

**Agricultural Research Institute, Pusa**

**Sugar and the Sugarcane in  
the Gurdaspur District**

BY

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## PREFACE

**I**N 1911 an analytical survey of the sugarcanes of the Gurdaspur District was commenced with a view to ascertain the average sugar content of country canes grown under ordinary conditions of cultivation. The enquiry was to show not only where the best canes were grown, but to what extent the different types differed in the composition of the juice as well as to give some idea of the influence of soil and climate.

As the survey was primarily undertaken to select a site for a central refining factory in what was then considered the best sugarcane district of the Province, it was of prime importance that our results should indicate every vicissitude to which the raw product of the factory might be subjected. It consequently includes a very large number of analyses of cane, and I have thought it desirable to give these results in some detail for future reference notwithstanding they make the Bulletin very bulky.

At the same time information gained from cultivators in the district on the losses occasioned by hard winters and dry summers indicated the need of prolonging the enquiry over several years so as to include bad as well as good seasons.

The results of the enquiry, which has now been pursued for five years, show that the time has not yet come when a central refining factory can be erected in the district with any chance of being a financial success. I shall show that the conditions for success of such a factory are not to be found there at the present time, and that, before refining on a manufacturing scale can be attempted, it will be necessary to improve very materially the quality of cane grown by the importation of better varieties, which must be sufficiently hardy to resist the rigorous winter climate of this district and which will give much better yields than the cane now being grown there, as well as to improve the soils of the district by improved methods of cultivation and by the addition of those manurial constituents which the combined study of science and farming have shown to be necessary. The average out-turn of stripped cane per acre in the district appears to be about 10 tons. This figure and the average composition of these canes were enough to turn the only capitalist really willing and competent to undertake the erection of a sugar refinery in the Punjab further south. This was Mr. Thomas Hughes, Director of the Colonial Sugar Refining Company, Sydney, who visited the Punjab in 1914 to see if the new canal colony in the

Montgomery District would provide a suitable place to start such a factory.

If we are to refine sugar in the Punjab, we must aim at producing a heavy yielding cane or a series of canes which will ripen in from 8 to 11 months and which will give when ripe a suitable expression for the refining processes, a juice of sufficient purity to be easily handled in the factory. We are a long way from this at present though the testing of cane varieties has been one of the principal objects of the Gurdaspur Experimental Station since its foundation in 1910.

In 1913, the Government Sugarcane Expert, Dr. Barber, was invited to assist in the enquiry by the botanical classification of the canes of the district and the results of his enquiry will be found under a separate publication.<sup>1</sup>

The indigenous methods of cultivation described in Chapter I have been written from notes supplied to me by Mr. Southern, and I wish to express my indebtedness to this officer for his very able and kindly help in all stages of the enquiry.

I am much indebted to Maulvi Fateh-ud-Din, Officiating Deputy Director of Agriculture, and his staff for help in the district and on the Gurdaspur Farm. Many of the figures relating to out-turn, yield of *gur*, etc., have been provided by them.

I also acknowledge the painstaking care of my assistants, Mr. D. K. Ambekar, M.A., and Bh. Arjan Singh, L.Ag., who have done practically the whole of the sugar assays of this report.

J. H. BARNES.

PUNJAB AGRICULTURAL COLLEGE,  
CHEMICAL LABORATORY,  
*June, 1916.*

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<sup>1</sup> Barber, C. A. *Mem., Dept. Agri., India, Bot. Ser.*, vol. VII, no. 1.

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# Sugar and the Sugarcane in the Gurdaspur District

[Received for publication on 10th October, 1916.]

## CHAPTER I.

### THE GURDASPUR DISTRICT AND THE INDIGENOUS METHODS OF CANE-GROWING PRACTISED THERE.

#### 1. The climate.

The Gurdaspur District which is some 1,826 square miles in extent with a population in 1911 of 836,771, comprises the submontane and upper plains portions of the Bari Doab\* lying between the Bias and Ravi rivers, and extending across the latter into the submontane tract of the Rachna Doab between the Ravi and the Chenab. Its proximity to the foot-hills of the Himalaya secures for this district a far more generous rainfall than is the case with the greater part of the arid province of which it is a part, and it is largely owing to the abundance of water so secured that Gurdaspur has taken the first rank in cane cultivation in the Punjab.

The district enjoys a rainfall of from 24 to 50 inches of water per annum. This is not incomparable with that falling on the cane lands of Hawaii, but in the latter case there is a moist island climate of more or less equable temperature—in spite of this the amount of water received by the crop during 17 months is according to Deerr 27" of rain water and 76" irrigation water or 103" in all or about 1,000 lb. of water per lb of sugar produced.

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\* Doab means the space lying between two rivers; *do* (Persian) two and *ab* water.

O'Shaughnessy estimates the irrigation duty of water in Hawaii to be 134" per annum not counting natural rainfall. According to Tiemann, in Egypt which is much more comparable to the Punjab climatically, cane receives about 95" of irrigation water between the month of February (planting) and the end of October (when the harvesting commences).

We should expect, therefore, to find very little *barani*\* cane in the Punjab or indeed throughout North-West India.

TABLE I.

*Rainfall in Gurdaspur for past 8 years.*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total for the year (in inches)
1908 .	1-32	1-25	0-00	2-62	0-00	1-29	8-18	12-87	6-08	0-00	0-22	0-21	33-94
1909 .	1-16	1-51	0-00	1-87	0-00	1-38	6-34	15-47	9-10	0-16	0-00	2-32	36-21
1910 .	2-18	0-26	0-20	0-06	0-00	8-13	6-04	22-33	1-32	0-00	0-20	0-00	41-23
1911 .	8-95	0-29	8-41	0-24	0-00	3-39	1-83	6-50	2-23	0-24	1-75	0-00	33-98
1912 .	4-03	0-07	0-24	0-91	0-26	0-03	9-66	11-76	0-41	0-00	0-80	0-04	28-21
1913 .	0-50	2-91	1-76	0-00	1-18	4-29	6-62	9-26	0-00	0-08	0-00	1-03	27-58
1914 .	1-16	1-99	1-52	3-06	1-57	4-03	30-04	2-47	4-66	2-99	0-00	1-77	55-90
1915 .	2-22	3-94	2-43	0-35	0-00	0-55	2-76	3-83	3-36	2-04	0-00	0-07	21-66

In Gurdaspur the temperature frequently falls below freezing point (32°F.) during the months of December and January, and this causes an enormous amount of damage to the crop as well as constituting one of the most serious obstacles in its improvement. I shall show in Chapter III how this affects the cane and how, in the introduction of new varieties, the selection of hardy types is of prime importance.

## 2. The soil.

The soil of the district varies considerably in texture as we pass from the rivers towards the high-lying portions of the Doab and from the Doab towards the foot-hills. On the whole, it is a fairly light soil,

\* *Barani* means grown by rainfall alone, that is, no water either from canal or wells is used for irrigating the crop; see Tables V and VI.

like the bulk of the Punjab alluvium, but not too light to provide an excellent substratum for the growth of both wheat and cane, two of the most important crops grown in the district. The high-lying ridges of the Doab appear to owe their fertility in a large measure to the excellent drainage which they possess, for good drainage is one of the most important factors in the successful ripening of sugarcane. It is probable that this is one of the principal reasons why cane does so well in these parts, for as we proceed towards the rivers the quality of the cane falls off in spite of the richness of the land. Generally speaking, sugarcane is a plant which in its growth demands large quantities of water, and therefore naturally prefers a soil of water-retaining power like clay. In such soils, irrigation is not so frequent or so necessary, but in the Gurdaspur soils we have to deal with a more porous type, and the water supply of the plant has to be maintained in an artificial manner if the rainfall is not frequent and plentiful. This is accomplished by irrigation from both wells and from canals. The effect of starving the plant of water during its growth is to produce a thin woody cane; while excess of water and lack of proper drainage retard ripening. The ideal soil, therefore, for cane growing would seem to be a stiff heavy soil underlaid with sand. Throughout the Punjab alluvium we find such soils representing old clay pockets—the result of back waters and still ponds, when the soils were in course of being deposited. These beds may vary from a few inches in depth to many feet, but underneath all sand is invariably found. Such is the nature of the richest farm land, not only in this district but throughout the Province where sufficient water can be obtained to secure healthy plant growth. Too often, however, the water supply is deficient, and these clay beds then cause the accumulation of saline matter on the surface, which, barren of all vegetation, and showing as white excrescence on the surface, has the appearance of some loathsome disease of the land.

Cane appears to grow almost equally well in all soils, if it receives the water and manures necessary for its even and healthy growth, and if the temperature is suitable. Calcareous soils are generally considered to be among the best for cane growing, for such soils yield a rich and easily worked juice. The composition of the soils of the Hawaiian archipelago is of particular interest to the cane grower by reason of the exceptionally high returns obtained there. A study of these soils reveals the fact that they contain large quantities of lime and iron, smaller quantities of potash, and considerable quantities of phosphates in the form of apatite. The sedimentary soils are among the most productive in the island and are often of great depth.



The Gurdaspur soils are for the most part (Table III) deficient in the manurial constituents of lime and nitrogen. The exhausted condition of these soils for sugarcane cultivation is particularly emphasized by the small amount of lime as compared with the amount of magnesia present, and indicates the need of manuring combined with a much deeper cultivation than is at present given.

TABLE II.

*Mechanical analysis of soils from the Gurdaspur District, 1914.*

Grams per 100 grams of soil.

Source of soil	Stones and gravel	Soluble matters and hygroscopic moisture	Fine gravel	Coarse sand	Fine sand	Silt	Fine silt	Clay
Sugarcane soil from Batala	1.45	4.13	1.14	25.96	23.19	16.10	12.71	10.23
Sugarcane soil from Harchowal (Batala)	..	1.90	0.25	23.00	22.91	20.01	19.93	15.60
Sugarcane soil from Bham (Batala)	1.61	1.60	0.41	23.87	32.30	17.92	12.99	12.48
Sugarcane soil from Chhina (Gurdaspur)	..	2.33	0.48	8.13	19.02	27.45	26.02	12.96
Sugarcane soil from Gurdashangal (Gurdaspur)	..	2.23	0.23	14.30	23.84	26.82	18.20	9.23
Sugarcane soil from Méri Buchlón (Batala)	..	1.65	0.11	23.70	27.23	25.44	12.94	7.36
Experimental Farm, Gurdaspur	..	1.19	0.24	33.29	19.92	17.24	13.60	6.40
Experimental Farm, Gurdaspur	..	1.20	0.16	40.93	21.52	16.84	12.24	5.92
Experimental Farm, Gurdaspur	..	0.94	0.11	28.07	22.21	20.47	13.26	6.40
Experimental Farm, Gurdaspur	..	0.95	0.24	32.94	24.30	20.08	13.04	6.40
Experimental Farm, Gurdaspur	..	0.87	0.16	35.56	24.47	17.93	12.56	6.32
Experimental Farm, Gurdaspur	..	0.86	0.29	40.85	19.75	16.36	14.96	7.23

TABLE III.

Chemical composition of the soils referred to in Table II. Sugarcane soils from the Gurdaspur District, 1914.

Sources of the soil	Insoluble in boiling hydrochloric acid, silica, silicates, etc.	Al <sub>2</sub> O <sub>3</sub> and Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Nitrogen (N)	Total potash as K <sub>2</sub> O	Available K <sub>2</sub> O	Total P <sub>2</sub> O <sub>5</sub>	Available P <sub>2</sub> O <sub>5</sub>
Grams per 100 grams of soil.										
Sugarcane soil from Batala	84.33	8.08	0.90	1.03	0.08	0.083	0.351	0.050	0.449	0.147
Sugarcane soil from Harchowal (Batala)	83.44	9.01	0.28	0.97	0.05	0.058	0.304	0.032	0.435	0.032
Sugarcane soil from Bham (Batala)	88.68	6.87	0.27	0.82	0.04	0.052	0.292	0.027	0.486	0.112
Sugarcane soil from Chhina (Gurdaspur)	82.98	10.84	0.29	0.62	0.07	0.078	0.214	0.023	0.400	0.038
Sugarcane soil from Gurdas-hanzal (Gurdaspur)	86.15	8.47	0.29	1.04	0.07	0.075	0.386	0.023	0.436	0.066
Sugarcane soil from Mál Euchián (Batala)	88.08	6.07	0.27	0.79	0.07	0.052	0.317	0.022	0.330	0.038
Experimental Farm, Gurdaspur	88.66	7.82	0.35	0.46	0.064	0.048	0.366	0.015	0.71	0.023
Experimental Farm, Gurdaspur	88.79	7.40	0.30	0.99	0.073	0.045	0.343	0.014	0.65	0.032
Experimental Farm, Gurdaspur	88.87	7.49	0.51	1.17	0.073	0.046	0.381	0.013	0.56	0.025
Experimental Farm, Gurdaspur	87.99	7.62	0.30	0.88	0.032	0.049	0.446	0.016	0.64	0.026
Experimental Farm, Gurdaspur	89.15	7.05	0.48	1.17	0.115	0.046	0.422	0.014	0.62	0.020
Experimental Farm, Gurdaspur	88.35	7.23	0.43	1.23	0.068	0.043	0.448	0.017	0.82	0.025

### 3. Distribution of the varieties of canes grown in the district.

The greater portion of the cane produced in the district is grown in the tahsils\* of Batala and Gurdaspur, and it is generally considered among the farming classes that the Batala tahsil is the more favourably situated for the cultivation of this crop and that the average out-turn per acre is higher there than in any other part of the district. Generally speaking, the cane falls off in quantity and out-turn as we approach the foot-hills, for whereas the out-turn of raw sugar per acre is about 25 maunds in Batala, in Pathankot it is only about 9½ maunds.†

In the following table (Table IV) is shown the distribution of cane throughout the Gurdaspur District in the year 1913. In the same table are shown the different classes of land on which the crop was grown, viz., *chahi*, *nahri*, and *barani*, and sub-divisions of these.

