre over an area of from five to ten square miles. Here the *jagirdar* or *sardar* possesses land and cattle, and both he and his tenants keep bulls of known blood, especially on the side of the sire. The bull calves of known pedigree, which conform to the ideal type, are given full liberty to suck their mothers when at heel, are attended to carefully, and fed well, and are always housed well. When they attain the age of three years, that is to say, when they are about to cut the four middle incisor teeth, they are used for service and are mated with any good cow that may be brought for covering. In no case are the bulls allowed to roam about freely. No service fees are charged, for, the owner, by custom, is not allowed to refuse anyone the service of his bull. If the bull is found to be growing too heavy before cutting the sixth tooth, it is almost always removed from service, castrated, and used as a bullock. If this is not done they are allowed to serve up to the age of five years.

By adopting this practice, the breeders maintain a continuous success of new bulls, and every two years a new animal heads the herd. This system would seem at first sight to be uncertain, but it certainly results in cattle very true to one type. The breeders of different zones often introduce new blood from one another's stock, and so prevent close in-breeding. They always maintain a reserve stock of young bulls, giving them light work, and when not wanted they are castrated and sold as bullocks. The stock is very highly prized, and in no case and under no extreme of famine or poverty would the breeders part with their foundation breeding stock, especially the cows. The "Sale trade pass", that is to say, the necessity of Government or Sardar's permission to sell an animal is the main factor in maintaining the cream of the breeding stock.

FEEDING, MANAGEMENT AND CARE.

It has already been pointed out that the Nari tract produces three or more varieties of nutritious grasses in the *kharif* season in the plains. In addition extensive areas are sown with *jowar* with a sprinkling of pulses, especially *mug* (*Phaseolus mungo*). The *jowar* gives excellent hay, *kadbi*, and this when stored forms the mainstay of the feeding during the annual period of stress. The *mug* yields *kati*, or the remnant of leaves, stalks and dry pods which remain after the dry seeds have been removed,

and this with a sprinkling of crushed inferior *jowar* grain serves as a concentrated food to milch cows, calves and bulls. This latter is given to cows at the time of milking, and is fed to calves and bulls with their ordinary chaffed fodder. The animals are thus always kept in good condition.

When there is any grazing to get, the village cows are herded together for grazing at nine to ten o'clock in the morning after the morning milking, and are brought back at dusk to the village. When the *jowar* grain crop is in the milk stage, and the general *farman* or declaration has been given to each landowner by the Khan of Kalat fixing his share of the produce, then each breeder takes his cattle on to his farm, tethers them on the field embankments (bunds) near shady trees if possible, and feeds them with grass, *jowar* leaves, weeds, &c., taken from the fields. The breeder even feeds selected cattle with ripened *jowar* heads and *mug* plants. Cattle are taken back to the villages just at sunset.

The animals are housed in fenced open yards in summer and in thatched huts in winter. The cows are always kept separate and are attended to separately from the male stock, and the bull is kept away from the bullocks. The calves are kept in front of the owner's house in summer and in one corner of the house in winter.

REARING OF THE CALVES.

Great care is taken in the rearing of the calves. They are allowed to suck one teat of their mother in rotation at each milking for the first fortnight or one month according to the mother's yield, two teats at each milking for the next three months, after which they are allowed to take the whole of the mother's milk. In no case are they herded together with their dams till weaned, that is to say, until they reach the age of six months, or of ten months in the case of calves reserved as bulls.

When they are to be weaned, they are offered crushed *jowar* grain and fine *jowar kadbi* fully chaffed, and always green fodder if this is available. They are let out for exercise in the house yard when very young, and when about five months old they are sent out for exercise (once a day, in the morning, for three hours only) with the village cattle to fields adjoining the village.

All animals are watered from the village tank made by bunding up the river. This water is used for household

purposes, and this source of supply, in ordinary seasons, lasts up to March. In May and June there is always acute scarcity of water for watering the cattle and for drinking purposes, and small *katcha* wells are sunk, as already described, in the lowest part of the river bed. The shortage of water at this time of the year is the factor which limits the development of the live stock industry in this area.

MANAGEMENT OF COWS.

