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IMPROVEMENT OF MANAT LANDS IN THE NORTH KONKAN

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IMPROVEMENT OF MANAT LANDS IN THE NORTH KONKAN

I. INTRODUCTION

The Problem.—Lands which are known as “*Manat*” or “*Manavat*” are found in the North Konkan in large stretches in the almost flat plain areas bordering the littoral belt or creek sides or sometimes even in the interior where the landscape runs almost level over wide stretches. These are made up of a surface layer of fine plastic clay of brownish black colour, often intermixed with hard nodules of limestones and pebbles; this layer varies in depth from a few inches to two to three feet and overlies layers of murum either white or grey in colour and made up of lime nodules, pebbles and other material deposited by water. The underlying trap rock is found at a depth of 15 to 20 feet. The further peculiarities of these lands are that their surface is uneven by the occurrence of many small natural depressions, that they are very absorptive of moisture and become practically inaccessible in rains and that they crack badly in the hot season. The worst forms are almost barren even of natural grasses. In some cases they are turned into rice fields which require very heavy doses of farm yard manure to improve them so as to get a fair outturn. In less worse descriptions of soils *Ful* (*Anthisteria ciliaris*) and *Ber* (*Ischaemum aristatum*) grasses grow. They are to some extent utilised for growing *rabi* and irrigated crops.

2. **General Lines of Investigation.**—The subject was taken up for investigation since the year 1914-15 and it was brought to a termination in the year 1922-23 with the abolition of the Alibag Agricultural Station. The investigation was directed to all possible aspects of the problem including a broad survey of the *manat* land regions, the use to which they are, at present, put, physical, chemical and bacteriological examination and experimental work for ascertaining the scope and methods of improvement.

II. DETERMINATION OF DETAILED CONDITIONS OF MANAT LANDS

3. **Extent, Distribution and Importance.**—In order to determine the extent and importance of this problem and to investigate into the causes of their barrenness, a broad survey of these lands was made.

Out of the two districts—Kolaba and Thana—of the North Konkan, the latter has by far the largest area under these lands; in this district the coastal talukas of Umbergaon, Dahanu and Palghar occupy the largest portion, while in the other district, Alibag, Panwel, Mangaon and Roha are the talukas, having these lands on a fairly large scale.

These lands are, in fact, not separately classed in the land revenue settlement records. They are sometimes included in the *rabi* class and

sometimes in the *varkas* class. These are shown graphically, taluka by taluka, in the accompanying map as well as in figures, tabulated in Appendix No. I, from which it will be seen that the total area of these lands is 200,415 acres or about one-fifth of the total cultivated area in both the districts; out of this only 62,315 acres, i.e., about 31 per cent. is under cultivation while 138,100 acres are under grass or barren. In the coastal talukas of Umbergaon, Dahanu and Palghar of the Thana District the total area of *manat* land which is mostly under grass is as much as 56 per cent. of the total area under cultivation. This shows that in these talukas the problem of improving these lands is of considerable importance.

4. **Physical Composition.**—In comparison with the ordinary good rice soils of the North Konkan, *manat* land is exceedingly stiff and gets hard almost like a cement block on drying. It is fine textured and very retentive of moisture. The further peculiarity of this land is that, being liable to contraction on drying in the fair season, it cracks very badly. Appendix No. II furnishes the mechanical analyses of this and the ordinary rice soils. A glance at the same reveals that the *manat* nature is characterised by less coarse and more fine sand and silt.

5. **Grades.**—There are several grades of these lands varying in the amounts of clay and colloids and consequent stickiness. The typically sticky soils, representing full *manat* character, are almost devoid of any vegetation.

6. **Depth.**—The depth of the *manat* soil varies from 2 feet to 5 feet or even more. A layer of decomposing trap is usually found at a depth of 15 feet to 20 feet. Between the decomposing and the underneath undecomposed impervious hard layers of trap rock, there are usually found feeble perennial or nearly perennial currents of sweet water.

7. **Underground Water Supply.**—In the fair season, sweet water can be tapped at a depth of 20 feet to 25 feet from the surface above the bed of the hard rock. The supply of water is generally small. It can, however, be usually increased by deeper excavation or boring through the bed of hard rock. In Palghar and Dahanu talukas of the Thana district a large number of deep bores recently taken in these lands have tapped a fairly large supply of water useful for irrigation.

8. **Chemical Composition.**—Appendix No. III furnishes figures of the chemical compositions of the *manat* in comparison with the ordinary rice soil. A scrutiny of these data shows that all the important elements of plant food such as nitrogen, phosphoric acid and potash are present in fairly equal proportions to those in the ordinary good rice soils and hence the infertility of the *manat* soils cannot be ascribed to deficiency of plant food.

The composition of sub-soil water in these soils as given in Appendix No. IV also shows that the *manat* soils do not contain salts harmful to plant growth.

**MAP OF THE THANA & KOLABA DISTS.
SHOWING THE AREA OF MANAT LAND.**



ONE DOT = 1000 ACRES.

THANA DIST. (T)

- T1 = UMBARGAON TALUKA.
- T2 = DAHANU "
- T3 = PALGHAR "
- T4 = BASSEIN "
- T5 = SALSETTE SOUTH "
- T6 = SALSETTE NORTH "
- T7 = KALYAN "
- T8 = BHIWANDI "
- T9 = WADA "
- T10 = MURBAD "
- T11 = SHAHAPUR "

KOLABA DIST. (K)

- K1 = KARJAT TALUKA.
- K2 = PANVEL "
- K3 = URAN "
- K4 = PEN "
- K5 = NAGOTHANA PETA.
- K6 = ALIBAG TALUKA.
- K7 = ROHA. "
- K8 = MANGAO "
- K9 = MAHAD "

9. **Bacteriological Examination.**—Some samples of these soils were kindly examined for us by the Imperial Bacteriologist, Agricultural Research Institute, Pusa, who reports :—

“All the specific organisms essential for the complete decomposition of organic matter are present in these soils. When, however, in order to test whether organic manures would be nitrified, half a per cent. of oil cakes was added to the soil with the requisite amount of moisture, it was found that the soils failed to form any nitrates even at the end of 8 weeks, although 30 per cent. of the nitrogen in the soil was ammonified at the end of the first week. This shows that although ammonification occurs in these *manat* soils fairly rapidly, nitrification is inhibited. Under field conditions *karanj* (*Pongamia glabra*) leaves and rice hulls remain undecomposed for a long time. These substances which were added during the rains in 1918 had remained undecomposed in clods when the field was ploughed in January 1919. This non-decomposition cannot be due to lack of water as the soil is nearly saturated during the rains. This is most probably due to the mechanical condition of the soil. A number of substances generally used to improve the physical properties of soils were tried for their effect on the flocculation of colloidal clay of *manat* soils. Among these that were found quick in action were lime, gypsum, rice hulls, straw and superphosphate, the last being the quickest of the whole lot. The addition of glucose had also a similar effect after some acids were formed from it.”