\* Tahsil is a division of the district for administrative purposes. It is under the charge of a superior official (Indian) called a tahsildar, who is a magistrate of the second class.

† The maund referred to in the Bulletin is the standard measure of weight in North-West India—it is approximately equal to 82 lb. avoirdupois.

1 maund = 40 seers.

1 ton = 27.3 maunds.

TABLE

## Sugarcane cultivation in Gurdaspur

Description of crop	TAHSEIL BATALA						TAHSEIL GURDASPUR					
	Bet Ravi	Maira Kiran	Nabri Shargull	Nabri Gharhi	Bangar	Total of Tahsil	Bet Ravi	Maira Kiran	Nabri	Bangar	Bet Beas	Total of Tahsil
1. Chahi	1,182	2,431	623	2,767	4,904	11,907	278	1,901	1,894	1,123	14	5,210
2. Chahi Nabri Zamindari	32	88	13	56	188	378	..	84	48	87	..	118
3. Nabri Zamindari	..	..	..	..	..	..	..	25	..	..	12	37
4. Abi	21	89	2	5	1	118	1	27	11	14	1	54
5. Sallab	240	82	645	5	..	972	1,861	..	..	..	1,156	2,018
6. Barani (I)	57	10	17	19	88	141	698	1,147	683	447	268	2,238
7. Shah Nabri	4	2	8	2	14	30	58	82	28	35	37	230
8. Barani (II)	..	209	2,721	3,755	..	6,686	..	363	5,803	174	99	6,439
9. Chahi Nabri	..	..	66	67	..	133	..	8	99	2	1	108
10. Sallab Chhamb	..	..	12	8	23	43	14	57	70	113	39	203
11. Sallab Chhamb	..	..	1	..	7	8	..	10	3	10	3	26
12. Barani (III)	..	..	21	2	..	23	..	3	12	..	..	15
13. Sallab Ghair	..	..	1	..	..	1	..	..	..	..	..	..
14. Sallab Chhamb	..	..	..	..	..	..	..	781	165	..	650	1,796
15. Sallab Ghair	..	..	..	..	..	..	..	37	2	..	100	130
16. Sallab Chhamb	..	..	..	..	..	..	..	..	..	..	213	213
17. Sallab Ghair	..	..	..	..	..	..	..	..	..	..	76	76
18. Barani (III)	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL	1,500	2,821	4,041	6,561	4,966	19,869	2,852	4,304	8,638	1,871	2,649	20,314
	64	100	116	127	200	616	177	146	184	85	293	935

1. Chahi=  
 2. Chahi Nabri Zamindari = Irrigated  
 3. Nabri Zamindari=  
 4. Abi = Irrigated from tank or  
 5. Sallab = Land moistened by the  
 6. Barani =  
 7. Shah Nabri = Irrigated

10. Sallab Chhamb Mustaqul = Permanent  
 11. Sallab Chhamb Ghair Mustaqul = Sallab fluctuating—not permanently moistened or flooded by lake, but flooded or  
 N.B.—Figures in ordinary type indicate the area in acres under matured crop, while figures in heavy type indicate the

SUGAR AND SUGARCANE IN THE GURDASPUR DISTRICT

IV

District, 1913-14, showing how irrigated.

TAHSIL PATHANKOT							TAHSIL SHAKARGARH					Total of the District
Andhar	Bet Ravi	Pathan-ti	Shah Nahr	Kandhi	Pahari	Total of Tahsil	Bharrari	Paintla	Bet Ravi	Darp	Total of Tahsil	
..	1	..	1	10	..	12	26	5	7	1,330	1,368	18,497
..	..	..	..	..	..	..	..	..	..	79	79	571
..	..	..	..	..	..	..	..	..	..	..	..	..
101	15	141	9	..	178	444	..	..	..	..	..	481
5	2	11	..	..	13	31	..	..	..	..	..	39
..	..	..	..	..	..	..	..	1	..	4	5	177
..	..	..	..	..	..	..	..	..	..	..	..	4
705	440	236	38	120	..	1,545	872	356	2,127	686	4,041	9,577
93	46	41	10	20	..	210	65	27	242	75	409	969
493	699	290	639	102	50	2,270	796	1,342	435	1,295	3,868	9,526
39	37	20	1	10	4	141	127	77	29	229	462	863
..	..	32	101	18	..	206	..	..	..	..	..	13,330
..	..	1	8	4	..	18	..	..	..	..	..	251
..	..	..	..	40	74	123	80	138	26	125	369	828
..	..	..	..	10	19	29	15	13	6	26	62	124
..	..	..	..	..	..	..	..	..	..	..	..	38
..	..	..	..	..	..	..	..	..	..	..	..	1
..	..	..	..	..	..	..	..	..	..	..	..	1,796
..	..	..	..	..	..	..	..	..	..	..	..	139
..	..	..	..	..	..	..	..	..	..	..	..	213
..	..	..	..	..	..	..	..	..	..	..	..	76
..	..	..	..	..	4	4	12	..	..	2	14	16
..	..	..	..	..	1	1	3	..	..	..	2	3
1,299	1,101	705	848	294	366	4,013	1,766	1,842	2,596	3,442	9,665	54,431
137	85	73	49	44	37	425	209	117	277	411	1,014	3,040

Well irrigated,  
 both from private works and from wells.  
 Irrigated from private works.  
 pond by human or bullock agency.  
 action of river or lake or flooded by river.  
 Depending upon rain water.  
 from Government works.  
 Ballab—permanently moistened or flooded by lake.  
 only moistened when the water in the lake is at a high level.  
 area that did not mature; and the sum of the two gives the total area sown.

The different varieties of cane found in the district will be described in detail in Chapter III. These are *Katha*, *Dhau*lu, *Teru* or *Tereru*, *Kahu*, and *Kansar*.

Their distribution is as follows :—

**Batala Tahsil.** In the western and eastern canal circles on canal-irrigated lands, *Dhau*lu is the predominating variety in this tahsil. It yields well on land that is not too light in texture and where the water supply is good. On the lighter sandy soils *Katha* is usually grown in preference to *Dhau*lu. *Teru* or *Tereru*—a cane similar to *Dhau*lu in appearance but having ivory markings on the stem—is grown on the same class of land as *Dhau*lu. It is not as popular with zemindars\* as *Dhau*lu cane but is thought to be slightly inferior. The quality of the *gur* and the yield from *Dhau*lu is higher than from *Katha*. In some villages in the western canal circle near the main canal, there is grown a thicker variety known as *Kahu-Katha* or *Kansar*. This cane is of the *Katha* type and is midway in thickness between *Dhau*lu and *Kahu*. It is similar in colour to *Katha*, and it requires very moist conditions for its successful growth, as it has a tendency to form a dry pith in drought. It ripens later than *Dhau*lu and earlier than *Kahu*. It gives heavier yields than *Dhau*lu—a good crop yielding under favourable conditions as much as from 40 to 60 maunds of raw sugar (*gur*) per acre. This variety is only grown extensively in the neighbourhood of Dabanwala. In this tract about 12 years ago, very large areas of *Kahu* cane were grown and from information obtained locally it appears that *Kahu* was practically the only variety found over a tract of country of 25 square miles in extent (see also *Gurdaspur Gazetteer*, 1891-92, page 95). At the present time, however, there is practically no *Kahu* to be found in this tract, its place having been taken by *Kansar* and *Dhau*lu. The information given by the villagers is that 13 years ago this variety was completely wiped out by red rot. This is probably correct, for in the season 1911-12 the farm crop of *Kahu* at the Experimental Station at Gurdaspur was so severely attacked by red rot at an early stage of its growth that the entire crop had to be destroyed. *Kahu*, owing partly to its susceptibility to red rot and frost and partly to the large amount of water it requires, is not being extensively grown, and from season to season the area under this cane varies considerably.

In the eastern canal circle on canal-irrigated land in the neighbourhood of Harchowal, this variety has for the past few years been again coming into favour, and in 1913 the area under *Kahu* was considerable, but this is unlikely to last, for the cultivation of this variety is more or

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\* Zemindar = a peasant farmer.

less a gamble against the climate ; if the conditions are favourable heavy out-turns of superior quality of raw sugar (*shakkar*) are obtained, and yields as high as from 60 to 80 maunds to the acre. It ripens late, however, towards the end of January, and consequently is more at the mercy of a fall in temperature than the early maturing varieties of sugarcane. *Kahu*, being a soft cane, is also grown for chewing.

There is also a considerable area of cane grown on well-irrigated lands in the eastern and western circles. *Dhauhu* and *Katha* are the varieties chiefly grown on them, *Dhauhu* on the heavier loams where the water supply is good, and *Katha* on the inferior lands. The *sailab* (*loc. cit.*) canes are practically all *Katha*, as this variety is hardy and is better adapted to stand the water-logged conditions of inundative irrigation. The drainage of these *sailab* lands would add considerably to the available area for the growth of better varieties of cane in this district, and should be one of the lines of agricultural improvement to be followed in the future.

In the Bangar circle, the cane is practically all well-irrigated and the variety most grown, especially round Batala, is *Katha*. The reason for this is that this cane requires less irrigation and gives better yields on the light soils of this tract than does *Dhauhu*. The yield on well-irrigated land is said to be higher than when grown under canal irrigation, but, from the appearance of the crops in this very fertile tract, we should say this difference must be very small. It is known that in the Punjab the irrigation duty of canal water is only about one-third of that of well water. It is also known that in dry years when the supply of canal water is reduced, the out-turn of wheat increases. The difference is probably due to the better cultivation given for well irrigation, and the greater precautions taken to conserve the soil moisture by preparing a good mulch.

In the Mairu Kiran circle the land is not so suitable on the whole for cane cultivation, as the soil there tends to become too light. However, considerable areas of cane are grown under well irrigation, *Katha* and *Dhauhu* preponderating with occasional patches of *Kansar*.

In the Bet\* Ravi circle, well-irrigated cane is also grown, but very little under inundative irrigation. *Barani* (*loc. cit.*) cane is hardly ever found in the Batala tahsil, though the cultivators state that before the construction of the Upper Bari Doab Canal, there were considerable areas of cane grown on *barani* lands.

**Gurdaspur Tahsil.** What has been said with regard to the suitability of the different varieties of cane for different soils and systems of irrigation in Batala applies equally to Gurdaspur and the other tahsils of the district.

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\* Land adjoining rivers and liable to flooding when the rivers rise is known as *bet*. It is generally fairly well drained.

In the Gurdaspur tahsil the area under cane is about the same, or a little less than that in Batala. Rice cultivation however comes into competition with sugarcane in this tahsil, as may be seen from Tables V and VI. In addition to that grown under well and canal irrigation, a considerable amount of cane is grown under *barani* and *sailab* conditions, though the area under *barani* cultivation has declined during recent years.

The varieties found are *Dhau* on the best lands and *Katha* on the inferior soils. There is an inferior type of wet raw sugar termed *leb* produced from the cane grown near the Beas, and to a less extent in the Ravi Bet. *Katha* is the only variety of cane grown in these tracts and it also predominates in the *barani* lands. The yields of cane in the south of this tahsil, where the best soils are to be found, are as good as those of Batala, but, as we go further north and east, the crops get poorer and the yields fall off. It is interesting to note that the quality of raw sugar from a *barani* crop is as a rule superior to that grown on irrigation. This is in fact due to the better drainage enjoyed by *barani* lands, but it is also due in large measure to the fact that the land in this case gets a year's fallow before sowing the cane, thus endorsing what we have said above about the exhausted condition of these soils.