The following details with regard to the management of the cows may be added to what has been already stated. The foundation stock of the best breeds are looked after like the Arab's mare. The cows are fair milkers, as Indian cows go, the average per day being ten to twelve pounds of milk. It is not uncommon to get cows yielding fifteen to twenty pounds of milk. Though they have good conformation for milk production, they have never been exploited for this purpose. There is no sale of the milk, and no demand for ghee. Therefore only just enough milk is required or taken to satisfy household demands for milk, buttermilk, and butter. As every farmer is a breeder and every *jagirdar* and *sardar* has a herd of his own, and further as there are no *banias* or outside merchants in the villages whose presence would give an impetus to trade in dairy produce, there has been no inducement to work up the cows as milk producers. At the same time, there is evidence that by careful selection good milking strains could be developed.

MANAGEMENT OF BULLS AND BULLOCKS.

As already stated, bulls are never let loose with the herd, and are stall-fed. They are exercised in the farmhouse yard when the rest of the herd is out for grazing.

Bullocks are also stall-fed except in the very slack season and when there is scarcity of fodder. They are fed chaffed *kadbi* and other seasonal fodder. They seldom get any other ration. In size they are similar to Nellore or Krishna Valley Cattle, but are not as heavy and slow as the latter. They are excellent transport animals, and have been used extensively for heavy draught including the drawing of siege trains for military purposes, and also as pack animals. They are not as fast as Gujarat (*Kankrej*) bullocks, but in heavy work they do not lose condition like the latter, and they are not so nervous and timid. As there is a steady sale for the bullocks, they are rarely maintained for more than

three years. The export is not, however, as great as formerly owing to the introduction of mechanical military transport, higher railway freight, and greater difficulty in getting passes to sell.

GENERAL FODDER SUPPLY.

Provision for fodder supply in the hot weather is made by stacking *jowar kadbi* as a reserve to last for three to five months. If there is a failure in the floods in the Nari river, or in the rains in the valley itself, a serious fodder famine occurs. Such scarcity of fodder, coupled with no drinking water, drives the people out, and they, with their best animals, migrate to the Upper Sind Frontier and Larkana Districts of Sind, returning when normal conditions again prevail. They never, however, sell their animals in Sind or settle there. These periodic scarcity of fodder and water has, in fact, the effect of weeding out the inferior animals and thus assists in maintaining the quality of the stock.

CATTLE DISEASES.

Owing to the isolated character of the Kacchi tract and the rare introduction of outside animals, cattle diseases are not very prevalent among the Bhagnari cattle in their home. Contagious diseases do, however, occur. Foot and mouth disease, so common throughout India, is also found here frequently. It usually appears in the hot weather, but cases are known in winter. It varies much in virulence, but causes no mortality, though it damages the animals seriously. They become emaciated, and working bullocks are debilitated and are incapable of work for a month on account of sore feet. The method of treatment locally adopted is to make the animals stand in hot sand or in mud, or else kerosene is applied to the sore feet. The sores on the mouth are rubbed with soft warm *jowar* bread.

Other diseases occurring sporadically, and more or less frequently are black quarter, anthrax, and haemorrhagic septicaemia. Rinderpest occurs at intervals and seriously about once in four years, but is not so frequent as in other parts of India. The mortality is, however, severe and there is no substantial remedy known to the people.

It is probable that the mortality from diseases is much less than in the British districts of the Bombay Presidency, but there are no reliable figures available.

CATTLE TRADE.

It is very difficult to find the extent of the trade between the Kacchi tract and outside centres like the Upper Sind Frontier District, and the Larkana District, both of which adjoin the area. This is because no records have ever been maintained by the State, or the Sardar and Jagirdar. Dealers from other parts of India, especially from Sind, the Punjab, and Quetta visit the local markets of the tract or *piris*, at various breeding centres like Taj, Dandor, Mian Takri, Chisti and Chandor in Bala Nari and Tangote, Chalgari, Bhatti Band and Munjhu in Zarin Nari. The cattle bought are either taken away by rail or by road, the markets being chiefly held between January and March. Many animals are, however, brought for sale to the horse and cattle show at Sibi in December, and a number are even seen at the weekly markets in Jacobabad.