10. **Use to which these lands are put.**—The worst types of these lands produce very scant vegetation while on better types certain kinds of grasses grow more or less successfully. These soils are sometimes turned into lower-grade rice fields and where irrigation facility exists, garden crops are likewise found to grow well on the better sorts of these soils in the fair season. The following is a list of crops grown with the approximate yields per acre :—

Name of crop	Season and whether rain grown or irrigated	Outturns per acre		Remarks	
		Grain in lbs.	Straw in lbs.		
Grass	Kharif, natural growth.	..	2,000 dry.	} Nearly same as on good grass land. These yields are about half of those on good <i>rabi</i> lands. Yield about three-fourths of the normal on good rice land.	
Castor	Rabi, dry ..	350	..		
Tur	Do. ..	240	300 dry.		
Rice	Kharif, commanded by some stream	1,400	1,500 dry.		
Chillies	} Rabi season, irrigated.	10,000 green pods.	..	} Nearly same as on good rice lands.	
Lucerne		20,000 green.
Onions	15,000		..

The reason why grass is allowed to grow in preference to more valuable garden crops is that owing to the proximity of short railway communication to Bombay, grass fetches the best return without any trouble, expenses or risk. Besides, there is not enough labour and the position is not favourable to get flood water to cultivate these lands with adequately remunerative crops of rice. The garden crops cannot also be grown to any large extent on account of the very limited water supply and the uncertainty of profits.

III. EXPERIMENTAL WORK

11. Experimental work for finding out the scope and the methods of better utilisation of these lands was undertaken from the year 1913 on a plot of a very bad type of *manat* soil at Varsoli near Alibag as a part of the Alibag Agricultural Station.

12. The plan of work adopted and developed from time to time was as under :—

(i) Testing of the following treatments which are known generally to improve the physical condition of the soil :—

(1) Addition of coarse organic matter in the form of—

(a) green manures ;

(b) dry vegetable matter such as rice hulls, dried leaves, etc.

(2) Addition of coarse inorganic aerating material.

(3) Liming.

(4) Drainage—

(a) Open drains.

(b) Underground tile drains.

(c) Underground drains filled with brick pieces.

(5) Impounding water in the rainy season.

(6) Burning or heating the soil.

(7) Use of mulches.

(ii) Testing the effect of chemical manures such as superphosphate and sulphate of ammonia, etc.

(iii) Finding out which crops would thrive best under *manat* conditions—

(1) in the kharif season ;

(2) in the rabi season :—

(a) as dry crops ;

(b) as irrigated crops.

13. **Crops and General Methods of Cultivation used for the Experimental Work.**—The land which had been fallow for several years was cleared and was ploughed to a depth of about 9" by a turn-wrest plough.

(Ransomes C.T. 2) in October and November of 1913 and it was further broken and pulverised during the rest of the season so as to make it fit for sowing in the next monsoon. The preparatory tillage given to it during the subsequent years was shallow with the Deccan harrow or the local wooden plough. Crops used for testing the effect of the various experimental treatments planned under (i) and (ii) above were mostly *rabi*, i.e., *shalu*, castor and gram. The general methods of cultivation adopted were as follows:—The stubbles were removed after the harvest of the previous crops and the land was kept clean of weeds during the rainy season; at about the close of the monsoon (September) the land was tilled with the Deccan blade harrow and prepared for sowing. Interculturing was done at short intervals, shallow in the beginning with the Deccan or the Gujarat blade hoe and deeper at a later stage with a small plough, both worked by bullock power.

In the case of the *kharif* crops, which were few, the preparation of land consisted of the removal of the stubbles of the previous crops, ploughing with medium size plough and further pulverising and preparing for sowing in the usual way.

(i) *Treatments for the Physical Improvement of the Soil*

14. Addition of coarse organic matter in the form of green vegetation.—Growing of *san* (*Crotalaria juncia*) and *dhaincha* (*Sesbania aculeata*) were tried for the purpose in the *kharif* season on the flat lands during the initial years; but both of them failed on account of water logging of the soil brought about by the heavy rains characteristic of the Konkan monsoon. So in 1917 these crops were tried on ridges, but the heavy rains made it almost impossible to keep the ridges in good condition and the results were in no way better than on the flat land. Further, *san* was attacked by aphides. A third crop, i.e. *udid* (*Phaseolus radiatus*) met with no better fate. Other crops subsequently tried were *tur* (*Cajanus Indicus*) and *Tephrocia candida*. These were sown in June 1920; *Tephrocia candida* met the same fate as the foregoing crops while *tur* did fairly well, growing about 3 feet in 3½ months when it was pruned and the green stuff obtained was incorporated into the soil. The pruned crop produced afterwards new shoots and in about two months more the growth was sufficient to permit of a second pruning; some three months after the second pruning a third pruning was also obtained, but the output was poor. The green stuff obtained from these three cuttings amounted to 6,000 lbs. per acre with the wide sowing done as for grain.

Rabi season trials of green manuring crops were also carried on, using *tur*, *Tephrocia candida*, wild indigo and *dhaincha* for the purpose. The last two failed and *Tephrocia candida* gave a poor growth; *tur* alone did fairly well, yielding green stuff amounting to 2,500 lbs. per acre with sowing at a distance of 18 inches. All these trials thus lead to the conclusion that *tur* (*Cajanus Indicus*) is the only crop among those tried which is promising.

Green matter obtained from tree vegetation, such as *karanj* (*Pongamia glabra*), *nandruk* (*Ficus retusa*), *vad* (*Ficus Bengalensis*), etc., applied at the rate of 4,000 lbs. per acre, gave the results recorded below :—

Treatment	Area of each plot in acres	Quantity given in lbs. per acre	Outturns per acre				
			1917-18		1918-19		
			Grain	Straw	Grain	Straw	
<i>Shalu Jowar*</i>				lbs.	lbs.	lbs.	lbs.
Green manure	10	4,000	480	2,250	485	2,620	
Check	10	..	← Not provided. →				
<i>Castor</i>							
Green manure	10	4,000	305	..	270	..	
Check	10	..	← Not provided. →				

Treatment	Area of each plot in acres	Quantity given in lbs. per acre	Outturns per acre—contd.						Remarks
			1919-20		1920-21		1921-22		
			Grain	Straw	Grain	Straw	Grain	Straw	
<i>Shalu Jowar*</i>			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	*Grain damaged by birds to a fairly large extent due to small area.
Green manure	10	4,000	370	2,280	376	2,275	350	1,830	
Check	10	..	380	2,140	248	1,710	240	1,240	
<i>Castor</i>									
Green manure	10	4,000	156	..	342	..	434	..	
Check	10	..	188	..	320	..	336	..	
<i>Tur</i>									
Green manure	10	4,000	..	..	180	400	..	..
Check	10	..	..	..	160	260	..	..

It will be seen that green manuring had some beneficial effect.

15. Addition of coarse organic matter in dry form.—The stuff tried under this category were rice hulls and dried leaves. During the early years these were spread on the whole of the area and the land was ploughed with the local wooden plough ; but when it was discovered that the stuff did not get incorporated in the soil, by this method, the material was put into the furrow behind a turn-wrest plough going 6" to 8" deep.

