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SUGARCANE AT THE PARTABGARH EXPERIMENTAL STATION

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SUGARCANE AT THE PARTABGARH EXPERIMENTAL STATION, 1908.

THE collection of some of the characteristic varieties of the sugarcane of the United Provinces at the Partabgarh station provided an opportunity for some preliminary work in connection with the enquiry into the cultivation and quality of that crop, which the Agricultural Department proposes to take up on the lines laid down by the Board of Agriculture in 1907.

By working on the spot in the midst of the crushing and gur-boiling, and carefully observing any differences in growth and composition, it was thought that suggestions might be got as to the most promising lines, along which future enquiry may be directed.

The following varieties were available for experimental purposes :—

Patarki mango of Shahganj.	Sarauti of Partabgarh.
Hemja of Gorakhpur.	Kewahi of Benares.
Reora of Gorakhpur.	Reora of Benares.
Charkahiya of Azamgarh.	Reori of Benares.
Dhaura of Azamgarh.	Momcha of Basti.
Pansari of Usufpur (Ghazipur).	Sarauti of Basti.

Kuswar of Partabgarh.

These races of sugarcane comprised nearly all the kinds of Oudh and the Eastern districts which are noted especially for their sugar yielding qualities, the Kuswar and Sarauti among them being indigenous to the Partabgarh District. The seed of the last two kinds was obtained locally while seed canes of all the other varieties were imported by rail from the districts, in which they grow at their best.

The different races were not grown this year with the special object of comparing the outturns, but of raising seed for the next sowing, and determining their suitability to the soil and climate of Partabgarh.

For these reasons the areas allotted to the various kinds (approximately $\frac{1}{10}$ acre) varied slightly. The field operations in all cases except in the case of Kuswar treated with Sulphate of Ammonia being however exactly alike.

The method of cultivation may be described as follows :—

Previous to preparation of the land for cane cultivation half of the land comprising the cane plots was sown in the rainy season with Guar (*Cyamopsis psoralioides*), and the other half with Urd (*Phaseolus radiatus*). These autumn crops were removed from the land in November 1906. In December the land was irrigated with well water in order to soften the soil which was then broken up with the Watt's plough. It was again ploughed with the same implement and four ploughings with the country plough followed, the land being levelled after each ploughing with the *Patila* (the flat wooden beam). After the second ploughing with the country plough ordinary cattle manure at the rate of about 80 maunds per acre and indigo refuse at the same rate were spread on the plots, and worked in with the soil by means of the last two ploughings.

The cuttings about 15" in length were sown in the beginning of March 1907 in the usual manner behind the plough, and the land levelled. Sheep folding which is a common system of manuring cane-fields in the south followed, a flock of about 70 sheep being kept for the night on each plot.

In the plot treated with Sulphate of Ammonia no cattle manure or indigo refuse was used, the artificial manure alone being applied at the rate of 5 cwt. per acre in two doses, two-fifths of the total quantity being used in the furrows at the time of planting and the remaining three-fifths just before the advent of the monsoon rains. The comparison plot adjacent to the Ammonium Sulphate plot was not manured at all. Both of these plots had been fallow during the preceding rainy season.

The crop was watered altogether five times during the period of growth, four times in the hot weather, and once at the end of rains, this last watering having been rendered necessary owing to long cessation of the rain. After each watering the crop was hoed with *Kudalis*, and is customary among cultivators where the crop showed a tendency to "lodging" the plants were tied up so as to keep it erect.

Harvesting was commenced on 26th December 1907 and continued without any break until February 6th. The cane was cut and then crushed in four roller iron mills of the same pattern working uniformly. The same mills were used throughout the campaign.

The juice after sampling was boiled into gur by the local gurboilers in the simple native way without any elaborations. Advantage was taken of this to determine :—

(*a*) The actual loss of sugars (Sucrose and Invert) during the boiling process.

(*b*) The amount of inversion.

(*c*) The actual loss of Sucrose by the combined effect of (*a*) and (*b*.

The question of the actual loss of sugars and the amount of inversion has been previously investigated by Leather (Agricultural Ledger, 1896, No. 18), who as the result of 8 experiments at Cawnpore and Poona concluded that the average loss of sugar (Sucrose and Invert) was 10 per cent. It will be seen later that as the result of thirteen experiments we find an average loss of 15·7 per cent. Our results showing the amount of inversion, as represented by the increase in glucose ratio, are in agreement with those obtained by Leather. The subject however needs further investigation in view of the importance of producing a higher quality gur, *e.g.*, one containing a higher amount of recoverable Sucrose even at the expense of its appearance. The demand of raw sugar for recently erected refineries in and around these provinces last year was estimated at not less than 10 lakhs of maunds.

The difficulties of sampling small plots of sugarcane are well known, and are referred to by Howard in the Proceedings of the Board of Agriculture, 1907. At Partabgarh this year the whole of the cane was crushed, the juice weighed and each sample separately examined; the amount of Sucrose, Invert sugar, and the specific gravity being determined. In addition the number of stools per acre was counted. It was thought that this figure indicating the relative amount of space available for each stool to grow in would be a rough measure of certain other factors such as leaf area exposed to the active rays of light, and transpiration, which might have an important influence on the amount of the sugar formed, and the concentration of the juice.

These operations involved the examination of 55,000 lbs. of juice, containing 8,614 lbs. of Sucrose and Invert sugars, and yielding 8,622 lbs. of gur. The authors regret that they were unable to determine with the assistance available the weight of cane. This will certainly be undertaken in all subsequent experiments.