Further cattle are often smuggled through by road to adjoining parts of Sind, with the assistance of the local people. Such animals are of course, cheaper than those exported with State permission, as there is said to be often some difficulty in obtaining the necessary leave to export. Occasionally, in times of real or reputed fodder scarcity, the breeders themselves drive their cattle down to Sind in order to get food for them, when these may be sold to Sind traders dealing with the Punjab and adjoining areas.

The chief stations for the export of Bhagnari cattle by rail are Lindsay, Nuttal and Belpat, and the following figures of animals exported from these stations for two consecutive years have been supplied:—

1st year.

Lindsay Station—

- | | | |
|-------------------------------------|-----|--------------|
| (1) to the Punjab (Shershah, Chach- | ... | 226 animals. |
| aran, Gojra and Lahore) | ... | 10 animals. |
| (2) to Quetta | ... | |

Belpat Station—

- | | | |
|---------------------------------------|-----|-------------|
| (1) to the Punjab (Multan, Shujabad). | ... | 30 animals. |
| (2) to Jacobabad | ... | 30 animals. |

2nd year.

Lindsay Station to the Punjab and Quetta. 570 animals.

Belpat Station to the Punjab and Quetta. 210 animals.

Nuttal Station—to the Punjab and Quetta. 38 animals.

These figures give an idea of the extent of the trade by rail, but private inquiries showed that two hundred or more animals get to the Upper Sind Frontier District by road. Most if

not all such road-imported animals were purchased by small holders or tenants and not by the land-owning Sardars. They were then worked up to the end of the following *kharif* season and then were brought to market in good condition and in many cases sold to Punjab dealers. Few good animals were retained by the Zemindars of Upper Sind.

It must again be insisted on that all these animals sold to Sind or the Punjab were bullocks. No bulls or breeding cows are sold.

Bhagnari Cattle in Upper Sind.

Three Sardars of the Upper Sind Frontier and the Larkana Districts have herds of thirty to forty cows, with two bulls. Two of these which are very well known are those of Khan Bahadur Bahadur Khan Khoso, and Ghaibi Khan Chandio. As a result of the presence of these herds it is not uncommon to see a few good cows of this breed in villages in Upper Sind, but the breeding is in no case in an organised condition in the villages. The animals of the former gentleman mentioned above, and of his son, are in no way inferior to those seen in the original home of the breed. There is in fact no foundation for the popular belief in Sind that Bhagnari cattle of the original standard cannot be bred outside the Nari tract. The simple fact is that while the people of Upper Sind do appreciate the better features of the Bhagnari bullocks, their better size, power and working qualities, they are not prepared to give the same attention to breeding, rearing and general care as is given by the Nari people. Hence it is supposed that the Bhagnari cattle degenerate when they are brought to Sind. But even such degenerate animals are much superior to the ordinary local Sind Cattle.

Every Sind cultivator, be he a landholder or a tenant, prefers to get his cows mated with a Bhagnari bull if one is available within a few miles. One Government bull formerly kept by the Veterinary Department at Kandh Kot in the Upper Sind Frontier District seems to have produced wonderful progeny. Over forty animals, said to have been produced by him, which were examined, showed that in eighteen months to two years the young stock attained the size of their dams. Every young animal was better boned, strongly muscled and active. None of the female progeny of the bull in question were found that had come into milk, but the owners expected an increased milk yield from them. A higher price was expected both for bullocks and cows. The bull in question

was in great demand, and its condition showed that it had been used heavily and recklessly for service. There were many inquiries as to why the supply of such bulls was discontinued, and there is no doubt that the re-establishment of some such premium bulls would be strongly supported.

As already stated, there is a feeling that pure Bhagnari cattle do not do as well in Upper Sind as in their home in the Kachhi District. There does not seem, however, any justification for this position, and it seems certain that they will be a certain success in the Upper Sind Frontier District, in those parts of the Larkana District with Ghabhi Dero as the centre, and in the Sukkur District. Breeding elsewhere is not such a certain success, but it may be noted that a Bhagnari bull is now serving in Lower Sind under the auspices of Dr. Asudamal of Hyderabad, on the land granted to him for cattle breeding, but the results are not yet available.

SUMMARY.