The results of this trial are given below :—

Treatment	Area of each plot in acres	Quantity of organic material given in lbs. per acre	Outturns per acre					
			1916-17		1917-18		1918-19	
			Grain	Straw	Grain	Straw	Grain	Straw
<i>Gram</i>			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Rice hulls ..	·10	10,000	130	..	..	..	..	..
Dried leaves ..	·10	10,000	80	..	..	..	..	..
Check ..	..	..	Not provided.					
<i>Castor</i>								
Rice hulls ..	·10	10,000	140	..	275	..	270	..
Dried leaves ..	·10	10,000	350	..	195	..	300	..
Check ..	..	..	Not provided.					
<i>Shalu Jowar</i>								
Rice hulls ..	·10	10,000	..	..	500	2,300	445	3,260
Dried leaves ..	·10	10,000	..	..	320	2,100	285	3,420
Check ..	..	..	Not provided.					

Treatment	Area of each plot in acres	Quantity of organic material given in lbs. per acre	Outturns per acre—contd.						Remarks
			1919-20		1920-21		1921-22		
			Grain	Straw	Grain	Straw	Grain	Straw	
<i>Castor</i>			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
Rice hulls ..	·10	10,000	264	..	400	..	483	..	
Dried leaves ..	·10	10,000	220	..	388	..	392	..	
Check ..	..	..	188	..	320	..	336	..	
<i>Shalu Jowar</i>									
Rice hulls ..	·10	10,000	420	2,080	358	2,550	473	2,300	Grain damaged by birds to a fairly large extent due to small area.
Dried leaves ..	·10	10,000	380	2,590	276	2,250	369	1,890	
Check ..	..	..	330	2,140	248	1,710	240	1,240	
<i>Tur</i>									
Rice hulls ..	·10	10,000	..	..	150	220	..	..
Dried leaves ..	·10	10,000	..	..	202	340	..	..
Check ..	..	..	..	..	160	260	..	..

Both forms of dry coarse organic matter show some advantage, that from rice hulls being more striking than from the dry leaves. The natural productivity of the lands is so low that the increased returns do not off-set the expenditure upon the manures.

16. Addition of coarse inorganic aerating material.—As recommended by A. Howard in his Bulletin on Soil Aeration—Bulletin No. 61 of 1916 of the Agricultural Research Institute, Pusa—aerating materials such as

thikra (pieces of bricks) and *murum* (decomposing rock) were experimented with; 40 cart-loads per acre of each were spread on and mixed into the soil by ploughing in the year 1917. *Murum* was again added in 1918. The results are given below:—

Treatment	Area of each plot in acres	Quantity of inorganic material given in lbs. per acre	Outturns per acre					
			1917-18		1918-19		1919-20	
			Grain	Straw	Grain	Straw	Grain	Straw
<i>Shalu Jowar</i>								
Thikra i.e. brick pieces ..	·10	40 cart-loads applied in 1917-18.	340	2,200	412	2,700	310	2,200
Murum ..	·10	Do. ..	440	2,250	385	3,250	340	2,140
Check ..	·10	....	Not provided.				330	2,140
<i>Castor</i>								
Thikra i.e. brick pieces ..	·10	40 cart-loads applied in 1917-18.	250	..	310	..	272	..
Murum ..	·10	Do. ..	320	..	320	..	264	..
Check ..	·10	....	Not provided.				188	..

Treatment	Area of each plot in acres	Quantity of inorganic material given in lbs. per acre	Outturns per acre—contd.				Remarks	
			1920-21		1921-22			
			Grain	Straw	Grain	Straw		
<i>Shalu Jowar</i>								
Thikra i.e. brick pieces ..	·10	40 cart loads applied in 1917-18.	416	2,775	380*	1,900	Jowar grain was damaged by birds to a fairly large extent due to small areas.	
Murum ..	·10	Do. ..	436	2,900	464*	2,500		
Check ..	·10	.....	248	1,710	240	1,240	
<i>Castor</i>								
Thikra i.e. brick pieces ..	·10	40 cart loads applied in 1917-18.	388	..	460*	..		
Murum ..	·10	Do. ..	350	..	432*	..		
Check ..	·10	....	320	..	336	..	
<i>Tur (pigeon pea)</i>								
Thikra i.e. brick pieces ..	·10	40 cart loads applied in 1917-18.	250	380	..	..
Murum ..	·10	Do. ..	202	280	..	..
Check ..	·10	....	160	260	..	..

*In 1921-22 the treatments were repeated namely 40 cart loads of inorganic material per acre were applied.

The incorporation of large quantities of coarse inorganic substances seems to have had some beneficial effect; that from *murum* is more than that from *thikra* for the fibrous rooted crop of *shalu jowar*, but the reverse in the case of thicker tap rooted crops of *castor* and *tur*.

17. Liming.—Slaked lime was added every year from the year 1915-16 to 1921-22 and the results are tabulated below:—

Treatment	Area of each plot in acres	Quantity of slaked lime given in lbs. per acre	Outturns per acre					
			1916-17		1917-18		1918-19	
			Grain	Straw	Grain	Straw	Grain	Straw
<i>Shalu Jowar</i>								
Liming ..	·10	2,240	..	..	540	2,200	285	2,610
Check ..	·10		← Not provided. →					
<i>Castor</i>								
Liming ..	·10	2,240	510	..	245		285	..
Check ..	·10		← Not provided. →					

Treatment	Area of each plot in acres	Quantity of slaked lime given in lbs. per acre	Outturns per acre—contd.						Remarks
			1919-20		1920-21		1921-22		
			Grain	Straw	Grain	Straw	Grain	Straw	
<i>Shalu Jowar</i>									
Liming ..	·10	2,240	400	2,340	276	2,076	375	1,890	Jowar grain was damaged by birds to a fairly large extent due to small area.
Check ..	·10	..	330	2,140	248	1,710	240	1,240	
<i>Castor</i>									
Liming ..	·10	2,240	224	..	422	..	406	..	
Check ..	·10	..	188	..	392	..	336	..	
<i>Tur (pigeon pea)</i>									
Liming ..	·10	2,240	..	..	..	..	203	340
Check ..	·10	..	..	..	..	..	160	260

Liming seems to have shown some benefit.

18. Open Drains.—These consisted of a central open drain, 6 feet wide and 2½ feet deep, fed by side drains, crossways, each 1½ feet deep, 1 foot wide and arranged at intervals of 33 feet.

Drains filled with thikra (brick pieces).—Trenches three feet apart, one and a half foot wide and eight inches deep were half filled with *thikra* while the top four inches was filled with soil. These were designed so as to discharge into a large central open drain. In the second year of the experiment, the depth of these trenches was increased to 18 inches so as to ensure that the four inch layer of *thikra* remained undisturbed during tillage operations.