TABLE V.

*The area under sugarcane, rice and cotton in acres together with the rainfall in the Gurdaspur Tahsil of the Gurdaspur District.*

Year	Total rainfall	Rainfall, January to May	Area under rice	Area under cotton	Total area under sugarcane	SUGARCANE AREA					Price of Gur (per maund of 82 lb.) in rupees.
						Chahl	Nahri and Chahl Barani	Abi	Sailab	Barani	
1901	23-22	11-05	19,002	2,380	16,738	4,448	4,275	224	3,314	4,522	..
1902	19-46	2-06	18,713	2,910	17,766	5,373	4,856	61	4,373	2,603	..
1903	?	7-09	17,309	2,195	17,552	4,953	5,158	43	4,258	3,140	..
1904	23-48	7-99	12,715	2,723	10,729	4,462	4,343	56	3,614	4,256	..
1905	16-69	7-75	15,300	4,956	9,149	2,587	1,994	13	2,454	2,101	..
1906	45-12	8-11	13,171	3,225	16,918	4,929	5,306	29	3,721	2,928	7-07
1907	32-47	13-9	11,615	2,774	15,662	4,237	4,707	249	3,138	3,331	4-31
1908	33-94	5-19	14,870	3,552	18,491	4,922	5,230	59	4,324	3,456	5-58
1909	39-31	4-54	13,974	2,545	21,712	5,344	6,946	13	5,561	3,348	4-38
1910	41-22	2-70	13,611	1,634	20,208	4,578	6,179	63	5,084	4,304	4-18
1911	33-53	17-99	11,556	4,120	14,256	3,939	4,015	62	2,961	3,229	4-55
1912	28-21	5-51	14,151	3,507	18,602	4,998	5,929	43	4,510	3,117	5-94
1913	27-53	6-35	14,209	5,404	20,314	5,210	5,401	54	5,023	3,531	4-55

TABLE VI.

The area under sugarcane, rice and cotton in acres together with the rainfall in the Batala Tahsil of Gurdaspur District.

Year	Total rainfall in inches	Rainfall, January to May	Area under rice	Area under cotton	Total area under sugarcane	SUGARCANE AREA					Rate of Gur, January to May, in seers per rupee	Price of Gur (or raw sugar) per maund in rupees
						Chahi	Nabri and Chahi Nahri	Abi	Sallab	Barani		
1901	22-55	8-11	7,051	5,233	18,102	12,430	3,150	370	1,050	1,102	..	..
1902	13-04	2-73	8,442	5,737	15,660	10,525	3,642	109	1,268	116	..	..
1903	40-28	5-91	8,520	4,052	18,438	10,933	6,024	108	983	300	..	..
1904	25-23	8-17	7,316	5,208	17,155	11,085	4,554	125	575	766	..	..
1905	30-04	5-71	9,927	8,242	6,283	4,493	1,220	80	300	181	9-0	4-14
1906	27-35	6-76	8,595	4,910	15,399	10,308	4,064	83	750	194	6-9	5-94
1907	19-74	11-39	6,765	4,827	17,162	11,486	4,751	124	541	260	9-8	4-18
1908	32-42	4-23	9,854	5,638	17,662	10,239	5,888	85	1,010	420	8-5	4-82
1909	42-42	5-55	8,143	4,931	17,801	11,425	4,383	132	897	459	9-5	4-31
1910	31-40	2-18	8,838	4,957	19,614	12,167	6,110	145	830	382	10-0	4-10
1911	24-10	14-99	6,663	7,601	14,387	9,742	4,243	113	420	360	8-5	4-82
1912	25-27	5-72	9,861	5,901	20,803	12,912	6,754	93	837	207	7-1	5-77
1913	26-42	4-72	8,130	10,357	19,887	11,907	6,706	118	972	184	8-4	4-83

**Shakargarh Tahsil.** As we go further east nearer to the hills, the rainfall increases, and with it the area under *barani* cultivation naturally increases also.

The average rainfall for the four tahsils of the district for the past 26 years has been :—

	Inches
Pathankot	43-0
Shakargarh	38-4
Gurdaspur	31-7
Batala	30-8

In the Shakargarh tahsil, with the exception of 1,300 acres of well-irrigated cane in the Doab circle, the whole of the cane grown is either *barani* or *sallab*. *Katha* is the prevailing variety as we should expect though some *Dhauku* is grown too. In this tahsil cotton is a severe competitor (see Table VII).



TABLE VII.

The area under sugarcane, rice and cotton together with the rainfall in the Shakargah Tahsil of the Gurdaspur District.

Year	RAINFALL		Area under rice	Area under cotton	Total area under sugarcane	SUGARCANE AREA				
	Total	January to May				Chahli	Nahri	Abi	Sallab	Barani
1901	23-69	10-67	5,547	13,598	9,069	1,311	..	2	3,960	4,806
1902	20-49	3-23	5,496	8,338	9,929	2,301	..	8	4,998	2,029
1903	..	7-58	5,032	10,349	11,500	1,015	..	1	5,222	4,662
1904	24-05	9-61	3,322	10,559	12,757	1,467	..	..	4,922	6,862
1905	29-71	8-43	3,157	6,743	9,070	1,918	..	2	4,503	3,547
1906	46-26	8-57	3,357	10,764	11,648	1,173	..	4	5,318	5,159
1907	27-40	14-23	834	8,058	9,335	1,193	..	28	4,397	4,297
1908	31-90	4-33	4,389	7,989	8,974	1,263	..	..	4,816	2,895
1909	36-25	6-15	5,122	8,315	13,073	1,333	..	10	5,323	6,497
1910	39-64	2-09	5,178	2,051	12,534	1,331	..	3	5,031	6,169
1911	29-25	18-20	2,724	7,823	8,613	877	..	14	3,737	3,945
1912	26-28	4-30	4,604	6,935	9,220	1,113	..	1	4,433	3,623
1913	29-98	6-14	5,033	10,324	9,665	1,368	..	5	4,041	4,251

The yields in the Darp circle are good, but not so high as on well-irrigated lands in the Gurdaspur and Batala tahsils.

**Pathankot Tahsil.** The less said about the cane crop in this tahsil the better. *Katha* is the only variety found there, and is very inferior to the cane grown elsewhere in the district. Nearly all the crops in this tahsil are either *barani* or *sallab*. The principal crop, as might be expected, is rice (see Table VIII).

TABLE VIII.

The area under sugarcane, rice and cotton in acres together with the rainfall in the Pathankot Tahsil of the Gurdaspur District.

Year	Total rainfall	Rainfall, January to May	Area under rice	Area under cotton	Total area under sugarcane	SUGARCANE AREA			
						Chahli	Nahri Zamindari and Nahri	Sallab	Barani
1901	52-61	16-99	27,824	3,761	4,972	9	1,043	1,353	2,568
1902	20-71	2-50	27,500	2,461	4,876	13	1,304	1,596	1,971
1903	..	9-22	26,430	3,292	5,194	9	1,230	1,787	2,168
1904	27-25	7-38	25,763	4,411	4,979	6	948	1,025	2,391
1905	35-76	9-19	23,977	4,528	2,618	..	465	862	1,291
1906	66-36	12-57	24,772	4,714	4,185	2	1,004	1,402	1,787
1907	37-19	18-19	22,102	3,322	4,323	7	941	1,256	2,119
1908	62-78	7-23	26,231	3,922	5,005	9	1,079	1,593	2,324
1909	51-58	6-43	27,796	2,877	6,273	10	1,158	1,753	2,357
1910	49-71	4-58	27,181	1,419	4,799	16	1,129	1,656	2,997
1911	49-87	22-19	24,549	3,648	3,199	2	689	923	1,364
1912	29-90	9-01	26,132	3,842	4,660	11	1,049	1,473	2,127
1913	42-66	10-75	26,729	3,402	4,513	12	650	1,545	2,306

#### 4. Preparation of the land.

The old system of cultivation in which the land was allowed to lie fallow for 16 months before the sowing of the cane, has died out with the introduction of canal irrigation, with the result that the quality and out-turn of *gur* is said to be inferior nowadays. This may be only the garrulous reference of the farmer to "the good old times," for we have very few records left about the raw sugar then grown. In a note on sugarcane in the Gurdaspur District in 1883 Col. Harcourt (*Papers relating to Sugar Cultivation in the Punjab*, Punjab Government Secretariat Press, Lahore, 29th December 1883, 292, page 20) estimates the average out-turn of cane per acre as 7 tons and 2 cwt. and of raw sugar (*gur*) as 24 maunds or over 17 cwt. This is not very different from that of the present day, and is, if anything, rather less.

I have often examined excellent *gur* and *shakkar* from canal-irrigated cane, and the real reason for the production of a dry light coloured *gur* is ripeness of the cane at the time of cutting. This can never be obtained in this tract if the cane has suffered any set-back during its growth. for the growing season is so short that the plant has not time to recover.

Fallowing the land is, and always has been, recognized in the district as necessary in good cane cultivation. As a rule, the preliminary preparation of the land, i.e., ploughing, commences after the breaking of the monsoon in July. Ploughing and levelling with the *schaga* \* is continued up to the following March, as many as 30 to 50 ploughings being given. This extensive cultivation serves two purposes: (1) The accumulation of reserves of available plant food and (2) the conservation of soil moisture. Any system introduced to shorten this fallow period would have to include an adequate system of manuring as well as an increased water supply for this crop during the first few months of its growth. In building up a refining industry the economics of any method of shortening the fallowing system would need to be carefully gone into.

Under the existing conditions, the cane occupies the ground for from 1½ to 2 years. The land comes under cultivation in July after the breaking of the rains—it is continued up to the following March. Consequently no *kharif* (summer crop) or *rabi* (winter) can be taken. The cane is planted at the end of March or the beginning of April and

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\*The *schaga* is a beam of wood 6 or 7 feet long by 1 foot by 9 inches thick, made of a hard wood usually "shisham" (*Dalbergia Sissoo*) or "kikar" (*Acacia arabica*). It is fastened to the yoke and the oxen by ropes or chains attached to pegs at either end. In the use of this implement the driver often stands on the beam when driving the cattle to ensure a better packing of the soil. It serves to level land for irrigation purposes, as well as to consolidate the soil in the preparation of the seed bed.

remains in the ground until the following January. It thus occupies the ground for four agricultural seasons—2 *rabi* and 2 *kharif*.

### 5. Rotation followed.

(a) Sometimes the cane follows a *rabi* catch crop of *senji* (*Melilotus parviflora*) or *masar*, lentil (*Ervum lens*). Such catch crops are usually sown with maize in the preceding summer. They are cut and fed to the cattle in January and February. After the reaping of the cane the land lies fallow until the succeeding autumn, when wheat is sown. This is a three-year rotation, and is practised largely in the best sugarcane tracts of Batala and Gurdaspur and on both well- and canal-irrigated lands. In this rotation the manure is applied as a rule to the maize only, though sometimes a little is also applied before sowing the cane.

(b) Where the cane follows a cold weather crop after a ten months fallow: this is not a very common rotation on well-irrigated lands. After the reaping of the cane in December and January, *chari* (*Sorghum vulgare*) and maize (*Zea Mays*) or cotton are sown in the months of May and July and May respectively.

(c) Rotation followed on *sailab* lands where there is an annual deposit of silt. Cane follows cane every year or is rotated with wheat.

It is interesting to compare these systems with those practised in other parts of the province.

In Amritsar, the adjoining district further west, cane is grown on land which has been lying fallow for a year after maize or cotton. The rotation (a) wheat, (b) cotton or maize, (c) fodder (*senji*) and (d) cane is also followed in this district. In the Lyallpur District, still further west, which was in the first place populated with colonists from the Sialkot, Jullundar and Gurdaspur districts, the systems of cultivation are much the same, viz., (a) maize and *senji*, sugarcane, cotton, (b) cotton, sugarcane, (c) wheat, *toria* (*B. Campestris* var. *Dichotoma*), sugarcane.

In Ludhiana cane follows cotton or maize, the preparation of the land being done during the *rabi* season. The rotation is as follows:—

(a) Cotton or maize, (b) cane, (c) fallow or sometimes barley, (d) cotton or maize and (e) wheat or barley. In Karnal and Delhi the commonest rotation is:

- (i) (a) Sugarcane, (b) cotton and *methi* (*Trigonella Fœnum-Græcum*, Linn.) as a fodder.
- (ii) (a) Maize and *moth* (*Phaseolus acconitifolius*), (b) sugarcane, (c) cotton.