From the account given it would appear that the character of the land and climate in the Kachhi District, the home of the Bhagnari breed, does not differ materially from that of the Upper Sind Frontier District and of parts of the Larkana and Sukkur Districts. The animals of the breed are liked by the people of Upper Sind and are considered more useful from every point of view,—including both draught and milk,—than the local cattle. As the people of Upper Sind depend on cows and not on buffaloes for milk, the milking capacity is a matter of importance. There is, moreover, sufficient cattle trade at present between the Bhagnari Districts and the British Districts to show that a demand does exist, and that any attempt to make animals of this breed more largely available would be appreciated.

The first step to be taken would seem to be the placing of a number of the best Bhagnari bulls with Zemindars on the premium system, for the purpose of grading up the local cattle. The effect of such premium bulls in the past has been remarkable, and at least half a dozen Zemindars are anxious and ready immediately to start cattle improvement by taking such bulls on the premium system.

The question of starting a farm or farms for the maintenance and improvement of this breed may be considered later. But suitable centres for such farms would be Jacobabad, Larkana or Sukkur.

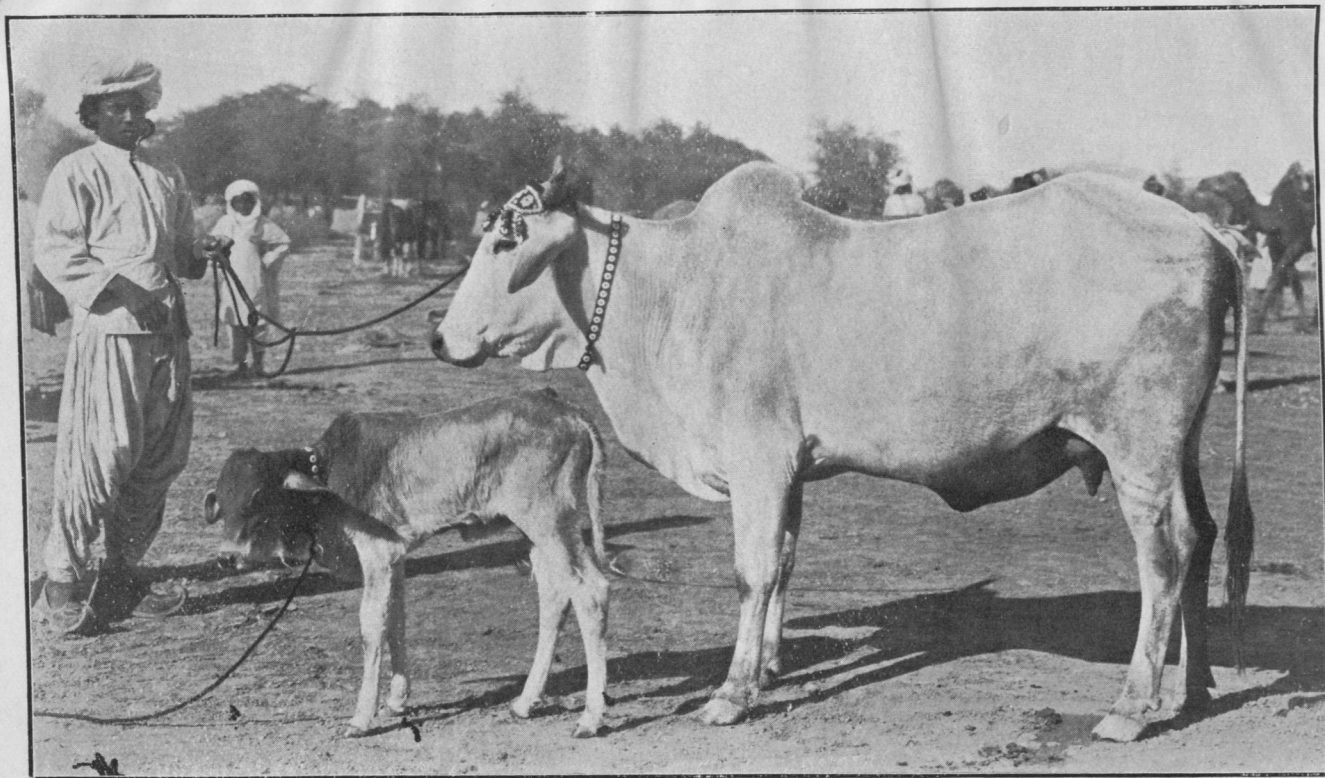
APPENDIX.