Underground Tile Drains.—For this purpose ordinary round tile pipes were used. Two sizes of pipes were used, one 3½ inches and the other 5½ inches in diameter. The small sized pipes were laid at a depth of about 1½ feet below the surface with a gentle slope, and the interval between drains was 20 feet. These drains discharged into cross drains which again

discharged into a natural low level channel. These tile pipes were made with one end wider than the other so as to facilitate joint making. The dimensions of these drainage pipes were as follows :—

Pipe	Length in inches	Diameter of big end in inches	Diameter of small end in inches
Minor	9	3½ to 3¾	2 to 2½
Main	10	5½ to 5¾	3½ to 3¾

The results of all the drainage systems are given in the following table :—

Treatment	Area in acres	Outturns per acre					
		1916-17		1917-18		1918-19	
		Grain	Straw	Grain	Straw	Grain	Straw
<i>Castor</i>		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Open drains .. ..	.30	377	..	115	..	235	..
Underground drains with <i>thikra</i> .. ..	....	..	..	..	..	290	..
Underground tile drains .. ..	.044	..	..	..	..	..	..
Check (no drainage) .. ..	.081	Not provided.				270	..
<i>Shalu Jowar*</i>							
Open drains .. ..	.20	..	..	496	2,350	427	1,030
Underground drains with <i>thikra</i> .. ..	....	..	..	..	..	308	1,670
Check (no drainage) .. ..	.075	← Not provided. →					

Treatment	Area in acres	Outturns per acre—contd.					
		1919-20		1920-21		1921-22	
		Grain	Straw	Grain	Straw	Grain	Straw
<i>Castor</i>		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Open drains .. ..	.30	181	..	..	..	..	..
Underground drains with <i>thikra</i> .. ..	....	232	..	..	..	..	..
Underground tile drains .. ..	.044	..	..	290	..	392	..
Check (no drainage) .. ..	.031	232	..	380	..	455	..
<i>Shalu Jowar*</i>							
Open drains .. ..	.20	300	2,160	..	..	..	..
Underground drains with <i>thikra</i> .. ..	....	330	2,480	250	2,840	..	..
Check (no drainage) .. ..	.075	420	2,320	180	2,520	..	..
<i>Cotton</i>							
Underground drains with <i>thikra</i> .. ..	.02	..	..	252	..	..	..
Check (no drainage) .. ..	.02	..	..	255	..	..	..

* Grain damaged by birds to a fairly large extent due to small area.

From the results recorded above for the open drains it may be concluded that these do not seem to help in any way. These get silted up in the rainy season every now and then with the result that the cost of maintaining them in good condition becomes very high. The provision of underground drainage with brick pieces has likewise not proved effective on the whole. In the year 1919-20 in which tile drains were laid, water from the outlet of the main drain flowed out during heavy showers of rain, and the soil was found to part with its surplus water and became accessible fairly soon. A crop of castor that was taken on drained land did not, however, show any superiority over that on the undrained; this may be so because it was grown in the *rabi* season.

19. **Impounding Water in the Rainy Season.**—In certain parts of the Thana district it has been the practice in some of the lowlying fields to keep them uncultivated and to allow the rain water to stand there. This water is let out in September or October and the land is then broken and prepared for *rabi* sowing. *Val* (*Dolichos lablab*), gram, mustard, wheat (Umbergaon, district Thana) are the crops grown in the *rabi* season. In order to study the effect of this practice, an experiment was laid out in 1919-20 and wheat yielded a fair crop.

20. **Burning or Heating the Soil.**—It was casually observed that a plot on which rubbish had happened to be burnt gave strikingly superior plants which happened to grow thereon. Accordingly a number of crops was grown in the *kharif* season in small strips in a plot specially burnt. Check plots were provided as shown in the following sketch :—

Burnt land	Un-burnt land (check)
Crop—A	
Crop—B	
Crop—C	
and so on	
"	"

The results of this experiment in respect of crops for which full data are available are recorded below, those for which only partial data about growth are available being given as Appendix V.

Serial No.	Name of crop	Observations on growth		Outturn per acre in lbs.				Remarks
		Unburnt	Burnt	Unburnt		Burnt		
				Main product	Bye product	Main product	Bye product	
1920-21								
1	Tur	5 feet, fairly vigorous.	6-6½ feet, vigorous	200	..	355	..	
2	Ambadi	5 feet, fairly vigorous.	6-6½ feet, vigorous	455 (seed).	565 (fibre).	600 (seed).	725 (fibre).	
3	Jowar	5-5½ feet, fair ..	6½-7 feet, vigorous	615	4,385	890	5,570	
4	Bhendl (Vegetable).	2-2½ feet, very fair.	2½-3 feet, vigorous	1,580 (green)	..	2,030 (green)	..	
5	Dhaincha	4½-5 feet, fair ..	6½-7 feet, vigorous	700 (seed).	..	925 (seed).	..	
6	Castor	½-1 foot, poor ..	1½-2 feet, fair ..	55	..	105	..	
7	Udid	1½-1¾ feet, pretty well.	1½-2 feet, vigorous	225	..	350	..	
8	Groundnut	1-1½ feet, fair ..	1½-1¾ feet, very fair.	457	..	1,155	..	
1921-22								
1	Tur	5 feet, fairly vigorous.	7½-8 feet, vigorous	290	..	510	..	
2	Ambadi	5-5½ feet, fairly vigorous.	7½-8 feet, vigorous	375 (seed).	4,000	900 (seed).	5,000	
3	Jowar	5-5½ feet, fair ..	7-7½ feet, vigorous	37·5	9,000	75	13,000	Grain completely damaged by birds.
4	Dhaincha	4-4½ feet, fair growth.	8½-9 feet, very vigorous with profuse branching.	150	7,000	400	12,000	
5	Udid	1½-1¾ feet, pretty well.	2½-3 feet, vigorous	250	2,500	500	4,000	
6	Groundnut	1-1½ feet, tolerable.	1½-1¾ feet, very fair.	500	3,000	1,625	5,000	
7	Sannhemp	3-3½ feet, poor ..	5½-6 feet, fair ..	200	1,500	275	2,500	

These results indicate that burning is decidedly beneficial for almost every crop grown. *Tur* (*Cajanus Indicus*), *ambadi* (*Hibiscus cannabinus*) and *jowar sorghum* (*sorghum vulgare*) seem to be benefited most; *bhendl* (*Hibiscus esculentus*) and *dhaincha* (*Sesbania aculeata*) come next; while groundnut, castor and *udid* (*Phaseolus radiatus*) stand third.

In order to see whether this beneficial effect can be associated with any chemical or physical changes in the soil, samples of burnt and unburnt soil were examined chemically and physically through the kindness of -

Mr. V. A. Tamhane, the then Soil Physicist to the Government of Bombay.

The chemical composition was found to be as follows :—

Name of Constituent	Below 1" from the surface		Below 4" from the surface	
	Non-burnt	Burnt	Non-burnt	Burnt
	Per cent.	Per cent.	Per cent.	Per cent.
Stones	13·36	12·11	14·79	9·21
Moisture	4·56	3·16	4·55	3·68
Loss on ignition (excluding moisture) ..	7·23	6·22	7·50	6·46
Sand	53·04	58·30	52·58	60·05
Iron and Aluminium oxide	19·75	18·89	19·60	19·14
Lime	·05	·008	·14	·10
Nitrogen	·08	·11	·10	·09
Phosphoric acid (P ₂ O ₅)	·17	·18	·17	·20
Potash (K ₂ O)	·05	·08	·05	·09

These figures do not throw any light on the beneficial effect of soil burning upon plant growth.