Having decided to weigh and examine the whole of the juice from the plots, and so to make sure at least of an accurate estimate of the yield of juice and its composition, considerable latitude was afforded to deal with the cane in such a way as to get some idea of the variations in composition from place to place in the same variety, and to find out if a method could be devised enabling one working on a comparatively small sample to assay the crop correctly. This has not been found to be the case and a glance on the table giving the results in detail will show that figures of

widely different value were obtained, except where several hundred lbs. of juice were employed, and even then considerable variations were liable to crop up.

Variety No. 2 Patarki Mango of Shahganj was cut in successive 50 stools up and down the field. The cane was not laid and to all appearances was a uniform crop.

The variation in composition is large, and such as would lead to an entirely wrong conclusion of the value of the crop, if any particular one was taken to represent its composition. The Sucrose varies from 16·19—13·22 per cent. and the Invert sugar from 1·0 to 2·4 per cent. Low sucrose being accompanied in this, as in all other cases, by high Invert sugar pointing to unequal ripening. Indeed it appears as will be seen from tables referred to later on that unequal ripeness is the result very largely of unequal germination and development. The plants being crowded together in one part of the field with an insufficient supply of light and air; and too sparse in another.

To further investigate this point of variation another variety of a different appearance and growth Sarauti of Partabgarh—one of the thin reed-like canes—was examined successive 25 stools being taken. Here the Sucrose varies from 16·50—15·29 per cent., and the Invert sugar from 1·10 to 1·52 per cent.; differences which are considerably less but which nevertheless are large enough to have a very marked influence on the composition of raw sugars. It was found that variation in these sturdy reed-like canes which germinate and grow very regularly was generally less than the more delicate tall canes of the Mango and Reora type.

The only case in which close agreement was found in samples of juice from cane of the above type was when the number of stools per acre was small enough for each one to have apparently more than enough space for full development.

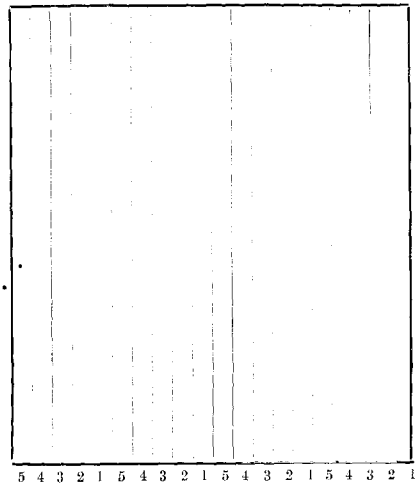
The problem of obtaining a juice of even composition and ripeness seems to be one presenting difficulties analogous to those which face the maltster at home in securing a uniform sample of malt from barley. Unless the conditions on the floor are such that the germination and growth of each grain to a certain point is uniform, an unequal sample of malt is obtained. In the case of sugarcane, unless the conditions are such that a uniform growth and development of each stool is possible, juice varying in composition and ripeness will be the result.

The early and late ripening of the same variety is another question and an attempt is being made this year to determine some of the factors that influence this.

It seems, however, reasonable to suppose that if germination and space available for each plant to grow in are approximately the same, a juice of approximately the same quality ripe or unripe will be the result, although the question of finding out when it is ripe has yet to be faced.

This has an important bearing on the production of good quality gur because it would be possible to wait until the juice of a uniform crop is ripe, while if the reverse is the case and a little bit ripe here and there at one time it is impossible ever to secure a uniform juice without selective cutting, a thing very unlikely to be adopted in this country.

After various trials the following method of cutting the cane was adopted and used in plots 6—16. The following diagram illustrates the idea:—



Four strips one stool wide were taken at equal distances apart starting from the right hand, and cutting down the whole length of the field. The juice of the four strips was mixed and sampled. The cutting was continued in the same way from right to left, four strips being used for each sample (500—1,000 lbs. each). This method gave better agreement, but even here differences of $\frac{1}{2}$ per cent. were not uncommon.

Table I gives the details of the results obtained from each plot.

TABLE I.

Plot No. 2.

Name . . . . Patarki Mango of Shahganj.

Area . . . . .158 acre.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient.
50	169·5	15·17	27·7	1·55	2·6	10·2	1·0748	18·1	83·8
50	150·5	15·40	23·3	1·66	2·5	10·7	1·0790	19·1	81·1
50	125·7	15·85	21·5	1·82	2·5	11·4	1·0810	19·5	81·3
50	177·7	15·82	28·1	1·54	2·7	9·7	1·0796	19·2	82·4
50	182·5	15·77	28·8	1·72	3·1	10·9	1·0800	19·3	81·7
50	125·0	15·58	19·5	1·84	2·3	11·8	1·0794	19·2	81·1
50	108·5	11·48	24·4	2·10	3·5	14·5	1·0754	18·2	79·5
50	155·2	14·98	23·2	1·88	2·9	12·5	1·0775	18·7	80·0
50	226·0	15·38	34·7	1·85	4·2	12·0	1·0804	19·4	79·2
50	196·0	14·98	29·4	1·58	3·1	10·5	1·0774	18·7	80·0
50	247·0	15·58	38·5	1·26	3·1	8·0	1·0760	18·4	84·6
50	243·0	16·19	39·3	1·01	2·4	6·2	1·0778	18·8	86·1
50	240·0	15·71	37·7	1·23	2·9	7·8	1·0776	18·7	84·0
50	175·0	15·46	27·0	1·32	2·5	9·1	1·0778	18·8	82·2
50	182·0	13·22	24·1	2·10	4·0	16·5	1·0752	17·3	76·4
50	158·0	13·70	21·6	2·40	3·8	17·5	1·0750	18·3	74·9
50	176·5	14·16	25·0	2·27	4·0	16·0	1·0773	18·7	75·7
50	168·5	14·47	24·4	2·23	3·7	15·4	1·0760	18·4	78·6
50	100·0	13·27	17·2	2·04	2·6	15·3	1·0710	17·3	76·7
50	139·0	13·38	18·6	1·93	2·7	14·4	1·0705	17·1	78·2
50	205·0	11·50	24·1	1·83	1·3	12·6	1·0667	16·3	85·9
50	284·0	14·11	39·0	1·41	3·8	10·0	1·0707	17·2	82·0
58	165·0	14·42	23·8	1·49	2·4	10·3	1·0728	17·6	81·9
1158	4179·6	14·92	622·9	1·70	71·1	11·5	1·0758	18·3	81·5

TABLE I—*contd.*

PLOT No. 3.