### 6. Manuring.

In the first rotation mentioned for the Gurdaspur District, namely, (a) maize and *senji*, (b) cane, and (c) wheat, the maize crop usually gets

manure at the rate of about 360 to 390 maunds per acre (13.2 to 14.3 tons). The residue of this, together with the *senji* stubble, just leaves the land rich enough for sugarcane. The zemindars are very careful not to overmanure the cane crop as this leads to a falling off in the quality of the *gur*. This has not yet been fully investigated, and a careful study of this problem will certainly repay the scientific agriculturist. It appears as if the limit has been reached for the indigenous canes with the present plough. The season is short, and excessive manuring will merely result in promoting vegetative growth and lengthening the growing period, thus giving a large green and unripe cane at harvest time.<sup>1</sup> The stimulation of the crop should be given for the most parts in the initial stages of the growing period, and to render this more effective a deeper-rooted crop must be induced by deeper cultivation and by giving the young plant an adequate water supply.

The value of *senji* (*Melilotus parviflora*) lies in the conservation of soil nitrogen effected by this crop : as much as 21 lb. of fixed nitrogen per acre has been recorded at Lyallpur as a result of the growth of this plant. It occupies the ground for nearly 5 months.

In the two other rotations followed in this district the manure is applied directly to the cane, about the same quantity per acre being used. In this case only well rotted and fully ripe manure is applied, for fresh manure not only results in a retardation in development but also attracts white ants which damage the sets. In this system the manure is applied in February a week or two before sowing the cane. Manure is seldom purchased by the farmer but its price when sold is from 4 to 6 annas per cart-load ( $\frac{1}{2}$  ton). Near Batala as much as 12 annas or 1 rupee is often paid, but this is only for the cultivation of thick *Pounda* cane, a valuable garden crop sold locally for chewing.

The quantity of manure applied to sugarcane in other parts of the Province does not differ much from that above quoted for Gurdaspur. In 1883 Harcourt (*loc. cit.*) in a report to the Punjab Government on cane cultivation in the Gurdaspur District states that manure is applied at the rate of 21 tons per acre at a cost of Rs. 15, but he makes no mention of the type of cane for which this quantity is used, and most probably refers to the *Pounda* variety grown in the Batala tahsil. In the Deccan, Keatinge (Bombay Government Report, 1913) reports that as much as Rs. 180 per acre is spent in manuring for *Pounda* cane and the out-turn is about 36 tons per acre. But in the Deccan the climate places little or no restriction on the length of the growing period.

It is impossible to make any comparison of the manure rates or system here practised with that of other parts of India or of other sugarcane-

<sup>1</sup> Cf. Taylor, C. S. Pusa Agri. Res. Inst. Bull. no. 37.

growing countries. In the cane-growing countries where modern refining industries exist, artificial manures are almost entirely used, and the requirements of the soil have in each case to be worked out experimentally. Exactly the same applies to the sugar industry in the Punjab. At the present time cane growing both in the Gurdaspur District and in the Province is a zemindari industry of very low grade and only animal refuse and rotations can therefore enter into any feasible system of manuring, owing to the high prices of artificials and their unknown value to both the local farmer and the scientific agriculturist.

### 7. Planting and seed rate.

This takes place about the middle of March. The seed cane is always buried at the first appearance of frost. Whole canes are buried and not the tops only. In this respect the system of planting in the Gurdaspur District differs from that in Jullundar and Hoshiarpur. In some cases when the season is mild, the seed canes are left standing in the fields. Seed canes which have been buried for some time germinate quicker and better than unburied sets. Discretion has to be used in the time when different types of canes may be buried, as otherwise considerable damage may result. In no other cane country in the world save Louisiana does this system of burying the cane sets exist.

One bundle of canes containing about 500 sticks is the quantity generally used for sowing one *kanal*\* of cane (seed rate about  $\frac{1}{2}$  ton per acre), and this costs about R. 1. The seed cane is cut into lengths of two eyes each, that is one internode and two nodes. The sets are sown after the plough in lines and are placed nearly a foot from each other in the furrow. The sowers press the sets down with their naked feet as they walk along and about 6 or 7 men are employed in this way for every plough in use. The furrows are set about 8 to 9 inches apart so that the plough does not cover the sets in the preceding furrow—this is done by the *sohaga* which is run 3 or 4 times over the field after the sets have been planted.

### 8. Cultivation of the crop.

**Hoeing.** The cane shoots appear above the ground from ten days to a fortnight after planting. A few days before this takes place, the field is hoed with a broad bladed hoe called a *baguri* in which the blade is set at an angle of 45° to the handle. This operation is termed by the farmers "blind hoeing" as it is done before the shoots appear and its object is to improve the texture of the soil so as to render it easy for the shoots to come up in clusters. It also serves to conserve

\* One *kanal* =  $\frac{1}{2}$  acre

the moisture of the soil. It is said to preserve the sets from attack by termites but in what manner is not clear.

After this hoeing the field is again gone over with the *sohaga* and is then laid out into beds for irrigation. Wherever canal water is available, the irrigation beds are of the roughest type of flooding and no attempt is made to irrigate by furrows. Under well irrigation this is not the case; for the farmer, having the whole labour and cost of water raising on his hands, takes every care to use his water as economically as possible, and hence a lateral system of furrow irrigation is common on these lands. After a week or so has elapsed, the crop is irrigated for the first time, and when the land comes into condition the field is hoed with a *khurpa*, a small trowel-like implement. After hoeing the soil with this implement, the labourer beats it with his *khurpa* so as to obtain a fine surface; this serves to retain moisture. One, and if possible two, hoeings are given with the *khurpa* after each irrigation, until the breaking of the rains at the commencement of the monsoon period. In the Gurdaspur District this takes place towards the end of June or the beginning of July.

The crop then receives a hoeing with a large spade, or *kahi* as it is called, and this hoeing is termed "spade hoeing" to distinguish it from that given with the smaller hand implements used in the earlier stages. This latter operation with the spade is the deepest hoeing that crop receives and its object is to let in the rain water and prevent loss of water by surface drainage. All these operations are of particular interest as they show in a marked manner that the Punjab peasant is well aware of the necessity of conserving the natural water supply which the land receives, and that he achieves this in a remarkably efficient manner considering the implements at his disposal. Improvement to be effected will have to be brought about by the more economic use of his power by labour-saving devices and in this respect the spring and peg tooth harrows are becoming popular.

#### 9. Irrigation system in vogue and the quantity of water necessary for the growth of the cane.

The methods of cultivation outlined above indicate in a very clear manner the scarcity of water as compared with the water requirements of this crop in the Gurdaspur District, and applies with equal force to every cane-growing district of the Province. Before the construction of the Bari Doab Canal in 1872-73 there were 62,130 \* acres under cane cultivation in the district and of this 8,447 acres of thick cane were under well irrigation and 49,079 acres under *barani* and *sailab* cultivation.

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\* These figures (the average figures for 1865-69) are the nearest available.

Reference may be made to Table IV, page 7, for the distribution of the cane crop in 1913-14. From this it will be seen that in addition to the area under canal irrigation there is still a great deal of cane grown by means of water raised from wells, and that all the systems of cultivation in vogue 43 years ago are still practised at the present day. As noted in the first pages of this chapter the rainfall of the district varies from 24" to 50" per annum, the greater part of which falls during the summer months.

In 1912-13 the rainfall from January to March was 4·3" (15 per cent. of the whole) and between April and December was 23·82" (85 per cent.), while in 1916 from January to March it was 5·17" and from April to June it was 5·47".

Let us consider for a moment the maximum amount of water which could be conserved in the soil by the various systems of rotation followed.

In the first system above described the land does not possess more than 15 per cent. of the total rainfall of the year at the time of sowing, since the catch crops sown with maize are reaped in the months of January and February. We must not forget that this is the system principally practised.

In the second system the cane follows a cold weather crop after a ten months' fallow. Here we can say that the soil contains upwards of 90 per cent. of the year's rainfall, less that lost by evaporation and transpiration through weeds. In this system it is evident the cane starts with a greater reserve of soil moisture than it does under the first system. Now this latter method is largely practised in the lands irrigated by wells or on the *barani* lands.

In the third system, cane follows cane on *sailab* lands, or is at least only rotated with wheat in the dry years. Hence the land receives an annual flooding and the depth to which this takes place varies considerably. The water table too is much nearer to the surface. For the purpose of our enquiry in this connection we may omit the consideration of this case.

The first is of paramount interest because it is the only method in which we have any records of the amount of water actually applied to the crop. This will be :—

- (a) Water present in the soil previous to sowing.
- (b) The amount of irrigation water applied.
- (c) The rainfall received during the growth of the crop.

Speaking roughly, this will be the annual rainfall plus the irrigation water applied. In the second system the amount of water reaching the crop equals the irrigation water artificially applied plus two years' rainfall less what is dissipated by evaporation. The farmer of course

takes every precaution to prevent water losses under the 10 months' fallow system by continuous ploughing of his land and the establishment of a permanent surface mulch.

Taking the rainfall as from 24" to 50" per annum and the amount of irrigation water applied as from 84" to 90" (see *Papers Relating to Sugarcane Cultivation in the Punjab*, appendix, page 111, No. 579-C1, dated March 5th, 1883, from Superintendent of Works, Bari Doab Circle, to the Financial Secretary to Government, Punjab, Public Works Department) we can estimate that the amount of water used for this crop is not less than 108" and may be as much as 140".

Under the second system of rotation, the soil may contain moisture equivalent to ten months' rainfall, say, from 20" to 40" of water, and receives a further 20" to 40" during the growth of the crop, say, in all from 40" to 80" of water. In addition to this irrigation, water from wells is applied. We have no accurate measure of the amount of well water applied. All we know is that the irrigation duty of canal water is about one-third of that of well water. From the above figures this could not amount to much more than 30" of water. This brings up the water requirements of the crop to vary from 70" to 110" of water.

Compare this with other cane-growing countries. In Hawaii, Deerr (*Cane Sugar* by N. Deerr, published by Norman Rodger) states this to be 103" (27" of rain and 76" of irrigation), and again on same page (92) to be from 112" to 123" inclusive of rain and irrigation water, while O'Shaughnessy<sup>1</sup> places the irrigation duty of water for cane growing in this island as 134" *not counting natural rainfall*. In Egypt—a country much more comparable with the Punjab—Tiemann<sup>2</sup> gives the irrigation duty of water for cane as 95" irrespective of rain water and the water present in the soil at the time of sowing. While Leather<sup>3</sup> as a result of pot culture-experiments at Pusa places the water requirements of cane as 45.5" for the season. Summarized these results are as follows:—

*Water requirements of the cane crop.*

Gurdaspur	{ (a) well-irrigated . . . . .	70" to 110"
	{ (b) canal-irrigated . . . . .	108" to 140"
Pusa (Leather)	. . . . .	45.5"
Egypt (Tiemann) upwards of	. . . . .	95"
Hawaii (O'Shaughnessy) upwards of	. . . . .	134"
" (Deerr) " . . . . .	. . . . .	112" to 123"
" " . . . . .	. . . . .	103"
Java (Kammerling's <sup>4</sup> transpiration experiments)	. . . . .	about 18"

<sup>1</sup> *Transactions of the American Society of Civil Engineers* 54, 129.

<sup>2</sup> "Sugarcane in Egypt" by Tiemann, published by the *International Sugar Journal*.

<sup>3</sup> *Agricultural Journal of India*, volume VI, July 1911, page 266.

<sup>4</sup> Kammerling. *Proceedings, 4th Congress, United Syndicate of Java Sugar Manufacturers*, 1900.



Two features are remarkable in these figures; firstly, the evident heavy demands of this crop for water, and, secondly, the seemingly close agreement between the amount of water required in Hawaii, where there is a damp island climate, and Gurdaspur which lies over 1,000 miles from the sea and is isolated from it by semi-arid or desert tracts. This latter, however, is not so true as it at first appears.

Deerr (*ibid*) has calculated the amount of water used per lb. of sugar produced. This amounts to 1,000 lb. of water for each lb. of sugar in Hawaii. In Gurdaspur taking a ton of raw sugar per acre as the average out-turn—and this is rather over than under the real figure—we have consumed for every lb. of sugar produced in the case of well-irrigated cane 9,000 lb. of water and in the case of canal-irrigated cane 12,411 lb. of water, or ten times the quantity of water used in Hawaii; in other words, the value of water for cane growing in the Punjab is only one-tenth of the value of water in Hawaii. This result is of the highest importance for it indicates in a remarkable manner the waste of water resulting from the growth of this crop outside its natural zone.