The observations upon the physical characters of the soil were as follows.

Burning brings about a distinct change in the physical character of the soil. The soil improves a good deal. A part of the colloidal material is changed to non-colloidal. About 4 per cent. of the clayey portion becomes sandy. Percolation of water through the soil becomes easier. 133 ccs. of water percolates through burnt soil in 24 hours as against 96 ccs. through the same quantity of unburnt soil in the same period. These changes indicate better drainage and better aeration in the burnt than in the unburnt soil, and may be responsible for better growth of plants on the burnt land.

21. Use of Mulch.—In order to study the effect of mulching upon the cracking of these soils in the fair season, mulches of stones of the size of road metal and of soil made by interculturing were tried in 1921-22. The cracking was naturally considerably reduced. The outturn results are given in the following table from which it will be seen that the yield of *Shalu Jowar* has responded to the treatment.

Treatments	Area in acres	Outturns per acre	
		Grain in lbs.	Straw in lbs.
Stone metal mulch at the rate of 1 cart per 100 square feet	·175	340	1,880
No mulch of any kind	·0175	230*	1,350*
Soil mulch made by interculturing with a bullock hoe.	·0175	375	1,880

* 30 per cent. of the plants lodged down due to bad cracking of soil.

(ii) *Effect of Manures*

22. In the bacteriological examination and treatments of the *manat* soils by the Imperial Bacteriologist (see paragraph 9) superphosphate has been found to be the quickest acting in improving the physical properties of this soil. As superphosphate also provides an important plant food, this fertilizer and certain other manures were tried on rice grown for the first time on this soil. The following table records the results obtained :—

Name of manure	Quantity per acre in lbs.	Area of plot in acres	Outturns per acre	
			Main product in lbs.	Bye product in lbs.
Poudrette	6,000	·025	2,220	2,520
Bone superphosphate	400	·025	2,100	2,400
Farm Yard manure	4,800	·025	1,820	2,560
Bonemeal	400	·025	1,140	1,840
Lime	2,240	·025	840	1,440
No manure .. .. .	..	·025	255	960

These results, though only for one year, clearly bring out the beneficial effect of superphosphate on the rice crop when grown on this type of soil.

The results obtained both with organic and inorganic manures, show that *manat* soils respond in a remarkable degree to manurial treatments notwithstanding the fact that this soil is not deficient in any of the principal constituents of plant food, as compared with good rice soils.

(iii) *The most suitable crops for Manat Soils*

23. The existing cropping of these *manat* soils has already been described in paragraph 10 above.

Experiments were arranged to test other crops according to the following plan.

24. **Kharif Season (June to September).**—At first many crops, on a very small scale, were tried on the flat land, but most of them failed on account of water-logging brought about by the heavy rains. Only the more promising ones were, therefore, retained in the following years. Details regarding these crops such as their growth and outturn are reported in paragraph 20 above. A reference to that paragraph will show that out of all the crops tested, *tur* (*Cajanus Indicus*) and *ambadi* (*Hibiscus cannabinus*) fared best; next came *jowar*, *dhaincha* and *bhendi*. Groundnut was only fair, while *udid* and *san*, were exceedingly poor.

25. **Fair Season (October to May).**—The results obtained with fair weather crops are reported in the appendix VI, which lead to the following interpretations :—

Shalu.—As this was the only jowar crop in the locality, considerable damage was caused by birds which accounts for the low outturns of grain. The outturns of *kadabi* however, show that the produce was not far behind that of the average dry crop in the Deccan. In comparison with all the other dry crops tried, it stands first in point of the value of yield, and it furnishes grain for human food as well as nutritious fodder for cattle. Hence this crop may have a future in the Konkan as the bird trouble may diminish if the area of the crop is substantial.

Cotton stands next to *shalu* in profits per acre, N.R. variety doing the best among the annuals and Bourbon amongst the perennials. The most suitable time for sowing appears to be September. It has been observed that growing period extends almost up to the end of the fair season. Manuring with sulphate of potash or superphosphate does not materially hasten the maturing of cotton but it brings about some increase in yield. The quality of cotton obtained was found to be in no way inferior to that in the tracts of the Bombay Presidency where cotton forms the staple crop.

This result may prove valuable as cotton comes next to food crops as an essential requirement of mankind and can also furnish a good rotation to the *shalu jowar* crop which has been found to be suitable.

The Bourbon crop of 1919-20 was cut back at the beginning of the following monsoon, leaving 6" to 8" high stumps. These stumps produced new shoots which flowered in the following month of December and yielded a bumper crop of 1,337 lbs. of seed cotton per acre in five pickings up to the end of the fair season.

In the case of Bourbon, propagation by cuttings was tested. For this purpose, some cuttings were planted at the beginning of the monsoon 4 feet apart. Most of the cuttings struck root and put forth fairly vigorous growth, which produced flowers in the following December and yielded 141 lbs. of seed cotton per acre as against 60 lbs. by a crop grown from seed.

Tobacco did not do quite so well as expected.

A note explaining the best manipulation of the *manat* land for dry cropping in the fair season is appended as Appendix VII.

26. **Rabi season irrigated crops.**—Sugarcane, lucerne and chillies were the crops tried. Out of these the first was tried on a large scale while the remaining two were tested on a small scale. The following conclusions seem to be justified.

Sugarcane.—This crop, on the whole, fared as well as it does on *non-manat* soils.

Striped Mauritius, an early ripening variety, was found to escape red-rot and to thrive well, attaining a high Brix reading of 18° to 20° in 10 months. It has, however, a slight tendency to lodge. The green

coloured sport without any stripes from this variety behaved exactly like the parent in all respects. The red varieties from Ratnagiri, Manjri Farm and from the locality of the Experiment Station, Alibag, were more or less alike, standing erect and escaping red-rot. They are, however, late. The *Pundia* variety from Poona, though growing well, was much attacked by red-rot which manifested itself from October; but the local variety resembling *Pundia* was found to be less attacked. *Kabirya* is a slow grower and is liable to attack by red-rot. Red sport is a very promising variety; it ripens early, grows well and resists lodging to some extent. Waxy red resembles striped Mauritius. *Manjav* also appeared to be promising as could be judged from one year's trial. *Khajuria* or *Dosa*, the latter term meaning in Gujarati "Old" and signifying that it is so soft that even an old man can chew it easily, does fairly well growing 5 to 5½ feet in height and attaining 16° to 17° of Brix reading; it grows erect, lodges less and possesses a wonderful capacity for tillering. It is, however, very thin and possesses short internodes and does not appear to command much attention in the market.

It is a common practice in the Konkan to burn the soil before planting cane with such material as cowdung, grass etc. as is done for *rabbing* rice seed beds. The results of experiments, noted in the table above, however, show that burning is in no way superior to applying the same quantity of farm yard manure direct to the land.

Ratoon cane has also been found to do well, but it is liable to attack by scale insects on the leaves, which can however, be controlled by spraying with fish oil rosin soap (1 per cent. strength).

Lucerne and *chillies* which were tried on a small scale gave very good results.