Measurements of Bhagnari Cattle in Kachhi District.

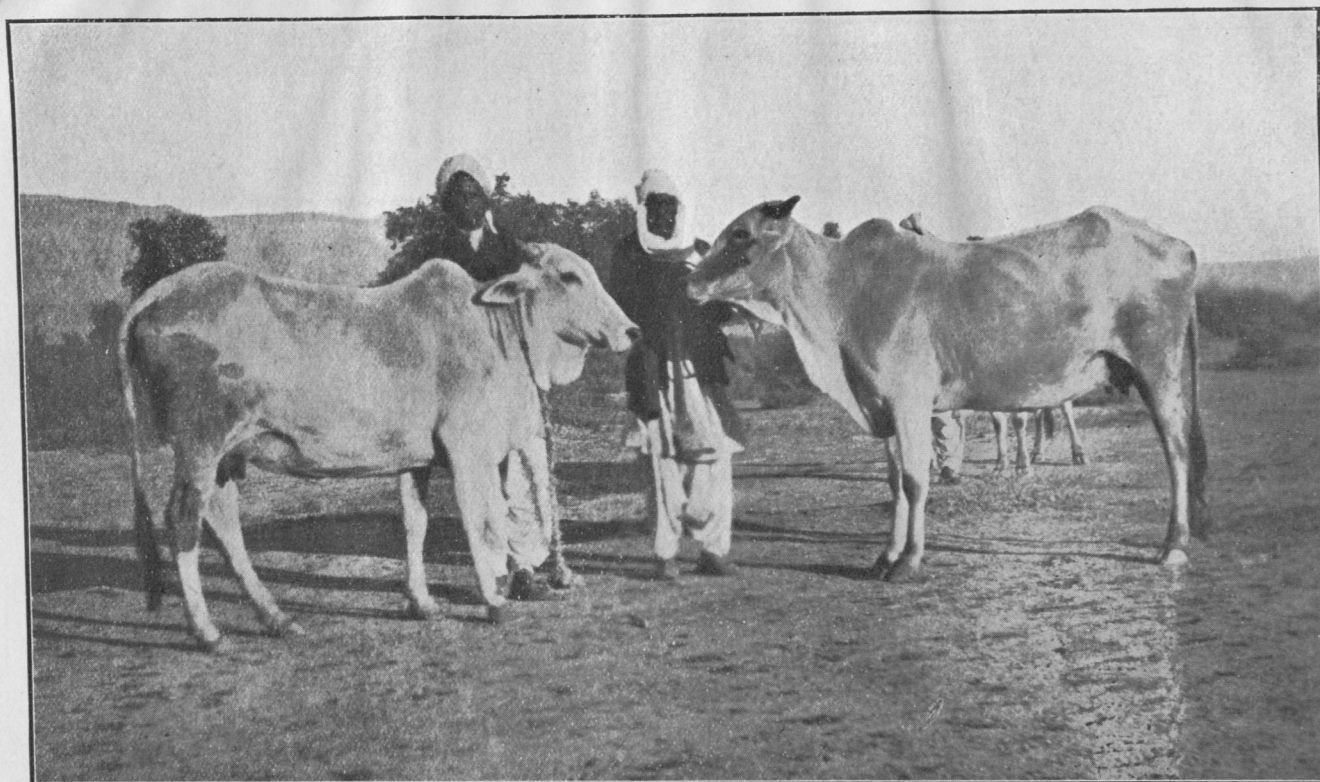
	Height at withers	Height at croup	Height at elbow	Length	Girth at chest	Girth at abdomen	Girth at forearm	Girth at shank	Length hump	Length horns	Length ears	Length face	Breadth of forehead	Length of neck
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
I. Bulls—														
(a) 2½ years old (average of 2)	52½	55½	30	52½	69	78	15½	7½	6½	1½	10	20½	8½	15
(b) 3 to 3½ years old (average of 6)	52½	55½	29½	52½	71½	82½	15½	7½	6½	2½	9½	20	8½	16½
to 4½ years old (average of 4)	53½	56½	29½	54½	73½	81½	16½	7½	6½	3½	10	20½	8½	16
II. Bullocks—														
(a) 4 years old (average of 4)	50½	53½	27½	52½	71	80½	15½	7½	6½	4	9½	19½	8½	16½
(b) 5 years old (average of 4)	54½	57½	29½	56½	76½	89½	16½	7½	6½	6½	10½	21½	9½	16
(c) 6 years old (average of 2)	51	58	29½	55½	74½	84	16½	7½	6½					17
III. Cows—														
(a) 3 to 3½ years old (average of 2)	49	51	27½	47½	61½	72½	13½	6½	6½	5	9	18½	6½	17
(b) 5 years old (average of 3)	51½	53½	28	54½	71	86½	14½	6½	6½	6½	10	19½	7½	16
(c) 6 years old (average of 2)	49½						14	6½	6½		9½	14½	7½	15½
IV. Bull calves														
(a) 10 to 14 months old (average)	50½	50½	27½	47½	62½	69½	14½	6½	6	1	9	17½	8½	14½
(b) 15 months old	50	53	29	50	64	72	14½	6½	6½	1	10	18	7½	15
2 years old (average of 3)	52½	56	30½	53	69	76½	16½	7½	7	2	10½	19	8½	16
V. Heifer—														
18 months old					70	14		6½		11	9	17½	6½	15