Keatinge<sup>1</sup> gives Rs. 40·11 as the cost of water in Hawaii per ton of sugar. In Gurdaspur the cost is about Rs. 12 for well-irrigated cane, and about Rs. 7 for canal-irrigated cane (per acre). Thus, in spite of the scarcity of water in the Punjab, its value as reckoned by the value of the produce grown is far below the value of water in Hawaii. From every standpoint, therefore, the Punjab farmer when growing cane is obtaining a much poorer return for both land used and water applied than is the case in other sugar-growing countries.

It is our object (1) to obtain such information as will enable us to give an adequate reason for this discrepancy, and (2) to examine the possibilities of removing it. Water is used by the cane crop in two ways; firstly in building up the tissues of the plant itself, of which it constitutes about 95 per cent., and secondly in maintaining an equable temperature of the plant; this is achieved by the transpiration of water through the leaves. Besides this, water is lost by evaporation from the soil, though as we have seen the farmer takes all the precautions known to him to keep this loss down.

Kammerling (*ibid*) has calculated that an acre of cane in Java transpires about 1,800 tons of water in the course of the growing season: this is equal to about 18" of water.

In a crop of 40 tons of cane, we shall have 38 tons of water. This is equivalent to 0·38" of water—almost negligible. Lastly we have water losses from the soil. These are evidently very great and constitute

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<sup>1</sup> Paper A 3002, 1914, Bombay

the greater part of the water used. The transpiration losses must vary very considerably, and must be much higher in a dry climate like that of North-West India. In view of the scarcity of water in Northern India further information on this point is urgently required.

From preliminary experiments made at Lyallpur in 1916, it seems that in the application of irrigation water to the land a flooding of 6" of water does not penetrate more than 8 feet, and that upwards of this quantity is required before a drain gauge 6×6×8 feet begins to show a discharge. The losses of water from the soil have been calculated as follows :—

TABLE IX.

*Farm drain gauge readings. Measurement of the block = 7' 4" × 6' × 6'.*

Date of irrigation	Irrigation in inches	Quantity of water passed through in centimeter	Percolation of water in inches	Percolation of water in inches
				Quantity of water passed through Area of the block
21st February, 1916 . . .	2	4951	0.7903	The earth outside the gauge and well was loose and so sank down. Water probably leaked into the receiver.
29th February, 1916 . . .	5	6766	0.1080	Do.
13th March, 1916 . . .	2.7	61.55	0.009828	Earth sank down but little.
30th March, 1916 . . .	2.8	23.18	0.0037	Land seems to have settled down in contact with the plates of the gauge and the leakage observed in the first three cases is not apparent here.
11th April, 1916 . . .	3.2	26.61	0.004248	
18th April, 1916 . . .	1.9	..	..	
1st May, 1916 . . .	6.2	9.27	0.00148	
3rd June, 1916 . . .	4.0	2007	0.3203	
24th June, 1916 . . .	0.59	5.37	0.0008572	Rainfall.
9th July, 1916 . . .	0.84	9.456	0.001510	Do.
13th July, 1916 . . .	0.38	4.576	0.0007310	Do.

TABLE IX—*contd.*

*Farm drain gauge readings. Measurement of the block=7' 4" × 6' × 6'*  
—*contd.*

Date of irrigation	Irrigation in inches	Quantity of water passed through in centimeter	Percolation of water in inches	Percolation of water in inches
				Quantity of water passed through — Area of the block
21st July, 1916 . . .	4.0	..	0.3378	
22nd July, 1916 . . .	..	16.96		
23rd July, 1916 . . .	..	1372.79		
24th July, 1916 . . .	..	529.16		
25th July, 1916 . . .	..	149.39		
26th July, 1916 . . .	..	29.75		
27th July, 1916 . . .	..	9.02		
31st July, 1916 . . .	..	9.33	0.0001655	Rainfall
		2116		
31st July, 1916 . . .	0.05	..		
1st August, 1916 . . .	..	1.037		
2nd August, 1916 . . .	0.17	..		
3rd August, 1916 . . .	..	2.380		
4th August, 1916 . . .	0.30	..		
5th August, 1916 . . .	..	1.586		
7th August, 1916 . . .	..	1.403		
8th August, 1916 . . .	..	1.281		
9th August, 1916 . . .	..	1.525		
11th August, 1916 . . .	2.57	..		
12th August, 1916 . . .	..	584.5		
13th August, 1916 . . .	1.02	..		
14th August, 1916 . . .	..	2959		
15th August, 1916 . . .	..	1162		

We have no record of what may be the losses of water from the soil elsewhere, but a hot dry climate like that of the Punjab must give very much higher figures than those of an island climate or land near the sea enjoying a moist atmosphere, and this probably accounts for the high water requirements of cane in North-West India. The high temperature will also result in greater losses by transpiration.

### 10. Harvesting and the length of the season.

Since pig and jackal are not numerous in this tract, with the exception of the Bias and Ravi Bet lands, fencing is not generally resorted to. If it is done, it is usually with the object of preventing trespass. Fields containing sugarcane which are situated near roads are sometimes seen fenced for this purpose, and often the crop is surrounded with a thin line of *sankukra* (*Hibiscus cannabinus*) or *arhar* (*Cajanus indicus*) with this same object.

When the crop is heavy, the stools are tied together in bundles of 2 or 3 shoots by means of their own leaves to prevent laying of the crop.

*Cutting and stripping.* This is done in the field by manual labour. In some places the labourers are neighbouring farmers who take the cane tops to be used as cattle food in lieu of money payment. 80 men can cut and strip an acre of cane in a day of from 8 to 9 hours.

Harvesting commences in the end of November or beginning of December and goes on until the end of February, and sometimes to the beginning of March.

### 11. Yields per acre.

As with all agricultural products the yield of the cane is the most important criterion of the condition of the industry, and all attempts at improvement aim first at increasing it. Where a refined product has to be made from the raw material and where, as in the case of sugar making, the material has to be put through a lengthy and complicated manufacturing process, other objects have to be kept in view also, such as the production of a cane which gives a pure juice and one capable of easy refining in the factory.

Important as these objects are, nevertheless they must be considered as second in importance to the out-turn of raw product, for this more than anything else regulates the price of the material at the factory. The yield of cane per acre is difficult to estimate with any degree of accuracy unless the cane from large areas can be weighed. This is never done by the farmers themselves, and they view with suspicion any enquiries of this nature by a Government official, since they imagine the information

will be used for revenue purposes, and will probably result in increased taxation. Their figures therefore are quite useless. We have used three methods for gaining some idea of the yield of cane per acre under the ordinary conditions of country cultivation.

The first is based on a knowledge of the ratio of *gur* to cane, which is roughly 10 per cent. of the weight of cane. This varies according to the efficiency of the mill and the composition of the expression. With ripe cane and good extraction as much as 12 per cent. may be obtained, while with a poor mill and low quality of cane we have seen this ratio as low as 7 per cent.

This estimate is, therefore, only of use in rough field measurements, and in conjunction with a reasonable knowledge of the condition of the crop and of the mill. The other two methods are (a) weighing the cane from a small carefully measured area and (b) by taking a strip across the crop of a measured area, counting the number of stools and average number of canes per stool in the strip, and from this and a knowledge of the weight of a stool of canes calculating the out-turn per acre. The following two examples will illustrate these methods which were applied in field estimates at Harchowal.

(a) Date January 7th, 1913, village Harchowal. A field belonging to Sham Singh, Natha Singh and Naraina.

Type of cane.—*Dhaultu*.

Area of the plot from which the canes were weighed . . . . .	91×51 feet or 516 square yards approximately.
Weight of cane removed from this plot (after stripping) . . . . .	39.6 maunds.
Weight of cane per acre . . . . .	$\frac{4840 \times 39.6}{516} = 366$ maunds or 13.48 tons per acre.

(b) Area of the strip, the stools of which were counted and weighed.

	$= \frac{35 \times 5}{9}$ square yards.
Number of stools in strip . . . . .	80
Number of canes in strip . . . . .	309
Average number of canes per stool . . . . .	3.88
Weight of canes in the stools . . . . .	{ 70 seers 140 lb.
Weight of canes per stool . . . . .	{ 0.881 seer. 1.762 lb.
Number of stools per acre . . . . .	$\frac{80 \times 4840 \times 9}{35 \times 5} = 19,913$
Number of canes per acre . . . . .	$19,913 \times 3.88 = 76,940$
Weight of canes per acre . . . . .	$\frac{70 \times 4840 \times 9}{40 \times 35 \times 5} = 435$ maunds = 16 tons approximately.

The following table shows the yields per acre from a number of observations made at Harchowal in January 1913 using both these methods :—

TABLE X.

Date and No.	Owner's name	Area on which the estimate was made	YIELD OF CANE PER ACRE IN MAUNDS	
			First method	Second method
1. 7th January, 1913.	Sham Singh, Natha Singh and Naraina	516 square yards	366	..
"	"	19-44 yards	..	..
2. 10th January, 1913	Inder Singh	429 "	308	..
"	"	333 "	..	392
3. 10th January, 1913	Mala Singh	268 "	398	..
"	"	225 "	..	388
4. 9th January, 1913	Rur Singh, Lal Singh	172 "	544	..
5. 8th January, 1913	"	28 "	..	477

The estimated out-turn shown in No. 4 in the above table, was from the heaviest cane crop in Harchowal. Many of the stools contained upwards of 20, and a few as many as 25 canes in one stool. Average length of this cane was 6 feet 5½ inches, average length of internodes 3-64 inches, average thickness of the internodes 0-548 inch. The first three estimates were for good average crops near Harchowal, and the average of the first six estimates gives 380 maunds of cane per acre. These results are probably much above the average for the whole district.

In 1882 a general survey of the industry throughout the Province gave the following out-turns. These are not very reliable, since no mention is made of the types of cane on which the estimates were based, and it is well known that thick *Pounda* cane used for chewing and grown under garden conditions near the large cities gives a much higher out-turn than does the country cane grown for *gur* and *shakkar* making.

TABLE XI.

*Out-turn of cane (abstracted from Papers Relating to Sugar Cultivation in the Punjab, Punjab Government Press, 1882).*

District	OUT-TURN PER ACRE IN TONS		
	Cane	Juice	Gur
Karnal . . . . .	10.7	4.5	0.75
Amritsar . . . . .	13.2	6.69	0.92
Gurdaspur . . . . .	7.1	3.2	0.85
Sialkot . . . . .	6.5	3.25	0.8
Bannu . . . . .	22.0	..	0.9
Peshawar . . . . .	17.7	10.8	1.46
Multan . . . . .	16.0	5.0	1.2
Hoshiarpur . . . . .	..	..	0.706
" . . . . .	10.8	5.48	0.94
Jullundar . . . . .	7.1—17.4	3.3—11.7	0.7—2.2

During the past few years, a record has been kept at the Gurdaspur Experimental Station of the yields obtained there from the ordinary varieties of district cane. These results will be found in Tables XLV to XLVIII, Chapter V, and in the following statement —

TABLE XII.

*Yield of cane per acre of the principal varieties in the district (determined at the Gurdaspur Experimental Station).*

Variety	YEAR			
	1913	1914	1915	1916
	M. s.	M. s.	M. s.	M. s.
Dhaultu . . . . .	324 8	379 11	418 6	..
Katha . . . . .	351 8	260 13	322 7	416 16
Kanara . . . . .	..	458 10	254 26	359 12
Teru or Teroru . . . . .	680 5	360 21	428 12	404 32
Kahu . . . . .	..	270 26	576 21	..
Merthi . . . . .	366 1	356 27	427 31	..
Kansar . . . . .	570 3	224 15	441 39	351 8
Bodi . . . . .	..	544 31	358 4	310 24

The out-turns per acre obtained at the Lyallpur Experimental Station for the principal varieties, viz., *Katha*, *Dhauhu* and *Kahu* were as follows :—

Variety	YEAR	
	1911	1912
<i>Katha</i>	Maunds 200	Maunds 240
<i>Kahu</i>	291	279
<i>Dhauhu</i>	231	..

These canes received 15 tons farmyard manure per acre.

On the whole I am inclined to believe that 10 tons of stripped cane to the acre is probably a very fair average for *Katha* for the whole of the Gurdaspur District, and perhaps a little higher than this for *Dhauhu*. The other types grown are too variable and too liable to the influence of climatic changes to admit of any round figures being given for their out-turns.

At the same time the very wide variation in the yield obtained for cane in the district shows that improvement can be effected in this direction. In Tables XLV to XLVIII in Chapter V are given the results of a number of variety trials at Gurdaspur in 1913-16.