Name . . . . . Hemja of Gorakhpur
Area . . . . . ·112 acre.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient.
50	253·0	15·08	38·1	1·16	2·9	7·6	1·0744	8·0	83·7
50	203·0	13·28	26·9	1·20	2·4	9·0	1·0666	16·2	81·9
168	731·0	12·70	92·8	1·65	12·0	13·0	1·0664	16·2	78·3
184	621·0	13·45	83·5	1·52	9·4	11·3	1·0685	16·7	80·5
225	907·0	13·37	121·2	1·54	13·9	11·5	1·0674	16·4	81·5
677	2715·0	13·35	362·5	1·50	40·6	11·3	1·0670	16·5	80·9

PLOT No. 4.

Name . . . . . Reora of Gorakhpur.
Area . . . . . ·133 acre.

200	781·5	11·62	90·8	1·84	14·4	15·8	1·0617	15·	76·9
189	719·2	10·91	78·4	1·67	14·2	18·0	1·0596	14·6	74·7
209	618·0	10·44	64·5	2·05	12·6	19·6	1·0578	14·2	73·5
283	954·0	9·23	88·0	2·29	21·8	24·8	1·0548	13·5	68·3
361	721·5	10·61	76·5	2·17	15·6	20·4	1·0602	14·8	71·6
	505·2	10·52	53·1	2·24	11·3	21·2	1·0592	14·5	72·5
1232	4299·4	10·48	451·3	2·09	89·9	20·0	1·0587	14·4	72·7

PLOT No. 5.

Name . . . . . Charkahiya of Azamgarh.
Area . . . . . ·0975 acre.

200	723·0	11·94	86·3	1·97	14·2	16·5	1·0643	15·7	76·0
217	673·7	12·88	86·8	1·83	12·3	14·2	1·0673	16·4	78·5
192	792·5	11·56	91·6	2·03	16·1	17·5	1·0635	15·5	74·5
151	329·5	11·70	38·5	2·03	6·7	17·3	1·0637	15·6	75·0
163	605·0	11·12	68·5	2·16	13·0	19·0	1·0627	15·3	73·0
923	3123·7	11·87	371·7	1·99	62·3	16·8	1·0643	15·7	75·6

TABLE I—*contd.*

PLOT No. 6.

Name . . . . . Dhaura of Azamgarh.
Area . . . . . ·129 acre.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient
30	116·0	12·82	14·9	1·90	2·2	14·8	1·0680	16·5	77·7
107	669·0	14·28	95·5	1·46	9·8	10·2	1·0720	17·5	81·6
141	1050·5	13·72	144·1	1·50	15·7	10·9	1·0704	17·1	80·2
152	889·5	14·05	125·0	1·45	12·9	10·3	1·0712	17·3	81·2
178	1120·2	14·19	159·0	1·48	16·6	10·4	1·0717	17·4	81·5
628	3845·2	13·99	538·5	1·56	57·2	10·6	1·0711	17·3	80·8

PLOT No. 7.

Name . . . . . Pansari of Usufpur (Ghazipur).
Area . . . . . ·138 acre.

102	897·5	14·74	123·4	1·30	10·9	8·8	1·0726	17·6	83·7
151	652·7	14·96	97·6	1·22	7·9	8·1	1·0729	17·6	85·0
192	945·0	14·85	140·3	1·24	11·7	8·3	1·0731	17·7	83·8
208	908·0	14·91	135·4	1·29	11·7	8·6	1·0728	17·6	84·7
275	1320·5	14·96	197·5	1·23	16·2	8·2	1·0730	17·7	84·5
988	4663·7	14·88	694·2	1·25	58·4	8·4	1·0728	17·6	84·5

PLOT No. 8.

Name . . . . . Sarauti of Partabgarh.
Area . . . . . ·019 acre.

187	551·5	15·40	84·9	1·49	8·2	9·6	1·0774	18·7	82·3
230	687 0	15·41	105·8	1·44	9·9	9·3	1·0770	18·6	82·8
417	1238·5	15·40	190·7	1·46	18·1	9·4	1·0771	18·6	82·7

TABLE I—*contd.*

PLOT No. 9.

Name . . . . . Kewahi of Benares.
Area . . . . . ·0617 acre.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient.
172	507·5	14·20	72·0	1·42	7·2	10·0	1·0713	17·3	82·0
185	520·7	13·87	72·2	1·50	7·8	10·8	1·0707	17·2	80·6
195	578·0	14·10	81·5	1·53	8·8	10·8	1·0708	17·2	81·9
552	1606·2	14·05	225·7	1·49	23·8	10·5	1·0709	17·2	81·6

PLOT No. 10.

Name . . . . . Reora of Benares.
Area . . . . . ·118 acre.

115	665·2	17·22	114·5	0·92	6·1	5·3	1·0824	19·8	86·9
92	460·0	17·36	79·8	0·92	4·2	5·3	1·0837	20·1	86·3
120	463·0	17·32	80·2	1·09	5·0	6·2	1·0830	20·0	86·6
126	554·7	17·37	96·3	0·87	4·8	5·0	1·0834	20·0	86·8
453	2142·9	17·31	370·8	0·94	20·1	5·4	1·0830	20·0	86·5

PLOT No. 11.