The trials under irrigation, though small, seem to indicate that the crops mentioned above thrive well on these soils. This is further corroborated by experience in other parts of the tract where similar types of soil exist on an extensive scale. In the Palghar, Dahanu and UMBERGAON talukas, wherein these soils are extensive, many crops are grown under irrigation with good results. The common crops so grown are chillies, brinjals, lucerne, onions and other vegetables as well as flowers. Similarly fruit trees such as mangoes, chikoos, etc., also do well.

IV. SUMMARY

I. The *manat* lands occur in large stretches of plain regions in the Thana and Kolaba districts of the Bombay Presidency, occupying on an average about one-fifth of the total cultivated area. The worst types are practically bare, although some better descriptions are able to grow grass or certain crops under favourable conditions. Generally these soils bake hard on drying.

II. The cause of the infertile nature of the *manat* soils appears to be the large percentage of fine grained constituents and colloids which do not allow the soil to part with water as freely as is necessary for plant

growth. In these soils bacterial action becomes inhibited, which is a further cause of infertility. The bacterial examination of these soils discloses the fact, that, although all the specific organisms essential for the complete decomposition of organic matter are present in these soils, they fail to form nitrates even at the end of 8 weeks after the addition of oil cake, which is believed to be due to the bad mechanical condition of these soils caused by the high proportion of colloids. Apart from this phenomenon the chemical examination of the soil does not reveal anything abnormal.

III. The experimental work has led to the following observations :—

1. (a) The incorporation of coarse organic matter, whether green or dry or inorganic materials such as pot-sherds or murum, has produced some improvement, but not to the extent of bringing the *manat* lands to the condition of good soils of the tracts even after five years' treatment.

(b) Neither open nor underground drains filled with brick pieces, one foot below the soil surface, have been found useful. Open drains are moreover difficult and expensive to maintain in these soils under the heavy rainfall conditions.

2. Burning the surface soil and manuring with bone superphosphate have brought about a decided improvement in the productive capacity of these lands as tested by the growth of various *kharif* crops and rice respectively. This beneficial effect appeared to be associated with the improvement of the physical texture of the soil.

3. Amongst the several crops tried, the following have been found to be successful :—

(a) *In the rainy season (June to September).*—Rice does well provided that there are facilities to have abundant water supply constantly renewed and large quantities of coarse organic material such as rice hulls vegetable matter or farm yard manure or superphosphate applied to the land.

Under non-swampy conditions *tur* and *ambadi* top the list ; *jowar*, *bhendi*, groundnut, castor, niger and *charli* do moderately well, while *udid* and *san* hemp have been *fair*.

(b) *In the fair season (October to May).*—As a dry crop, *shalu jowar* has done very well giving yields approximating to those obtained in the Deccan. Cotton (N. R.) when sown in September, fares moderately well, furnishing a good rotation crop for *shalu*.

Among irrigated crops, sugarcane, brinjals, lucerne, chillies and onions have done well.

V. CONCLUSIONS

In conclusion it is necessary to mention the scope and the limitations for the practical adoption of the successful methods of improvement summarised above :—

(1) The existing area under cultivation, with rice as the principal crop, keeps the present farming population almost fully engaged

especially in the rice growing season. The scope for turning the *manat* lands into rice lands which is already known to the people, is therefore not much.

(2) Burning of land is not also practicable as most of the burning material available is required for burning the seed beds for the existing area of rice cultivation.

(3) The incorporation of coarse organic matter whether green or dry or inorganic material would be too expensive for the results to be obtained.

(4) Amongst the other crops which have been found successful, *shalu jowar* and cotton in *rabi* season are the only ones which can have a wide scope for dry cropping. The preparatory tillage and the sowing of these crops do not conflict with the cultivation of rice and there should be no difficulty to find the necessary time to do the inter-culturing and harvesting operations which fall in the fair season, in which the Konkan cultivators are not so fully occupied. It must be noted however that these crops can but yield small financial returns per acre as compared with those of rice, and can only be looked upon as furnishing some return for the labour unoccupied and fetching nothing at present. This method of utilization of the *manat* lands is therefore only suitable for farmers putting in their own labour and not at all suitable for a business with hired labour. For this purpose these lands cannot afford to pay any more than nominal rent. The people would be quite new to the methods of cultivation of these crops and it will be therefore necessary to afford full facilities for their training. Any beginning that would be made should be based on a fairly large unit so as to admit of economical watching of the *shalu jowar* crop from birds.

(5) As regards the more remunerative crops under irrigation, paucity of cheap irrigation facilities and limited demand for such commodities restrict the scope for them.

APPENDIX I.

Statement showing areas of Manat lands and total areas under cultivation in the Thana and Kolaba Districts of the Bombay Presidency.

Serial No.	Name of Taluka	Area under Manat lands in acres					Total area under cultivation	Percentage of Manat land to total area under cultivation.	
		Grass in acres	Rice in acres	Rabi crops in acres	Irrigated crops in acres	Total in acres			
<i>Thana District</i>							Acres.		
1	Umbergaon (Petha).	40,000	9,000	2,000	400	51,400	142,583	65	
2	Dahanu ..	31,000	8,500	1,300	500	41,300		87,350	47
3	Palghar ..	28,000	12,000	750	400	41,150		41,573	22
4	Bassein ..	5,000	4,000	125	25	9,150		36,931	15
5	Salsette (South).	3,000	2,100	..	500	5,600		27,083	26
6	Salsette (North).	4,000	2,700	25	200	6,925		77,849	0
7	Kalyan ..	4,500	2,000	625	275	7,400		58,751	15
8	Bhivandi ..	5,500	3,000	400	100	9,000		57,658	3
9	Wada ..	1,000	200	300	..	1,500		62,518	3
10	Murbad ..	1,100	300	400	..	1,800		44,469	0
11	Shahapur ..	..	..	..	..	..
	Total ..	123,100	43,800	5,925	2,400	175,225	636,760	27	
<i>Kolaba District</i>									
1	Karjat ..	1,200	600	250	200	2,250	81,801	5	
2	Panvel ..	4,000	2,000	500	500	7,000		47,379	5
3	Uran (Petha)	100	50	10	30	190		57,935	7
4	Pen ..	1,000	500	100	150	1,750		26,923	11
5	Nagothana ..	400	100	100	25	625		58,534	8
6	Alibag ..	3,000	1,000	..	200	4,200		67,134	2
7	Roha ..	2,000	700	250	..	2,950			
8	Mangaon ..	2,500	1,200	800	200	4,700			
9	Mahad ..	800	250	250	225	1,525			
	Total ..	15,000	6,400	2,260	1,530	25,190	383,215		
	Grand Total	138,100	50,200	8,185	3,930	200,415	1,019,984	19	

APPENDIX II.

Physical Composition.

(Kindly determined for the authors by the Agricultural Chemist to the Government of Bombay.)

I. MANAT SOIL.

Sample No. 1 collected at Warsoli Manat Station on 17th June 1919.