In 1913-14 *Bodi* gave the highest yields of cane, and *Desi Suretha* the highest yield of *gur*, being 19.9 and 1.3 tons respectively; while in 1914-15 *Mango* gave the highest yield of cane and *Reora* of Benares the highest yield of *gur*, being 23.9 and 1.9 tons. These high out-turns are not entirely due to the variety alone, for we find that local canes like *Dhauhu* and *Katha*, when grown on the Government Farm at Gurdaspur, gave 17½ tons and 11.9 tons of stripped cane to the acre. These figures are probably much higher than those usually obtained by zemindars. The average yield of *gur* from the Gurdaspur Farm figures for local canes is 10.5 per cent. of the weight of the cane, and from the Lyallpur Farm 10.3 per cent. of the weight of cane. We can safely assume that the cane per acre will not be less than ten times the weight of *gur* made from it in this district, since the method of manufacture is uniform, the same type of mill and boiling plant being used throughout.

On a five-acre experiment of well-irrigated *Dhauhu* cane at the Gurdaspur Experimental Farm the crop was good and probably above the district average. The yield of *gur* was from 25 to 30 maunds per acre. This may be taken as a fair average figure for the district.



Taking the whole district the yield does not average more than 25 to 27 maunds of *gur* to the acre. On the above basis of calculation, namely, that the weight of cane is approximately ten times the weight of *gur* made from it by the process of manufacture used there, this would give a yield of 9.2 to 11 tons of stripped cane per acre. Ten tons of cane per acre may consequently be taken as a fair average.

A close study of this factor of yield reveals a wide seasonal variation even on the same soil, and manurial experiments have so far failed to yield conclusive results. We are forced to the conclusion here, as in other experiments, that season is one of the most important and influential factors in regulating the growth and out-turn of sugarcane in the Gurdaspur District.

### 12. Diseases and pests.

Little or nothing is known about cane diseases in this district. Red rot (*Colletotrichum falcatum*) is prevalent, and occasionally causes the complete destruction of entire fields of the softer canes of recent importation like *Kahu*.

Butler in 1914 found *Fomes Lucidus* (Ley.) on Gurdaspur cane stems, but this was identified in connection with the ivory markings on *Dhauhu* and was not suspected of causing any loss in the crop.

The cane suffers from a number of unstudied insect pests, which cause considerable damage and loss in wet seasons and on cane grown under canal irrigation, both perennial and inundative.

Subject as the district is to cold and damp, the losses caused from diseases must be great.

## CHAPTER II.

### MANUFACTURE : WORKING UP THE RAW PRODUCT.

#### 1. Extraction of the juice.

The canes are cut immediately before crushing in order to avoid deterioration in the quality of the juice. The old wooden mill or *belna* has almost disappeared from Gurdaspur, though it can still be seen in parts of Jullundar and Hoshiarpur. In the Gurdaspur District iron mills of the two roller type are most commonly used, though during the last few years three roller mills have been coming into use. Better types of mills are made in Batala and cost respectively for 2 and 3 rollers Rs. 28 and Rs. 35 per mill. If worked through an entire season, they last for four or five years. Superior three roller Nahan mills are occasionally seen, but these are usually hired at the rate of Rs. 78 per season. The cheap Batala mills are nearly always bought outright. The extraction effected by these mills is poor, and there is much room for improvement in this direction.

With the best type of three roller mill the extraction is generally under 60 per cent. of juice or less than 80 per cent. effective extraction of the sucrose. The two roller Batala mill is much less than this. I shall refer to this point later in describing Hulme's experiments in the United Provinces.

The two roller Batala mill will express about 96 lb. of juice per hour, while the three roller Nahan mill on the Gurdaspur Farm expresses 140 lb. of juice from *Katha* cane and 180 lb. from *Kahu* cane per hour.

With the old wooden mill, in which the cane was passed through the rollers from ten to fifteen times, the extraction was about 50-7 per cent. as will be seen from the following table :—

TABLE XIII.

<i>Extraction effected by the old wooden mill.<sup>1</sup></i>	Percentage of juice extracted
Karnal . . . . .	42
Gurdaspur . . . . .	50
Sialkot . . . . .	50
Hoshiarpur . . . . .	50
Jullundar . . . . .	67*
" . . . . .	50
" . . . . .	58
" . . . . .	46
" . . . . .	50
" . . . . .	60*

<sup>1</sup> Papers relating to Sugar Cultivation in the Punjab. (*loc. cit.*)

\* These high extractions were probably from thick canes of the *Pounda* type—the report makes no mention of the variety used in these tests.

Lehman <sup>1</sup> states that from 20 to 33 per cent. of the juice is left unextracted by the wooden mill (this represents a loss of 20 per cent. of sugar).

Clarke and Annett <sup>2</sup> give the following as the efficiency of the Nahan three roller mill.

*Average of juice extracted.*

Average extraction . 1908-09 1909-10 1910-11.  
59.7 per cent. 62.5 per cent. 63.1 per cent.

The following table shows the extraction effected by this type of mill with the Gurdaspur canes in 1912.

TABLE XIV.

*Table showing the extraction effected by the three roller Nahan mill at Gurdaspur.*

Number and date of the sample	Description and locality of the cane	Grams of juice extracted from 100 grams of cane	Percentage of fibre in the cane	Percentage of the total sucrose present in the cane extracted in the juice = Efficiency of mill in sucrose extraction
16, 2nd January, 1912 .	<i>Tereru—</i> Government Farm, Gurdaspur	63.2	15.36	76.3
25, 4th " " .	No. 5 Government Farm, Gurdaspur	57.9	20.10	77.2
31, 5th January, 1912 .	<i>Dhaultu—</i> Ghurala, Gurdaspur	58.7	21.21	83.4
46, 8th " " .	Hailehalan, Gurdaspur	61.1	15.95	83.5
50, 10th " " .	Ghuman, Gurdaspur	59.4	22.13	86.0
58, 11th " " .	Chuhar chak, Gurdaspur	52.5	27.48	80.0
195, 1st February, 1912.	Ahmadabad, Batala	55.3	17.78	79.0
220, 5th " " .	Chowra, Batala	57.8	18.23	81.3
257, 13th " " .	Ahmadabad, Batala	51.6	21.82	75.6
	AVERAGE FOR DHAULTU	58.6	20.60	81.2

<sup>1</sup> *Agricultural Journal of India*, vol. II, page 57.

<sup>2</sup> Clarke and Annett. Experiments on the cultivation of sugarcane at Partabgarh Experiment Station, 1909-11. *Pusa Agri. Res. Inst. Bulletin*, no. 27, page 8-

TABLE XIV—*contd.*

Table showing the extraction effected by the three roller Nahan mill at Gurdaspur.

Number and date of the sample	Description and locality of the cane	Grams of juice extracted from 100 grams of cane	Percentage of fibre in the cane	Percentage of the total sucrose present in the cane extracted in the juice— Efficiency of mill in sucrose extraction
68, 12th January, 1912 .	<i>Katha</i> — Bhumli, Gurdaspur	52.9	23.63	79.04
98, 16th " " .	Hawali, Gurdaspur	52.9	27.76	85.04
106, 17th " " .	Joura Chhitran, Gurdaspur	59.4	19.89	85.0
115, 18th " " .	Gurdasnangal, Gur- daspur	60.3	18.42	83.7
116, 19th " " .	Kalanaur, Gurdas- pur	60.5	19.77	83.9
28, 21st " " .	Shahpur Guria, Ba- tala	59.0	18.57	81.5
142, 23rd " " .	Gurman, Batala .	47.4	29.53	76.3
152, 25th " " .	Barila Kalan, Gur- daspur	69.9	11.97	83.0
157, 26th " " .	Mela-Athwal, Batala	54.2	24.93	78.4
187, 31st " " .	Wanjwan, Batala .	55.8	22.72	82.4
234, 7th February, 1912.	Kotla Musa, Batala	52.6	26.30	71.2
241, 9th " " .	Sandalpur, Gurdas- pur	58.4	20.07	75.4
247, 10th " " .	Morarah, Gurdaspur	57.2	22.90	74.7
260, 14th " " .	Dadiala, Gurdaspur	56.6	23.91	77.1
	AVERAGE FOR KATHA .	56.7	23.57	79.8
	<i>Katha and Dhauku mixed—</i>			
89, 14th January, 1912 .	Walta Gumunpur, Gurdaspur	60.0	18.20	80.0
90, 18th " " .	Bahehpli, Gurdaspur	47.3	28.25	72.3

TABLE XIV—concl'd.

Table showing the extraction effected by the three roller Nahan mill at Gurdaspur.

Number and date of the sample	Description and locality of the cane	Grams of juice extracted from 100 grams of cane	Percentage of fibre in the cane	Percentage of the total sucrose present in the cane extracted in the juice— Efficiency of mill in sucrose extraction
19, 3rd January, 1912 .	<i>Kansar—</i> Government Farm, Gurdaspur	67.5	15.28	84.2
120, 20th " " .	Padhal, Gurdaspur .	62.3	15.83	86.6
134, 22nd " " .	Kahlianwali, Batala	61.7	16.76	87.4
165, 27th " " .	Kotli Tahlan, Batala	53.6	25.44	78.5
	AVERAGE FOR KANSAR	61.5	18.33	84.1
	<i>Teru—</i>			
38, 7th January, 1912 .	Dhariwal, Gurdaspur .	55.9	22.47	75.6
32, 6th " " .	Katha and Teru .	59.8	17.97	79.3
74, 13th " " .	Do., Thikriwala, Gurdaspur	58.3	17.72	80.2
	<i>Kahu—</i>			
203, 2nd February, 1912.	Dialgahr, Batala .	63.0	13.73	77.6
217, 4th " " .	Sarupwali, Batala .	66.8	14.29	83.4
228, 6th " " .	Mari Pannan, Batala	66.3	12.60	80.6
	AVERAGE FOR KAHU .	65.4	13.54	80.5
	<i>Katha Kahu—</i>			
148, 24th January, 1912 .	Jourian Kalan, Batala	53.2	17.15	79.3
179, 29th " " .	Dabhanwali, Batala	87.1	21.60	81.0
	<i>Pounda—</i>			
211, 3rd February, 1912 .	Kaka, Batala	65.3	10.60	78.0

The juice extraction varies from 56 to 67 per cent., and the efficiency of the mill in sucrose extraction varies from 71 to 87 per cent., with an average of under 80 per cent. for the common canes of the district. *This represents a loss of upwards of 20 per cent. of sugar, and under what we may consider the best methods of extraction now at the disposal of the farmer.* The farmers mostly use the two roller Batala mill, in which the extraction is much less and the losses correspondingly greater. (See Hulme's estimate for the United Provinces, Chapter V.) This indicates very clearly the need for heavier mills and better extraction. Geerligs<sup>1</sup> states that the sucrose extraction in Java is about 91 per cent. of the sugar in the cane, with a loss of about 1.1 per cent. of sucrose in the bagasse on canes containing about 11 to 12 per cent. of fibre. All the district canes contain much more fibre than this, as may be seen from the tables in Chapter III. One of the objects in cane improvement will be to obtain a less woody cane. With this object I imported several varieties of cane from Egypt in 1912. One of these is Java seedling No. 105 which has been introduced into Egypt from Java by Monsr. Nous, managing director of the Egyptian Sucories Cie. This cane was doing well there when I visited Egypt in 1912. I anticipated that a cane which was suited to the dry climate of Egypt would probably do well in the Punjab. The analysis of this cane is as follows :—

Locality and date of analysis	Juice per cent. on cane	Glucose Sucrose		Total solids	Glucose ratio	Purity co-efficient	Fibre on cane
		(per cent in Juice).					
Government Farm, Lyallpur, 6th January, 1915	63.01	0.32	11.61	15.40	2.94	70.03	13.90
Government Farm, Gurdaspur, 21st January, 1916	70.21	2.57	8.75	13.06	29.32	67.05	9.24

It is interesting to note that with the mill at my disposal I was unable to trace any numerical relationship between the extraction value and the amount of fibre in the cane. There was a fairly close agreement between different extractions of the same variety of cane even when the amount of fibre differed considerably.

## 2. Boiling the juice.

The mill is always situated near to the boiling pans so that the juice can be taken straight from thence to the pans, and for this purpose the empty kerosene oil tin so much in evidence in North India is almost

<sup>1</sup> Geerligs' *Cane Sugar and its Manufacture.*

always used nowadays, though the old earthen jar is still to be seen in the more remote villages.

The boiling house is a mud hut roofed with beams and brushwood and overlaid with earth in the usual manner of the Punjab peasant's dwelling. The pit of the furnace is in the floor of the room and has an exit for the ashes outside, there being a slanting hole from the furnace to the ash pit. The fire is directly under the pans. The pans in use in this district are all of one pattern and are of iron being constructed by the local village blacksmiths. They cost about Rs. 17 each, and are from 4½ to 5 feet in diameter and a foot deep at the centre. They hold about 120 lb. (12 gallons) of juice per boiling.