Name . . . . . Reori of Benares.
Area . . . . . ·21 acre.

139	726·0	16·66	120·9	1·21	8·8	7·2	1·0828	19·9	83·7
117	488·0	16·74	81·7	1·30	6·3	7·7	1·0830	20·0	83·7
118	542·0	17·00	92·1	1·18	6·4	7·0	1·0833	20·0	85·0
125	636·2	16·70	106·2	1·20	7·6	7·1	1·0825	19·8	84·3
147	714·5	16·82	120·2	1·22	8·7	7·2	1·0817	19·6	85·8
136	733·0	16·98	124·4	1·19	8·7	7·0	1·0833	20·0	84·9
782	3839·7	16·81	645·5	1·21	46·5	7·1	1·0827	19·9	84·4

TABLE I—*contd.*

PLOT No. 12.

Name . . . . . Momcha of Basti.

Area . . . . . ·118 acre.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient.
179	519·5	17·50	90·9	1·17	6·1	6·6	1·0853	20·5	85·3
155	446·7	16·76	74·9	1·21	5·4	7·2	1·0835	20·1	83·3
165	576·0	16·93	97·5	1·26	7·2	7·4	1·0844	20·3	83·4
205	640·5	16·99	108·8	1·43	9·1	8·4	1·0839	20·2	84·1
174	508·0	17·34	88·1	1·27	6·4	7·3	1·0851	20·4	85·0
878	2690·7	17·10	460·2	1·27	34·2	7·4	1·0844	20·3	84·2

PLOT No. 13.

Name . . . . . Sarauti of Basti.

Area . . . . . ·127 acre.

172	481·5	17·62	84·8	1·01	8·8	5·7	1·0853	20·6	85·5
135	387·5	17·65	68·4				1·0835	20·6	85·6
158	404·2	17·26	69·7	1·03	4·1	5·9	1·0857	20·5	84·1
153	458·7	17·29	79·3	0·95	4·3	5·4	1·0850	20·4	84·7
265	752·5	17·22	129·6	1·09	8·2	6·3	1·0845	20·3	84·8
175	574·5	17·44	100·2	1·10	6·3	6·3	1·0855	20·5	85·0
1058	3058·9	17·39	532·0	1·04	31·8	5·9	1·0853	20·5	84·8

PLOT No. 14.

Name . . . . . Sarauti of Partabgarh.

Area . . . . . ·142 acre.

191	577·5	16·52	95·4	1·22	7·0	7·3	1·0806	19·4	85·1
192	515·0	16·65	85·7	1·11	5·7	6·6	1·0808	19·5	85·3
182	557·7	16·22	90·4	1·21	6·7	7·4	1·0800	19·3	84·0
154	462·2	16·27	75·2	1·18	5·4	7·2	1·0802	19·3	84·3
194	489·0	16·36	80·0	1·10	5·4	6·7	1·0804	19·4	84·3
191	536·0	16·57	88·8	1·12	6·0	6·7	1·0800	19·3	85·8
1104	3137·4	16·43	515·5	1·15	36·2	6·9	1·0803	19·4	84·6

TABLE I—*contd.*

PLOT No. 15.

Name . . Kuswar of Partabgarh—without manure.

Area . . . ·183 acre.

No. of Stools.	Weight of Juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in Juice. Per cent.	Purity co-efficient.
240	687·5	13·61	93·6	1·58	10·9	11·6	1·0696	16·9	80·5
181	616·5	13·34	82·2	1·48	9·1	11·0	1·0686	16·7	79·8
206	802·5	12·93	103·8	1·55	12·4	11·9	1·0650	15·9	81·3
233	837·2	13·14	109·2	1·61	13·4	12·2	1·0669	16·3	80·6
217	991·0	12·97	128·5	1·62	16·0	12·4	1·0668	16·3	79·5
179	583·0	12·95	75·5	1·62	9·4	12·5	1·0683	16·6	78·0
197	740·7	12·97	96·1	1·60	11·6	12·3	1·0663	16·2	80·0
211	966·0	12·83	123·9	1·61	31·6	12·5	1·0666	16·2	79·1
314	1181·7	12·65	149·5			12·7	1·0666	16·2	78·0
1951	7400·1	13·00	962·3	1·58	117·6	12·1	1·0670	16·3	79·7

PLOT No. 16.

Name . Kuswar of Partabgarh—with Sulphate of Ammonia.

Area . ·180 acre.

216	877·0	11·15	97·8	2·21	19·4	19·8	1·0611	15·0	74·3
200	940·5	10·66	100·2	2·38	22·4	22·3	1·0660	14·7	72·5
198	834·7	10·97	91·6	2·38	19·9	21·6	1·0620	15·2	72·1
191	690·5	10·34	71·4	2·51	17·3	24·2	1·0600	14·7	70·3
225	956·0	10·41	99·5	2·49	23·8	23·9	1·0597	14·6	71·3
202	999·5	10·84	108·3	2·42	24·2	22·3	1·0618	15·1	71·7
218	888·2	10·81	96·0	2·38	21·1	22·0	1·0602	14·7	73·5
244	1092·0	11·19	122·2	2·51	27·4	22·4	1·0634	15.5	72·1
1604	7278·4	10·81	787·0	2·41	175·5	22·2	1·0611	15·0	72·0

TABLE I—*concld.*

PLOT 17.

Name . . . . . Sarauti of Partabgarh.

Successive 25 stools.