	No. 1 Depth 1"—1½"	No. 2 Depth 1½"—4½"	No. 3 Depth 4½"—10½"	No. 4 Depth 10½"—22½"	No. 5 Depth 22½"—40½"
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Coarse sand	6.89	18.40	3.75	17.42	23.18
Fine sand	11.10	11.00	11.10	9.80	8.00
Coarse silt	19.35	32.00	26.60	34.20	19.40
Medium silt	34.20	6.00	26.20	6.90	18.20
Fine silt	11.82	9.20	8.20	8.48	8.20
Finest silt	16.64	23.40	24.15	23.20	23.02

Sample No. 2 collected at Warsoli Manat Station on 29th August 1918.

	No. 1 Surface soil up to 3"	No. 2 Soil below 3" up to 9"	No. 3 Soil below 9" up to 27"
	Per cent.	Per cent.	Per cent.
Coarse sand	9.55	8.60	8.37
Fine sand	61.04	68.78	64.78
Coarse silt	11.94	9.20	11.20
Medium silt	3.72	2.83	3.19
Fine silt	7.83	5.29	6.96
Finest silt and clay	5.92	5.21	5.50

Sample No. 3 collected at Tendhare, Panvel Taluka on 30th April 1921.

	No. 1 Depth 0"—3"	No. 2 Depth 3"—9"	No. 3 9"—21" depth
	Per cent.	Per cent.	Per cent.
Coarse sand including stones	47.32	52.20	42.25
Fine sand	34.62	32.85	40.93
Coarse silt	4.29	3.82	6.15
Medium silt	3.49	2.93	4.17
Fine silt including finest silt	10.28	8.11	6.50

II. ORDINARY RICE SOIL.

Sample No. 1 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"—6"	No. 2 Depth 6"—8"
	Per cent.	Per cent.
Coarse sand	38.81	41.65
Fine sand	35.21	29.13
Coarse silt	11.60	18.30
Medium silt	2.35	2.62
Fine silt	1.98	1.79
Finest silt	10.5	6.61

Sample No. 2 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"—6"	No. 2 Depth 6"—18"
	Per cent.	Per cent.
Coarse sand	49.39	22.91
Fine sand	32.54	40.91
Coarse silt	7.74	17.23
Medium silt	1.91	7.69
Fine silt	1.52	2.05
Finest silt	6.90	9.21

Sample No. 3 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"—6"	No. 2 Depth 6"—18"
	Per cent.	Per cent.
Coarse sand	14.22	39.64
Fine sand	45.37	33.07
Coarse silt	24.60	13.06
Medium silt	2.31	2.34
Fine silt	3.85	1.93
Finest silt	6.95	9.96

Sample No. 4 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"—6"	No. 2 Depth 6"—18"
	Per cent.	Per cent.
Coarse sand	43.12	36.53
Fine sand	33.31	38.14
Coarse silt	9.23	11.01
Medium silt	2.45	2.63
Fine silt	1.98	2.16
Finest silt	9.84	9.23

APPENDIX III.

Chemical Composition.

(Kindly determined for us by the Agricultural Chemist to the Government of Bombay.)

I. MANAT SOIL

Sample No. 1 collected at Warsoli Manat Station on 17th June 1919.

	No. 1 Depth 1"-1½"	No. 2 Depth 1½"-4½"	No. 3 Depth 4½"-10½"	No. 4 Depth 10½"-22½"	No. 5 Depth 22½"-40½"
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loss on ignition ..	15.6	15.2	16.24	16.24	16.52
Sand ..	58.4	59.72	60.56	59.92	59.23
Lime as Cao ..	1.08	1.075	1.26	.70	1.12
Potash ..	.361	.34	.28	.44	.38
Phosphoric acid ..	.085	.0403	.13	.062	.078
Nitrogen ..	.074	.082	.091	.061	.084

Sample No. 2 collected at Warsoli Manat Station on 29th August 1918.

	No. 1 Surface soil up to 3"	No. 2 Soil below 3" up to 9"	No. 3 Soil below 9" up to 27"
	Per cent.	Per cent.	Per cent.
Loss on ignition ..	11.60	13.66	13.92
Insoluble silicates ..	68.38	62.36	63.66
Lime as Cao ..	.168	.448	.224
Potash ..	.252	.329	.291
Phosphoric acid ..	.111	.111	.059
Nitrogen ..	.103	.098	.093

Sample No. 3 collected at Tendhare, Panvel Taluka on 30th April 1921.

	No. 1 Depth 0"-3"	No. 2 Depth 3"-9"	No. 3 Depth 9"-21"
	Per cent.	Per cent.	Per cent.
Stones ..	37.90	43.30	40.00
Moisture ..	3.90	3.90	4.15
Loss on ignition ..	5.62	4.50	4.71
Sand ..	38.07	33.89	36.17
Lime (Cao) ..	.31	.23	.27
Phosphoric acid ..	.07	.07	.06
Potash ..	.20	.18	.20
Nitrogen ..	.05	.04	.04

II. ORDINARY GOOD RICE SOIL.

Sample No. 1 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"-6".	No. 2 Depth 6"-18".
	Per cent.	Per cent.
Organic matter	1.84	1.00
Lime	0.24	0.67
Potash	0.38	0.58
Phosphoric acid	0.06	0.04
Nitrogen	0.06	0.04

Sample No. 2 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"-6".	No. 2 Depth 6"-18".
	Per cent.	Per cent.
Organic matter	2.04	1.35
Lime	0.50	0.89
Potash	0.74	0.54
Phosphoric acid	0.07	0.04
Nitrogen	0.06	0.01

Sample No. 3 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"-6".	No. 2 Depth 6"-18".
	Per cent.	Per cent.
Organic matter	2.24	2.19
Lime	1.4	0.89
Potash	0.12	0.54
Phosphoric acid	0.94	0.05
Nitrogen	0.01	0.29

Sample No. 4 collected from the Alibag Farm on 15th January 1912.

	No. 1 Depth 0"-6".	No. 2 Depth 6"-18".
	Per cent.	Per cent.
Organic matter	2.55	1.75
Lime	0.28	0.89
Potash	0.12	0.31
Phosphoric acid	0.04	0.06
Nitrogen	0.04	0.09

APPENDIX IV.

Composition of well water in Manat Land.

Sample collected from the well at the Warsoli Manat Station on 17th June 1919.

Name.	Parts per 100,000 parts.
Total salts	65.00
Containing—	
Calcium carbonate	29.88
Calcium sulphate	5.19
Magnesium sulphate	0.91
Magnesium chloride	23.08
Sodium chloride	0.49
Sodium carbonate	5.30
Nitrates	Nil.

APPENDIX V.

Results of crops tried on Burnt or heated soil, for which yield data are not available.

Serial No.	Name of crop.	Observations on growth.	
		Unburnt.	Burnt.
	1920-21.		
1	Chavali	1½-2½ feet (fair)	2½-3 feet (virgorous).
2	Sann hemp	Failed	Fair growth.
3	Maize	Poor	Tolerable.
4	Gowar	Do.	Do.
	1921-22.		
1	Bhenti (Vegetable)	3-3½ feet (very fair)	4-4½ feet (vigorous).
2	Chavali	Poor growth	Vigorous.
3	Castor	1½-2 feet (poor)	2½-3 feet (fair).
4	Maziy	10-11 inches (very poor).	12-14 inches (poor).
5	Gowar	5-8 inches (poor)	1-1½ feet (poor).
6	Tephrosia candida	1-1½ feet (tolerable).	4-4½ feet (very fair).