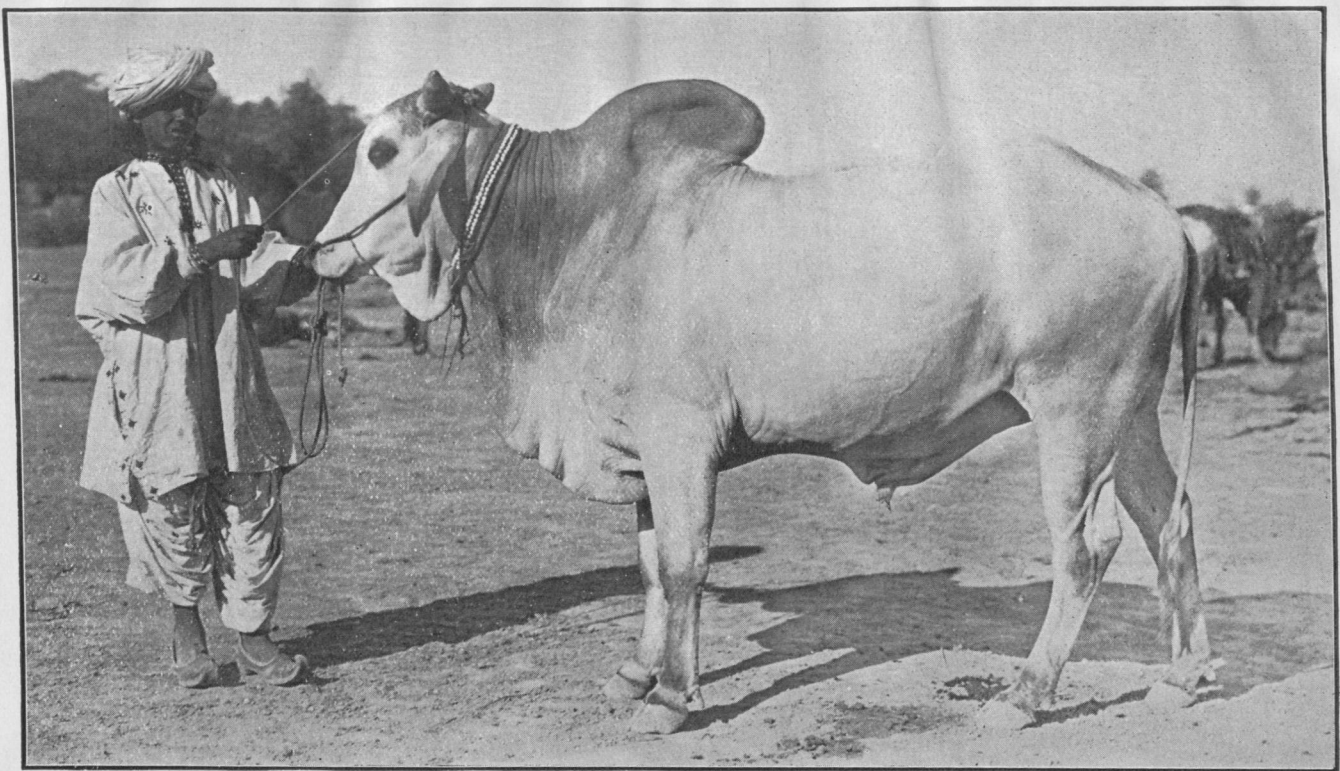
Bhagnari bull.
Height 57", Girth 83", Weight 13 cwt., Age 5 years.