No. of Stools.	Weight of juice. Lbs.	Sucrose. Per cent.	Sucrose. Lbs.	Invert Sugar. Per cent.	Invert Sugar. Lbs.	Glucose Ratio.	Specific gravity.	Total Solids in juice. Per cent.	Purity co-efficient.
25	112·0	15·65	17·5	1·34	1·5	8·5	1·0780	18·8	83·2
25	71·5	16·43	11·7	1·23	0·9	7·4	1·0804	19·4	84·6
25	7 ·5	15·57	11·0	1·27	0·9	8·1	1·0766	18·5	84·1
25	87·0	15·95	13·9	1·31	1·1	8·2	1·0783	18·9	84·3
25	66·5	15·45	10·3	1·37	0·9	8·8	1·0773	18·7	82·6
25	75·2	15·29	11·5	1·52	1·1	9·9	1·0772	18·7	81·7
25	76·0	16·02	12·2	1·22	0·9	7·6	1·0794	19·1	83·8
25	72·0	15·87	11·4	1·27	0·9	8·0	1·0786	19·0	83·5
25	81·0	16·12	13·0	1·15	0·9	7·1	1·0787	19·0	84·8
25	137·5	15·63	21·5	1·25	1·7	8·0	1·0775	18·7	83·5
25	78·7	16·50	13·0	1·10	0·8	6·6	1·0804	19·4	85·0
25	157·5	15·43	24·3	1·18	1·8	7·6	1·0771	18·6	82·9
25	86·2	15·92	13·7	1·25	1·1	7·8	1·0781	18·9	83·1
25	95·5	15·49	14·8	1·21	1·1	7·8	1·0792	19·1	81·1
25	125·7	15·77	19·8	1·24	1·5	7·8	1·0801	19·3	81·7
25	63·7	16·07	10·2	1·01	0·6	6·2	1·0790	19·1	84·1
25	76·5	16·28	12·4	0·98	0·7	6·0	1·0795	19·2	84·4
25	82·2	16·31	13·4	1·24	1·0	7·6	1·0805	19·4	84·0
25	85·7	15·88	13·6	0·98	0·8	6·1	1·0764	18·5	85·8
25	60·0	16·16	9·7	0·92	0·5	5·6	1·0788	19·0	85·0
500	1760·9	15·84	278·9	1·18	20·7	7·5	1·0785	19·0	83·3

It may be of interest to other chemists to briefly mention the methods used in the temporary laboratory at Partabgarh.

1. Sucrose.

50 cc. of juice was clarified with Lead Acetate and diluted to 100 cc.

The number of grams of Sucrose per 100 c.c. (S_1) was found in the usual way by the Clerget method using the formula—

$$S_1 = \frac{x-y \times 26{\cdot}048}{143 - \frac{1}{2}t}$$

where x = Direct reading.
y = Invert reading.
t = Temperature of the readings in °C.

The results are given in per cent. of Sucrose in juice, *e.g.*, grams of Sucrose in 100 gms. of juice, and this is got by dividing S_1 by the specific gravity.

2. The Specific gravity.

Determined at 20 °C by a Westphal balance.

3. Invert Sugar.

This was determined by a method first suggested by Soldiani (Gazz. Chem. Ital 6-324) and modified by Ost (Ber. d. d. Chem. Ges. 24-14-3003). It has been used in the United States by Ewell and in England by Wood, but its application in this country has not been general. It is accurate, rapid, and possesses many advantages over Fehlings original method.

It consists in using a solution of copper bicarbonate and potassium carbonate as the oxidising agent. Filtering off the precipitated cuprous oxide, and dissolving in a solution of ferric sulphate acidified with sulphuric acid. A quantity of ferrous sulphate proportional to the cuprous oxide present is formed, and this is estimated by titration with potassium permanganate of a convenient strength. The copper solution is made by dissolving in a litre.

23·5 gms. Copper Sulphate.
250 gms. Potassium Carbonate.
100 gms. Potassium Bicarbonate.

Its advantages over the usual alkaline tartarate solution are that it keeps for a considerable time without change. It has far less action on

cane and other non-reducing sugars, and a given weight of sugar reduces nearly twice as much copper as it does from Fehlings solution. It requires, however, ten minutes boiling to get accurate results.

The actual manipulation was carried out as follows :—25 cc. of the cane juice was clarified, made up to 100 cc. and filtered. 50 cc. of the copper solution measured into a 300 cc. conical flask and heated to boiling, 10 cc. of sugar solution run in, and boiling continued for 10 minutes. The cuprous oxide was filtered through a pad of fine asbestos on a perforated disc in an ordinary funnel under slight-pressure and washed with boiling water. The asbestos pad was returned to the flask, and the oxide adhering to the funnel washed out with a 10 per cent. solution of ferric sulphate in 25 per cent. sulphuric acid. A few crystals of Sodium Carbonate added to the acid solution in the flask to drive out the air, and to prevent oxidation of the Ferrous salt. The contents were slightly diluted, well shaken to dissolve the copper oxide, and titrated in the usual way. The permanganate is best standardised by a solution of glucose of known strength. Complaints have been made that the end point of the reaction is undecided. This is generally found to be the case with permanganate titrations unless care is taken that the reagents are free from chlorides.

The following table shows some of the figures obtained by this method :—

Sample.	cc. Copper Solution.	cc. Sugar Solution.	cc. $KMnO_4$ used.	Invert Sugar. Per cent.
2 (7)	50	10	10·6	1·30
	50	10	10·8	1·32
2 (2)	50	10	14·65	1·79
	50	10	14·90	1·82
1 (2)	50	10	13·7	1·67
	50	10	13·7	1·67
8 (2)	50	10	16·65	2·03
	50	10	16·4	2·00

The varieties at Partabgarh can be broadly divided into two classes on the lines already suggested by one of us.*

Class A.—Thin erect canes of reed-like form corresponding to the Dhaul canes—

Sarauti of Partabgarh.
Kewahi of Benares.
Momcha of Basti.
Sarauti of Basti.