The two roller Batala mill expresses about this quantity of juice in 1½ hours, and the boiling of this amount occupies about the same time. The three roller Nahan mill on the Gurdaspur farm expresses 140 lb. of juice from *Katha* cane and 180 lb. of juice from *Kahu* cane per hour. The bagasse is dried in the sun and used as fuel. As a rule it serves to evaporate the juice to the consistency of *gur*, except in the case of the more juicy canes when this source of fuel has to be augmented by cotton stalks or other local fuels.

*Gur*-making is a continuous process and is carried on night and day during the season. It only ceases with the cessation of cane cutting by rain, or when the bullocks have to be taken from the mill to work on the wells for irrigating wheat. The boiling begins about 9 months after sowing time towards the end of November or beginning of December. The juice after crushing goes straight to the pan without straining, except in special cases when the product is for private consumption or when making *rab*.\* The juice is boiled until the scum rises; this is then removed with ladles. It is unusual in *gur*-boiling to induce the formation of scum by the addition of foreign substances. In some cases the sugar boiler adds a little common soda. This improves the colour of the *gur* but impairs its keeping properties.

In the manufacture of *mal rab* (a liquid raw sugar) *suklai* or *suli* (*Euphorbia Royleana*) is added.†

After the removal of the scum and when the juice begins to boil, a little sweet oil (sesame oil) is added to check violent ebullition, and at the same time the fuel in the furnace is reduced. When the charge begins to assume a semi-solid consistency, vigorous stirring is resorted to.

\* *Rab* is a raw sugar product—for its composition see page 38.

† This bark when steeped in water gives a thick soupy solution of pentosans which precipitates on boiling, thus aiding the clarification of the juice. It serves the same purpose as white of egg in clarifying soup or bouillon in the preparation of bacterial culture media, or of fresh blood in the old West Indian sugar-boiling process.

The product is then transferred to a flat earthen vessel called a "gand," where it is kneaded into balls of about 2 lb. in weight.

From superior ripe cane a whiter product termed "shakkar" is obtained which is dryer and more friable; this is usually sold in the powder form. When boiling for *shakkar*, the charge of juice is slightly reduced and the concentration carried a little further than when making *gur*.

*Mal rab*. The process of *rab*-making differs from that of *gur*-making in the clarification of the juice and in the concentration not being carried so far. The contents of the pan are removed into large earthen jars and stored in a semi-solid, semi-liquid state until required for *khand*-making.

The proportion of juice to *rab* is about 5 to 1 and of juice to *gur* about 6 to 1.

#### *Manufacture of khand—a drained raw sugar.*

This process has been described by Montgomery in the Hoshiarpur settlement as follows:—

"The making of drained raw sugar, "khand," is generally carried out by a regular trader. The process requires a good deal of superintendence and few cultivators proceed further than the making of the first crude sugar products, *gur* and *mal rab*. In making *khand* the *mal rab* is emptied into large vats called "khanchi," which are made of wood and lined with matting. They are capable of holding from 80 to 400 maunds of *rab*. At the bottom of the vats are a number of small channels leading off to special reservoirs outside, and on this flooring are placed pieces of wood on which is a reed mat and over that a piece of coarse cloth the sides of which are sewn to the side mats in the vat. After a time the molasses known as *shira* exude through the cloth and matting at the bottom to the reservoirs and are thence collected in earthen jars. After the *rab* has been in the vat about 10 days, and the mass has hardened sufficiently to bear a man's weight, it is worked up with an iron trowel so as to break up all lumps, and then smoothed with a flat dish previously rubbed with *ghi*.\* The layers of *jala* (*Potamogeton*), a water plant, are placed on the top, and after every few days the *jala* is rolled up and the white sugar at the top of the mass of *rab* is taken off and fresh *jala* put in its place, the old *jala* being placed over, so that as the sugar is extracted the super-incumbent weight of *jala* increases. Towards the end it is found that the weight of *jala* is carrying sugar as well as molasses through the cloth strainer. It takes 3 or 4 months to empty a vat in this way. If begun when the weather is cold,

\* Clarified butter fat.



it is customary to light fires in the room containing the vats before putting on the *jala*, in order to make the molasses draw off quicker. The sugar taken off is spread out on a piece of coarse canvas on a hard piece of ground in the sun and is well trodden with the feet until it has been reduced to a coarse powder. This substance is called *khand*, and sometimes *chini*, and is the ordinary coarse ground sugar sold in the bazaars."

Sri Gobindpur is the centre of the *khand* industry in the Gurdaspur District, but *khand* is still made in several villages in the neighbourhood of Harchowal.

The following figures were obtained from the village of Jagalwala near Harchowal. Dimensions of the vat  $7 \times 4\frac{1}{2} \times 4\frac{1}{2}$  feet. Capacity 120 maunds (4.4 tons). The *rab* contained in it had been prepared from a *barani* crop of mixed *Katha* and *Dhau* canes. The following estimate of expenditure and receipts was given by the owner :—

<i>Expenditure.</i>		<i>R a n</i>
Cost of <i>rab</i> at Rs. 3-15-9 per maund . . . . .		478 2 0
Wages of workmen for 2½ months at Rs. 10 per month		25 0 0
Sweet oil for cleaning the juice and for burning at the rate of ¼ seer per day for 60 days costing R. 0-8-6 per seer . . . . .		10 0 0
Cost of <i>sukri</i> . . . . .		1 0 0
Cloth for bottom of vat . . . . .		1 8 0
Cost of earthen vessels . . . . .		0 8 0
Cost of <i>jala</i> at 4 annas per layer . . . . .		5 0 0
Cost of treading out the sugar at 8 annas per day (rate 5 maunds per day) . . . . .		3 0 0
Interest on Rs. 500 at 5 per cent. for 12 months . . . . .		25 0 0
	TOTAL EXPENDITURE .	549 2 0
<i>Receipts.</i>		
30 maunds <i>khand</i> at Rs. 12-8-0 per maund . . . . .		375 0 0
70 maunds molasses at Rs. 2-10-6 per maund . . . . .		185 15 0
	TOTAL RECEIPTS .	560 15 0

Nowadays the return on the industry is from 8 to 10 per cent. of the money invested, while in former years it was 15 per cent. The falling off is attributed by the *khand*-makers to the decline in the quality of the *rab*, which they say is due to the abandoning of the long fallow system of

cultivation. The *rab* industry is certainly on the decline but it is impossible to say if this is due to the poorer quality of the cane, since there is no record of the chemical composition of cane juice in previous years.

In all probability, several factors have contributed to the decline of this industry, and not the least among them is the rise in the price of raw sugar commodities with the extension of trade, which brings other agricultural products into more direct competition with local cane. (see Chapter V, crops in competition with cane). The importation of refined sugar from abroad has also had its influence on this local industry (see Chapter IV). In the village of Jagalwal from 10,000 to 12,000 maunds of *rab* were made annually, and its manufacture has declined until at the present day only 350 maunds of *rab* are used for *khand*-making.

### 3. Sugar products and their composition.

The principal sugar products made in the district are as follows :—

- (a) *Gur*—a raw sugar made by simple evaporation of the juice (see above).
- (b) *Shakkar*—a light dry *gur*.
- (c) *Rab* or *mal rab*—liquid sugar (see above).
- (d) *Khand* (see above)—a refined sugar from which molasses have been drawn off.
- (e) *Bura*—made from *khand* boiled in water and clarified with milk.
- (f) *Misri*—prepared from *khand* boiled with water and evaporated.
- (g) *Kuza misri*—prepared as *misri* only with the best type of *khand*.

In the preparation of *kuza misri* the best quality of *khand* is dissolved in boiling water to the consistency of a thick syrup. This is placed in small porous earthen vessels in which is suspended a cotton thread. When the sugar has crystallized the vessels are inverted to draw off the mother liquor, they are afterwards broken in order to secure the crystallized sugar in a lump. This is the ordinary candied sugar.

- (h) Sugar raw—By this is meant “sugar un-refined,” under which *bhura* or *bura sakar* or brown *shukkar*, *karkar* or *masti meeja* or *talauncha* and other local names are classified. The term does not include *gur* and molasses.

The composition of these materials may be judged from the accompanying table :—

TABLE XV.

The composition of various sugar products produced in the Gurdaspur District in 1914 and 1916.

Register No. for reference	Date of analysis	Description of the product under examination	Glucose per cent.	Sucrose per cent.	Specific gravity of solution	Total solids Brix, corresponding to sp. gravity	Total soluble matter	Moisture and insoluble impurities	Soluble organic impurities	Total solids as cane sugar by refractometer	REMARKS
140	{ 30th July, 1914 . . . 31st July, 1914 . . . }	Bura made in Qadian	6.45	81.04	1.0354	8.86	88.6	11.4	1.11	89.75	
150	Do. . . . .	Misri made in Sri Gobindpur from country <i>Khand</i> made from cane grown in the Bet	2.12	90.61	1.0375	9.36	93.0	6.4	0.87	92.5	
151	Do. . . . .	<i>Khand</i> from Sri Gobindpur made from <i>Dhau</i> and <i>Katha</i> grown in Boas Bet	1.30	91.81	1.038	9.49	94.9	5.1	1.79	93.75	
152	Do. . . . .	<i>Khand</i> prepared in Qadian	1.05	93.26	1.0382	9.53	95.3	4.7	0.99	93.0	
153	Do. . . . .	<i>Khand</i> prepared in Harchowal from <i>Katha</i> cane	1.80	92.21	1.0378	9.44	94.4	5.5	0.89	92.5	
179	Do. . . . .	<i>Shakar</i> from <i>Dhau</i> cane at Harchowal	0.20	75.5	1.0370	8.965	89.65	10.35	4.75	..	
168	Do. . . . .	<i>Gur</i> from <i>Dhau</i> at Gurdaspur	13.34	73.21	1.0363	8.905	83.05	11.95	1.5	..	<i>Gur</i> is very variable in composition
102	31st July, 1916 . . .	Red ( <i>Sairs</i> ) . . .	29.68	41.02	1.0330	8.27	82.74	17.26	12.04	81.50	
101	Do. . . . .	<i>Kuan misri</i> . . .	0.13	96.90	1.0389	9.70	97.0	3.0	0.0	97.00	

#### 4. Yield of *gur* and sugar in the *gur*.

The out-turn of *gur* obtained in this district varies with the type of cane from which it is made, with the cultivation this receives, and with the season. The milling which the cane gets is fairly uniform throughout the district, and we cannot say with any certainty that there is much variation on this account.

The following table gives the yield of *gur* (raw sugar) per acre of the principal varieties of cane grown in the district (determined at the Gurdaspur Experimental Station) :—

TABLE XVI.

*Table showing the yield of gur per acre at Gurdaspur.*

Variety	1913	1914	1915	1916
	M. s.	M. s.	M. s.	M. s.
Dhaultu . . . . .	26 0	30 6	32 25	..
Katha . . . . .	36 2	23 20	30 10	29 20
Kanara . . . . .	..	38 23	26 36	24 18
Teru or Tereru . . . . .	52 32	31 10	36 12	26 33
Kabu . . . . .	..	24 9	45 10	..
Merthi . . . . .	42 14	26 12	25 4	..
Kansar . . . . .	53 35	24 22	42 10	19 18
Bodi . . . . .	..	40 7	32 32	21 24

These figures are the result of a number of crushing and boiling experiments made on the Gurdaspur Experimental Farm, and are from canes grown there. The weight of cane crushed may be seen by reference to Table XII (Chapter I, page 26).

More reliance may be placed on the results shown for 1914, 1915 and 1916 than for 1913, when only small areas of cane were grown. In considering the results of this table, it is important to note that these have been obtained from the use of a three roller Nahan mill which gives a higher efficiency than that obtained by the zemindar in the district, who for the most part uses the two roller Batala mill.

From a knowledge of the chemical composition of the *gur* and the amount obtained per acre, we can estimate the actual amount of the biose sugar sucrose produced and recovered in the *gur*. If we allow for the efficiency of the mill as shown above to be about 80 per cent., the actual sugar produced per acre and recoverable as *gur* can be ascertained with a fair degree of accuracy. These figures are of interest to the manufacturer of refined sugar when working on *gur* as the raw product; they will not be accurate for the actual sucrose production, as this must be calculated on the analysis of the cane itself.

TABLE XVII.