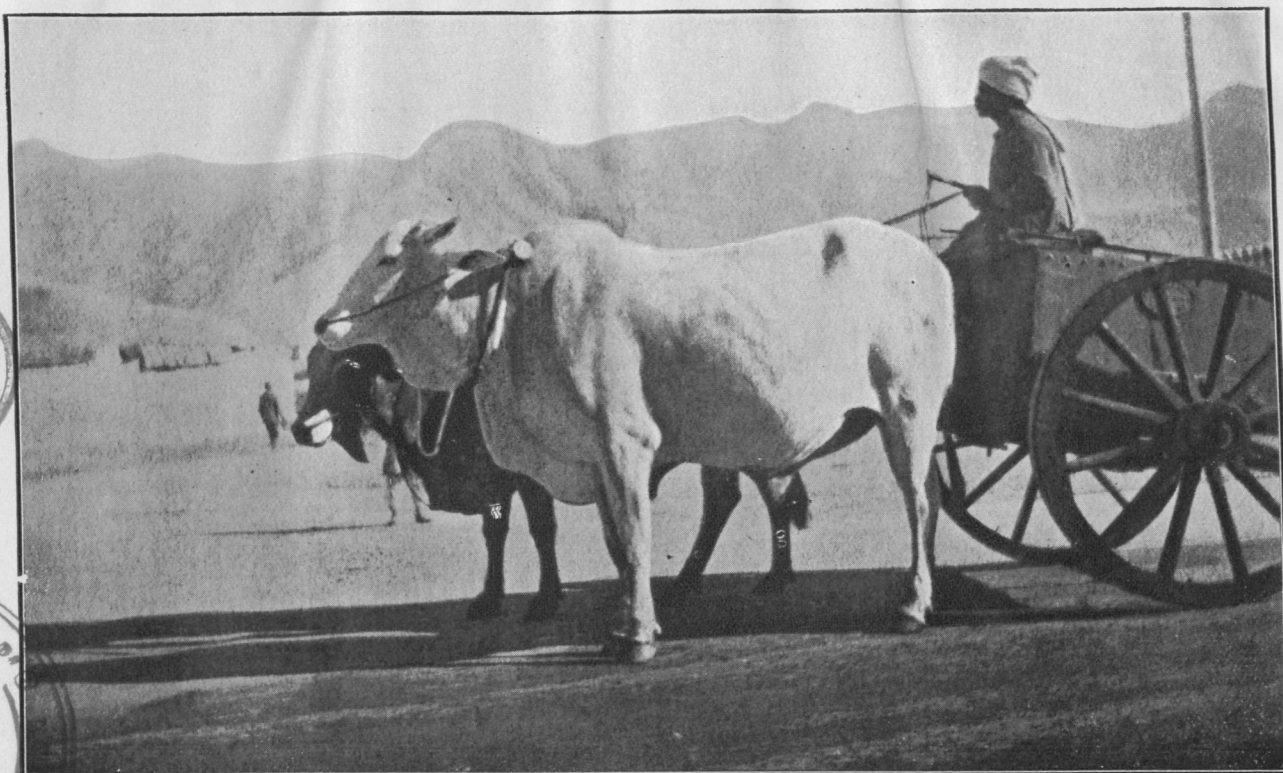
Bhagnari cow.
Height 45". Age 5 years.



Two young Bhagnari cows.



Bhagnari bull.
Height 54", Girth 72", Weight 11 cwt., Age, aged.



5311.231

A Pair of Bhagnari bullocks.

N25