Class B.—Thicker, stronger and more erect canes corresponding to the Kuswar series—

Patarki mango of Shahganj.
Hemja of Gorakhpur.
Reora of Gorakhpur.
Charkahiya of Azamgarh.
Dhaura of Azamgarh.
Pansari of Usufpur (Ghazipur).
Reora of Benares.
Reori of Benares.
Kuswar of Partabgarh.

It is interesting to compare some of the data obtained from the two classes. This is done in the following tables :—

CLASS A.

Plot.	Variety.	Juice per stool. Lbs.	Sucrose. Per cent.	Invert Sugar. Per cent.	Glucose Ratio.	Total solids in juice. Per cent.	Purity co-efficient.
8	Sarauti of Partabgarh .	2·4	15·10	1·46	9·4	18·6	82·7
14	„ „ „ .	2·8	16·43	1·15	6·9	19·4	84·6
9	Kewahi of Benares .	2·9	14·05	1·49	10·5	17·2	81·6
13	Sarauti of Basti . .	3·0	17·39	1·04	5·9	20·5	84·8
12	Momcha of Basti . .	2·9	17·10	1·27	7·4	20·3	84·2

* The Sugar Industry of the United Provinces by S. M. Hadi, Chapter II, pages 3 and 14.

CLASS B.

Plot.	Variety.	Juice per stool. Lbs.	Sucrose. Per cent.	Invert Sugar. Per cent.	Glucose Ratio.	Total solids in juice. Per cent.	Purity co-efficient.
2	Patarki mango of Shahganj . . .	3·5	14·92	1·70	11·5	18·3	81·5
3	Hemja of Gorakhpur .	4·0	13·35	1·50	11·3	16·5	80·9
5	Charkahiya of Azamgarh	3·4	11·87	1·99	16·8	15·7	75·6
6	Dhaura of Azamgarh .	6·4	13·99	1·56	10·6	17·3	80·8
7	Pansuri of Usufpur (Ghazipur) . .	4·3	14·88	1·25	8·4	17·6	84·5
10	Reora of Benares .	1·7	17·31	0·94	5·4	20·0	86·5
11	Reori of Benares . .	4·9	16·81	1·21	7·1	19·9	84·4
17	Kuswar of Partabgarh .	3·8	13·00	1·58	12·1	16·3	79·7

The yield of juice per stool was very uniform in the case of class A, the thin reed-like canes; and with one exception they gave juices, of high concentration, low glucose ratio, and high purity co-efficient. In other words juice, which was suitable in every way for the production of a high quality raw sugar. The yield of juice per stool from the canes of class B varied enormously, as also did the other data shown in the following Tables:—

CLASS A.

Plot.	Variety.	Stools per acre.	Sucrose. Per cent.	Invert Sugar. Per cent.	Sucrose per acre.	Invert Sugar per acre.
8	Sarauti of Partabgarh . .	8,510	15·40	1·46	3,891	369
14	„ „ „ . .	7,774	16·43	1·15	2,630	254
9	Kewahi of Benares . . .	8,946	14·05	1·49	3,658	385
13	Sarauti of Basti . . .	8,330	17·39	1·04	4,188	250
12	Momcha of Basti . . .	7,440	17·10	1·27	3,900	289

CLASS B.

No.	Variety.	Stools. per acre.	Sucrose Per cent.	Invert Sugar. Per cent.	Sucrose per acre	Invert Sugar per acre.
2	Patarki mango of Shahganj .	7,375	14·92	1·70	3,967	452
3	Hemja of Gorakhpur . .	6,044	13·35	1·50	..	..
5	Charkahiya of Azamgarh .	9,406	11·87	1·90	3,812	638
6	Dhoura of Azamgarh .	4,944	13·99	1·56	4,174	443
7	Pawari of Usufpur (Ghazipur) .	7,159	14·88	1·25	5,030	423
10	Reora of Benares . .	3,839	17·31	0·94	3,142	170
11	Reori of Benares . .	3,723	16·81	1·21	3,073	221
15	Kuwar of Partabgarh .	10,961	15·00	1·58	5,258	642

The differences in the latter case may have been due to one, or both of the following causes :—

(*a*) An inherent difference in the varieties themselves as sugar producers.

(*b*) A variation in one or more of the factors controlling photosynthesis brought about by varying conditions of cultivation.

The first condition may, and no doubt does, account for some of the variations, but it is unlikely that in races so similar in outward characteristics as Charkahiya of Azamgarh and Reora of Benares that it will account for a difference in Sucrose content of nearly 6 per cent.

It seems much more probable that some condition as the space available for the development of each stool is different, affecting in its turn the leaf area exposed to the active rays of light, transpiration, and factors of similar nature; and that these determine the composition of the juice. It is conceivable that the most economical production of sugar will be achieved by methods of cultivation, which give a larger and more evenly divided leaf area per weight of cane, provided the latter is not greatly diminished per acre.

In class B there was a large variation in the number of stools per acre, due to the unequal germination of these more delicate varieties, and it is

interesting in view of what has just been said to note that high concentration of juice generally accompanies a low number of stools per acre. No definite deduction can of course be made from one season's work with different varieties in an experiment not planned for this particular purpose, but the result seems suggestive, and points to the fact, already mentioned, that a great deal more attention will have to be given in sugarcane experiments to the study of the exact conditions of growth, and their influence on the factors which determine the yield and concentration of juice. Recent work on sugarcanes in other countries has shown that the canes yielding the most sugar were the heaviest, that is, the strongest tillered plants of the cane-field, and this may be due, though no mention is made of it, to a natural tendency of such canes to develop a large leaf area or possibly by being grown for selection purposes under conditions which favour vigorous leaf development. If this is so, it will have an important bearing on the methods of selection.