APPENDIX VI
Detailed Results of Fair Weather Crops

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Detailed Results of Fair Weather Crops.

Name of crop.	Area in acres.	Years of trial.	Time of sowing.	Time of final harvesting.	Average yield per acre.		Remarks.
					Quantity in lbs.	Value at average rates during the period of trial.	
<i>A. Dry Crops</i>						Rs. a. p.	
Castor ..	4 to 1.75	1916-22 (6)	September (middle).	April (end)	275 grain	16 10 8	
Shalu ..	2 to 1.75	1917-22 (5)	Do.	Do.	358 grain 2,776 straw.	40 14 0	Grain damaged by birds to a fairly large extent due to small area.
Tur ..	2 to .8	1920-22 (2)	Do.	Do.	240 grain 300 stalks.	24 0 0	
Cotton— <i>Different time of sowing</i> Bourbon variety— Beginning of monsoon ..	.01	1920-21 (1)	September (middle).	May (beginning)	60 Seed-Cotton	6 5 0		77 per cent. of the plants died.
August ..	.01	Do.	Do.	Do.	100 "	10 8 5	51 per cent. do.
September (middle)— First year ..	.01	1919-20 (1)	Do.	Do.	190 "	20 0 0	44 per cent. do.
Second year ..	..	Pruned in May 1920.	Do.	May 1921	1,337 "	140 11 9	
September end ..	.01	1919-21 (2)	Do.	May (beginning)	225 "	23 10 11	35 per cent. do.
N.R. Variety— Beginning of monsoon ..	.01	1920-21 (1)	Do.	Do.	40 "	4 3 4	90 per cent. do.

August .. ..	..	..	.01	1	Do. ..	Do. ..	105	..	11 0 10	76 per cent. do.
September (middle) .. ..	..	..	.01	1	Do. ..	Do. ..	200	..	21 0 10	54 per cent. do.
September (end) .. ..	..	01 to	.05	1919-21 (2)	Do. ..	Do. ..	295	..	31 0 10	41 per cent. do.
<i>Varieties—</i>										
Bourbon .. ..	..	..	.01	Do.	September (end)	Do. ..	225	..	23 10 11	
N. R. .. ..	..	01 to	.05	Do.	Do. ..	Do. ..	205	..	31 0 10	
Cambodia .. ..	..	..	.01	1019-20 (1)	Do. ..	Do. ..	210	..	22 1 8	
Dharwar-American .. ..	..	..	.01	Do.	Do. ..	Do. ..	205	..	21 9 3	
F. 4 .. ..	..	..	.01	Do.	Do. ..	Do. ..	42	..	4 6 9	
Dharwar No. I .. ..	..	..	.01	Do.	Do. ..	Do. ..	14	..	1 7 7	
Sea Island .. ..	..	..	.01	Do.	Do. ..	Do. ..	11	..	1 2 6	
<i>Different methods of propagation (with Bourbon variety)—</i>										
From seed .. ..	..	..	.01	Do.	June 1919 ..	May (beginning) 1920.	60	..	6 5 0	
By cuttings .. ..	..	..	.01	Do.	Do. ..	Do. ..	141	..	14 13 0	
<i>Different manures (with Dharwar-American variety)—</i>										
Sulphate of potash 5 cwts. per acre. .. ..	..	..	.01	Do.	September (end)	May (beginning)	385	..	40 8 5	
Sulphate of potash and superphosphate 5 cwts. each per acre .. ..	..	..	.01	Do.	Do. ..	Do. ..	455	..	47 14 4	
Superphosphate 5 cwts. per acre .. ..	..	..	.01	Do.	Do. ..	Do. ..	371	..	39 0 10	
No manure .. ..	..	..	.01	Do.	Do. ..	Do. ..	205	..	21 9 3	
Tobacco .. ..	..	..	.05	Do.	September (middle).	March (middle).	200	..	40 0 0	Watered only for about two weeks after planting.
<i>B. Under Irrigation</i>										
<i>Sugarcane—</i>										
Burning with dry cowdung 24,000 lbs. per acre. .. ..	..	0.05 to	0.075	1920-22 (2)	February ..	January ..	20½ tons of cane ..	..	600 0 0	
Addition of 24,000 lbs. of dry cowdung (unburnt). .. ..	..	0.025 to	0.0375	Do.	Do. ..	Do. ..	20½ do	..	600 0 0	

APPENDIX VII.

A note on the best Manipulation of Manat Land for dry cropping in the Fair Season.

It has been noted that certain new crops have been found to thrive well on these lands. It is intended to describe in this note, therefore, the methods of preparation and cultivation, which, it has been found, should be followed in the successful production of these crops in general and the dry crops in the fair season in particular.

The land, if fallow and foul, should first be cleared of shrubs and trees and should then be opened with a heavy turnwrest iron plough (say Ransomes C. T. 2 or D. T.), going 8" to 10" deep soon after the close of the monsoon. At this time the soil being neither too dried out nor too wet can be opened with comparatively less difficulty. The clods in the ploughed soil should be allowed to weather in the sun throughout the fair season during which they are found to crumble sufficiently. During the rainy season whenever there are breaks sufficiently long so as to render the soil accessible, the blade harrow should be worked so that the clods may be further pulverised and the weeds removed. At the close of the monsoon, i.e. the end of September, castor or *tur* should be sown in the first season. Unlike the usual practice in the Konkan, the crops should be sown in rows made by a light plough, 2 feet apart, in order to facilitate the interculturing operation. After 15 days the crop should be thinned out and gaps filled in. The interculturing operation should also be started at this time and repeated at intervals so as not to allow any cracks to form. The Gujarat bullock-hoe has been found to work well for this operation. During the advanced stages of the crop, if it be found that the hoe is too light to break the hard crust the ordinary Konkan plough should be used. These crops are ready for harvest by March.

During the following rainy season whenever there are breaks in the monsoon the stumps should be removed and the land harrowed and prepared for sowing in the forthcoming rabi season. This year *shalu jowar* should be grown and the land should be treated in the same way as for castor or *tur* for subsequent operations. In this way rotation of castor, *tur* or cotton (N.R. variety) in one year and *shalu jowar* in the other should be followed.

After some 3 to 4 years, a dose of farm yard manure or town sweepings at the rate of 5 cart loads per acre should be given. Addition of any form of organic material such as rice hulls, green or dry vegetation, coal residues, etc., is helpful in reducing the stiffness of the soil to some extent, and if any of these are available at a cheap rate they may be incorporated into the soil before the beginning of the rainy season in the same way as described in this bulletin. When it is not possible to get any form of organic material from outside a thick crop of *tur* (*Cajanus Indicus*) may be grown in the *kharif* season for green manuring purposes; when it is three months' old it should be pruned and the green material incorporated into the soil. The pruned crop will put forth new foliage which should be cut again after a lapse of another three months and buried below the surface. Whatever further tender growth may be obtained by the end of July in the next monsoon should be ploughed under and the stumps removed. The land should then be prepared for rabi sowing.