Experiments are being carried out this year with a view of throwing more light on the subject.

A good many sugarcane experiments hitherto recorded are content with describing differences in composition of the juice to manures without attempting to trace the influence of these on the factors mentioned in the preceding pages.

The importance of producing a concentrated juice (provided the yield of sugar per unit area is not appreciably affected) is perhaps emphasized by looking at the question from a slightly different point of view, *e.g.*, the amount of juice that has to be evaporated to obtain 5,000 lbs. of Sucrose. This is shown in the following table :—

Sucrose. Per cent.	Weight of juice per 5,000 lbs. sugar.
14·92	33,549
13·35	37,448
11·48	43,633
11·87	42,019

Sucrose Per cent.	Weight of juice per 5,000 lbs. sugar.
13·99	35,702
14·88	33,590
15·40	32,472
14·05	35,582
17·31	28,895
16·81	29,742
17·17	29,234
17·39	28,749
16·43	30,430
13·00?	28,450
10·81	46,244

Nearly 20,000 lbs. more water has to be boiled away in the juice of the lowest concentration to obtain 5,000 lbs. of sugar. This needs consideration in India where the question of fuel is an important factor.

At Partabgarh when the weak juices were being boiled down into gur every available piece of bagasse was used up, and often wood in addition. In the case of the concentrated juices a large quantity of bagasse was left unused.

A line of work which might well be taken up in connection with cane cultivation would be to find the conditions which give the most concentrated juice, without materially affecting the yield of sugar per acre.

Indeed something of this kind, with the results expressed in a slightly different way, will have to be done before the selection of sugarcane can be attempted. It is obviously impossible to attempt to improve a cane until you know what it can do under optimal conditions.

A good deal of discussion arose at the Board of Agriculture meeting at Cawnpore on the relative merits of valuing sugarcane by the quantity of juice and the percentage of sugar in it and by actually weighing the gur. In the course of the Partabgarh Campaign this year data were

obtained enabling us to calculate both values. These are shown in the following table :—

Comparison of yield of sugars and gur per acre.

Plot.	Variety.	Sucrose per acre.	Invert sugar per acre.	Total Sucrose + Invert Sugar.	Gur per acre.
2	Patarki mango of Shahganj .	3987·5	452·8	4420·3	4,09
5	Cherkahiya of Azamgarh .	3812·3	638·9	4451·2	4,04
6	Dhaura of Azamgarh . .	4174·4	443·4	4617·8	4,42
7	Patwari of Yusufpur (Ghazipur)	5030·1	423·1	5473·5	5,33
8	Saranti of Partabgarh . .	3891·8	260·2	4201·1	3,88
2	Kewahi of Benares . .	3965·0	385·7	4443·7	3,80
10	Reora of Benares . . .	3112·3	170·3	3312·6	3,24
11	Reori of Benares . . .	3073·8	221·4	3295·2	3,18
12	Momcha of Basti . . .	3990·0	289·8	4189·8	4,17
13	Saranti of Basti . . .	4188·0	255·3	4443·2	4,39
14	Saranti of Partabgarh . .	3630·2	274·9	3885·1	3,94
15	Kuswar of Partabgarh . .	5258·4	612·6	5901·0	6,04
16	,, ,, ,, (with manure)	4372·2	975·0	5247·2	4,98

As a matter of fact there is for this kind of work a curiously close agreement between them ; the amount of dirt and moisture left in the gur is the same as the sugar taken out and thrown away in the scum.

One would not expect the sampling of gur to present any difficulties as a thoroughly homogenous mixture of each pan is obtained by the constant stirring it gets when cooling. A small core of approximately the same weight was taken from each Bhela, and the whole of these

thoroughly mixed in an porcelain mortar. The following results of duplicate samples show that the method was truthful :—

Sample.	Sucrose. Per cent.	Invert Sugar. Per cent.
2	73·30	2·36
2 A	73·00	12·48
12	76·04	8·02
12 A	76·04	9·05
16	65·34	18·97
16 A	65·03	19·03

It is interesting to note the composition of the juice and the composition of the gur obtained from it. Fifteen samples of gur made from juice of known composition were examined ; the results are given below :—

Comparison of composition of juice and quality of gur.

Plot.	Variety.	Sucrose in juice. Per cent.	Sucrose in gur. Per cent	Invert Sugar in juice. Per cent.	Invert Sugar in gur. Per cent.
2	Patark, mango of Shahganj .	14·92	73·30	1·70	12·42
3	Henja of Gorakhpur . .	13·35	72·39	1·50	12·85
4	Reora of Gorakhpur . .	10·48	66·92	2·09	18·11
5	Chunkahiya of Azamgarh .	11·87	67·22	1·99	17·38

Comparison of composition of juice and quality of gur—(contd.)

Plot.	Variety.	Sucrose in juice. Per cent.	Sucrose in gur. Per cent.	Invert Sugar in juice. Per cent.	Invert Sugar in gur. Per cent.
6	Dhaura of Azamgarh . .	13·99	74·28	1·56	11·63
7	Punsari of Usnfpur (Ghazipur) .	14·88	76·37	1·25	10·40
8	Sarauti of Partabgarh . .	15·40	75·17	1·46	11·63
9	Kewahi of Benares. . .	14·05	73·96	1·49	12·24
10	Reora of Benares . . .	17·31	77·87	0·94	8·57
11	Reori of Benares . . .	16·81	76·06	1·21	9·05
12	Monecha of Basti . . .	17·10	76·04	1·27	8·29
13	Sarauti of Basti . . .	17·39	76·04	1·34	8·81
14	Sarauti of Partabgarh . .	16·13	76·95	1·15	8·81
15	Kuswar of Partabgarh (without manure)	13·09	74·82	1·58	12·61
16	Kuswar of Partabgarh (with Sulphate of Ammonia) . .	16·81	65·34	2·41	19·03

A rather striking point about all the juices at Partabgarh was the comparatively high amount of Invert sugar, even in the ripest canes. In plot No. 10 Reora of Benares cut on January 25th, it was approximately 1·00 per cent. The highest amount was in Plot No. 16 Kuswar of Partabgarh cut on January 30th, 2·4 per cent. This plot had been heavily manured with nitrogen and was cut at the same time as the plot of the same variety without manure to compare the juices.

The gur made from the ripe Reora of Benares contained 8½ per cent. invert sugar; the gur from the unripe Kuswar 19·0 per cent. invert sugar—an increase of 10½ per cent.

It is generally agreed that a per cent. rise in the per cent. Invert sugar means a per cent. loss in the amount of crystalizable sugar. These figures point out the necessity of a detailed study of the changes that go on during the ripening of one or two of the leading varieties of canes.

A table is given below showing glucose ratio of the gur and the juice, the figures agreeing with those published previously by Leather, but it was thought worth while to put them on record :—

Comparison of Glucose Ratio in juice and gur.

No.	Variety.	Parts glucose per 100 cane sugar.	Parts glucose per 100 cane sugar.	Increase in glucose ratio.
		Juice.	Gur.	
2	Patarki mango of Shahganj . . .	11·5	16·9	5·4
5	Charkahiya of Azamgarh . . .	16·8	25·8	9·0
6	Dhaura of Azamgarh	10·6	15·6	5·0
7	Parsuri of Usufpur (Ghazipur) . . .	8·4	13·6	5·2
8	Saraiti of Partabgarh	9·4	15·4	6·0
9	Kewahi of Benares	10·5	16·5	6·0
10	Peora of Benares	5·4	11·0	5·6
11	Reori of Benares	7·1	11·9	4·8
12	Mumcha of Basti	7·4	11·8	4·4
13	Saraiti of Basti	5·9	11·6	5·7
14	Saraiti of Partabgarh	6·9	11·4	4·5
15	Kuswar of Partabgarh (without manure) . .	12·1	16·8	4·7
16	„ „ (with Sulphate of Ammonia)	22·2	29·1	6·9
	MEAN .	..	..	5·6

It was stated at the beginning of this article that we found as the result of thirteen separate experiments dealing with 8,000 lbs. of gur that the average loss of total sugars (Sucrose and Invert) was 15·7

per cent. The detailed figures on which this calculation is based are given below :—

Total loss of sugars during boiling.

Plot.	Variety.	Total Sugar Sucrose + Invert. Lbs.		Lbs. Sucrose + Invert Sugar in Gur per 100 lbs. Sucrose + invert Sugar in Juice.
		In Juice.	In Gur.	
2	Patarki mango of Shahganj . . .	694·0	604·6	87·1
5	Charkahiya of Azamgarh . . .	434·0	383·2	88·3
6	Dhaura of Azamgarh	595·7	490·0	82·2
7	Pansari of Usufpur (Ghazipur) . . .	752·6	641·2	85·2
8	Saranti of Partabgarh	208·8	165·3	79·1
9	Kewahi of Benares	249·5	207·3	83·0
10	Reori of Benares	390·9	331·0	84·7
11	Reori of Benares	692·9	570·2	82·1
12	Monicha of Basti	494·1	419·2	84·8
13	Saranti of Basti	563·8	473·4	84·0
14	Saranti of Partabgarh	551·7	480·7	87·1
15	Kuswar of Partabgarh (without manure) .	1079·9	967·8	89·6
16	„ „ „ (with Sulphate of Ammonia)	9.62·5	756·4	78·5
	MEAN .			84·3

There is no doubt that most of it goes in the scum. It should not be a difficult matter to devise a simple filter-press at the cost of a few rupees which could be worked by hand. Even if half this loss was recovered it would mean a very considerable increase in the production of gur.

Sucrose is the desirable compound from the factory point of view. The loss of this depends on two things. Some of it is inverted during boiling, some of it is ladled out with the scum. The combined effect of these is the loss of nearly 20 per cent. of the total Sucrose, as shown in the following table :—

Loss of Sucrose during the manufacture of gur.

Plot.	Variety.	Sucrose in juice. Lbs.	Sucrose in gur. Lbs.	Lbs. Sucrose in gur per 100 lbs. Sucrose in juice.	Lbs. Sucrose lost per 100 lbs. Sucrose in juice.
2	Patarki mango of Shahganj	622·9	517·0	83·0	17·0
5	Charkahiya of Azamgarh	371·7	304·5	81·9	18·1
6	Dhaura of Azamgarh	538·5	423·7	78·7	21·3
7	Pansari of Usufpur (Ghazipur)	694·2	564·4	81·3	18·7
8	Sarauti of Partabgarh	190·7	143·2	75·1	24·9
9	Kewahi of Benares	225·7	177·9	78·8	21·2
10	Reora of Benares	370·8	298·2	80·4	19·6
11	Reori of Benares	645·5	509·6	78·8	21·2
12	Monecha of Basti	460·2	374·9	81·4	18·6
13	Sarauti of Basti	532·0	424·3	79·7	20·3
14	Sarauti of Partabgarh	515·5	431·3	83·6	16·4
15	Kuswar of Partabgarh (without manure)	952·3	828·2	86·9	14·0
16	Kuswar of Partabgarh (with Sulphate of Ammonia)	787·0	585·8	74·4	25·6
	AVERAGE	..	..	80·2	19·7

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