*Composition of raw sugar (gur) prepared from district canes grown and crushed at the Gurdaspur Agricultural Station.*

Variety and year	Glucose per cent.	Sucrose per cent.	Specific Gr. of 20 per cent. solution	Total solids Brix	Percentage of soluble matter	Percentage of moisture and insoluble impurity	Soluble organic impurity	FROM GUR		
								Sucrose per acre from table (in pounds)	Estimated out-turn of sucrose per acre allowing for mill losses at 20 per cent. (in pounds)	
Katha	1913	15.87	72.29	1.0732	17.8	89.0	11.0	1.34	2,310	2,081
	1914	8.74	72.36	1.0740	17.9	89.5	10.5	8.40	1,412	1,705
	1915	9.11	70.41	1.0720	18.0	90.0	10.0	10.48	1,753	2,101
Kansar	1913	14.68	72.81	1.0730	17.8	89.0	11.0	2.01	3,244	4,386
	1914	0.75	71.81	1.0746	18.05	90.25	9.76	8.69	1,874	2,342
	1915	8.92	64.54	1.0758	18.9	94.5	5.5	21.04	2,229	2,786
Merthi	1913	12.82	74.05	1.0733	17.8	89.0	11.0	1.73	2,654	3,317
	1914	15.26	69.72	1.0722	17.5	87.5	12.5	2.52	1,581	1,913
	1915	11.07	71.10	1.0756	18.9	94.5	5.5	12.39	2,455	3,069
Tereru of Batala	1913	17.39	68.15	1.0713	17.3	88.5	13.5	0.90	3,020	4,640
	1914	12.79	72.83	1.0733	17.75	88.75	11.25	3.13	1,902	2,379
	1915	15.24	66.41	1.0757	18.30	91.50	8.50	9.85	1,976	2,470
Dhau	1915	18.36	62.57	1.0766	18.45	92.25	7.75	11.32	1,675	2,094
	1916	21.75	59.33	1.0766	18.26	91.31	8.69	10.23	..	..

NOTE—Milling losses in the district are greater than this.

### 5. Losses of sugar in the manufacturing processes.

The losses which take place in working up the cane into marketable forms of sugar are also considerable. This is only to be expected when we consider the crude machinery at the disposal of the farmer and his lack of knowledge of the chemical processes involved in sugar boiling.

The first loss is in the milling of the cane. We have already described this in discussing the efficiency of the mills in use, and have estimated that upwards of 20 per cent. of the available sugar is lost in this process alone. The next great waste occurs in the boiling of the juice. Since the juice is always boiled immediately after crushing the cane, and as crushing goes on simultaneously with the harvesting of the crop, there are practically no losses in the cane itself before crushing.

In the boiling of the juice, however, a great deal of sugar is lost. Some sugar is lost by inversion, and this is inevitable since the juice is acid, and the attempts made to neutralize the acid are extremely crude and sometimes are absent altogether. Mention has been made above that sometimes a little crude soda is added to the juice in *gur* boiling, but this is not often practised, since the use of soda often leads to the production of an inferior raw sugar. This is because the soda can never be added in the exact proportion necessary to neutralize the acids present without the use of test papers, and such are unknown to the zemindar. The use of lime in sugar boiling is quite unknown in this district.

The following table has been compiled from Tables XII, XIV, XVI, and XVII, and shows the amount of sugar per acre in the cane and the amount of sugar recovered in the *gur* :—

TABLE XVIII.

*Losses in the manufacture of raw sugar (gur) at the Gurdaspur Experimental Station.*

Variety of cane and year of experiment	Sucrose per cent. on cane	Sucrose per acre in pounds	Invert sugar per cent. on cane	Invert sugar per acre in pounds	Pounds of sucrose in the <i>gur</i> from one acre of cane	Pounds of invert sugar in <i>gur</i> from one acre of cane	Total loss of sucrose per cent.	Sugar lost by inversion per cent.	Sugar lost in milling per cent.	Other losses, at present unaccounted for, per cent.	
Dhanlu .	{ 1914 .	10.38	3,216	0.36	102	1,680	180	41.65	3.08	20.0	17.59
	{ 1915 .	10.36	3,550	0.28	100	1,674	491	52.84	13.74	20.0	19.10
Katha .	{ 1913 .	12.14	3,495	0.45	130	2,255	479	35.47	13.68	21.0	0.79
	{ 1914 .	10.56	2,252	0.61	123	1,395	169	38.0	3.83	22.83	11.34
	{ 1915 .	11.07	2,923	0.31	82	1,747	226	40.2	6.64	21.0	12.56
Teru .	{ 1913 .	12.36	6,005	0.20	112	2,050	754	57.3	11.00	23.0	22.40
	{ 1914 .	11.25	3,326	0.45	133	1,366	325	43.0	8.37	23.0	12.58
Kahu .	1914 .	10.34	2,295	0.20	44	1,336	248	46.1	10.9	19.5	15.70
Kansar .	{ 1913 .	10.89	5,091	0.53	248	3,194	649	37.3	9.8	18.0	11.5
	{ 1914 .	11.57	2,177	0.89	163	1,445	196	33.6	3.1	16.0	14.5

These figures have been arrived at from a knowledge of the mill expression, the weight of cane and *gur* obtained per acre of crop grown and the analyses of the juice, bagasse and *gur*. I have not considered it necessary to give the details of the calculations as these are comparatively simple. The quantity of sucrose lost by inversion is obtained from the gain in invert sugar on boiling; this figure multiplied by the factor  $\frac{324}{360}$  gives the equivalent amount of sucrose, and is taken to represent that lost by inversion. The gain in invert sugar is obtained thus:—

We know that, unless the mill expression is very high, the glucose ratio  $\frac{\text{glucose} \times 100}{\text{sucrose}}$  is approximately the same in juice and bagasse. Any mill losses therefore will have to be taken into account. If, as in the case of *Dhau* cane in the above table, our milling losses on sucrose were 20 per cent., then an equal loss would occur in the glucose and the 100 lb. of glucose from 1 acre of cane would in the course of its milling fall to  $100 - (\frac{100 \times 20}{100})$ . This figure of 80 lb. of invert sugar should be present in the *gur* if only milling losses occur and no change takes place in the composition of the juice. By analysis, however, we find that the *gur* contains 491 lb. of invert sugar, so it has gained 491-80 lb. and this is from sucrose which has become inverted. This is equal to  $(491-80) \times \frac{342}{360}$  equal to 390 lb. sucrose lost by inversion, equal to 13.7 per cent. on the sucrose in the juice of the cane.

From the above table the total loss of sucrose in *gur* making appears to vary from 34 to 57 per cent. or nearly one half of the sucrose in the cane is lost in this process of raw sugar making.

Of this whole loss, from 16 to 23 per cent. is due to bad milling and from 3 to 14 per cent. to inversion of sucrose in boiling the juice. From 1 to 22 per cent. of the loss remains unaccounted for. It is probably due to losses in handling the raw and manufactured products, petty theft, in destruction of sugar in boiling and in a lower milling efficiency than that recorded. The extent and nature of this loss requires further investigation. I do not presume to state that in all *gur* making processes and with all canes, the losses are as high as 50 per cent.: they may in some cases be less, but this is unlikely since the mill used in these experiments (Nahan) was of a better type than is usual with the zemindar.

Clarke<sup>1</sup> gives an expression of from 71 to 87 per cent. for various canes, using this same type of mill, and our results at Gurdaspur fall within the limits quoted by the above observer. We know that the expression effected varies with the rate at which the mills are made to

<sup>1</sup> *Pusa Bulletin* No. 42; Notes on Cane Crushing in the United Provinces, pages 7 and 8.

revolve as well as with their adjustment. It also varies with the nature of the cane. The figures in the above table are, therefore, to be taken as approximately representative only. They are sufficiently accurate, however, to give us some idea of the magnitude of the losses effected in making raw sugar under the best possible prevailing conditions, and they indicate the immediate need of improvement, if cane cultivation is to compete successfully with the other agricultural products grown in the district.



## CHAPTER III.

### THE CHEMICAL COMPOSITION OF THE DIFFERENT VARIETIES OF CANES GROWN IN THE DISTRICT.

#### 1. System followed for sampling the canes and recording the results.

The usual methods of cane analysis were followed in obtaining the figures referred to in this report.

In sampling a field crop like cane, considerable errors are liable to be made owing to variations in the field. These may be so variable that the different canes of one soil may show a considerable variation in the composition of the expression. The only really satisfactory method is to examine the juice and bagasse several times in the course of the passage of a large quantity of cane through a standard mill so set and controlled as to give a fairly uniform extraction. In such an enquiry as the one described here, this was of course impossible. It was easier to multiply the number of analyses and strike an average than to undertake the costly arrangements attendant on the experimental crushing of large measured areas of cane. Another point in favour of the system adopted was that the ripening of the cane could be followed simultaneously in different parts of the district by carrying out the analysis at a central laboratory. A small laboratory was set up in the office attached to the Government Experimental Station at Gurdaspur, and the cane samples were collected in selected villages in the adjacent country and at such distances that not more than 24 hours elapsed between the cutting of the sample and its analysis in the laboratory.

One or two stools of cane were selected for each sample by the Field Assistant deputed for the work, care being taken to select an average rather than a good stool, and always at some distance from the edge of a plot of growing canes. The cane after cutting was stripped of leaves and then wrapped in the cane leaf, and at once despatched by messenger to the laboratory. As far as possible the sampling was done in the afternoon or evening so that the material reached the laboratory early the following morning or at least by mid-day. The cane was then weighed and milled in a three roller Nahan mill driven by bullocks, a record being kept of the amount of juice expressed.

Under these conditions, there is a probability of change taking place both in the concentration of the juice and in its composition. The

stripping of the stem and the wrapping in the cool and moist cane leaf reduces the change in concentration to a minimum. Even in exposed cut cane in bulk the loss in weight does not usually amount to more than 2 per cent. according to Deerr (*loc. cit.*). Weinberg estimates the loss of available sugar during the first 24 hours as about 2.7 per cent. It is not an uncommon practice among farmers in the Gurdaspur District to allow a day to elapse between cutting and crushing and this practice is said to yield a dryer and better *gur*.

The loss of sugar resulting from storing canes was examined at the outset of these experiments and the results obtained are given below in Table XIX.

In the above experiment the cane samples were stripped of leaves and analysed after storing for 24 to 48 hours. Out of 20 samples, only 4 showed a decrease of sucrose.

TABLE XIX.

*Showing the change in composition of sugars in juice on storing canes.*

Special experiments on the effect of stripping the cane on the sucrose contents.

Chak No. 79 near Agricultural Station, Lyallpur.

Special analysis of red, thin *Chin* purchased from Rura tenant.

No. and date of sample	Description and locality of cane	Juice per cent.	Glucose per cent.	Sucrose per cent.	Total solids	Glucose ratio	Purity co-efficient	Fibre on cane	Increase or decrease on the sucrose
1. 6th March 1912	Red thin <i>Chin</i> , Rura tenant, Chak 79, near Agricultural Station, Lyallpur	50.4	0.21	10.13	23.1	1.09	82.79	23.96	..
2. 7th " "	No. 1 after 24 hours	49.6	0.37	19.58	23.1	1.69	84.78	24.14	+0.45
3. 6th " "	Another stool analysed fresh	52.19	0.17	17.60	22.5	0.96	78.21	22.68	..
4. 7th " "	No. 3 after 24 hours	50.7	0.78	18.08	23.2	4.31	77.91	22.43	+0.44
5. 6th " "	Another stool analysed fresh	48.7	0.12	17.72	22.2	0.68	79.82	19.13	..
6. 7th " "	No. 5 after 24 hours	50.2	0.46	18.45	23.0	2.49	80.23	21.79	+0.73
7. 6th " "	Another stool analysed fresh	50.08	0.23	17.60	22.6	1.30	78.2	22.61	..
8. 8th " "	No. 7 after 48 hours	52.07	0.34	18.86	24.2	1.80	77.93	22.10	+1.2
9. 6th " "	Another stool analysed fresh	52.08	0.10	19.40	23.10	0.51	83.97	22.12	..
10. 8th " "	No. 9 after 48 hours	50.96	0.37	10.6	24.2	1.83	80.96	22.31	+0.2
11. 6th " "	Another stool analysed fresh	53.40	0.20	17.62	22.7	1.43	77.62	22.92	..

TABLE XIX—contd.

No. and date of sample	Description and locality of cane	Juice per cent.	Glucose per cent.	Sucrose per cent.	Total solids	Glucose ratio	Purity coefficient	Fibre on cane	Increase or decrease on the sucrose
12. 8th March, 1912	No. 11 after 48 hours	50.4	0.38	18.9	23.9	2.01	79.07	25.3	+1.28
13. 12th " "	Another stool analysed fresh	52.4	0.14	17.97	21.6	0.78	83.1	24.63	..
14. 13th " "	No. 14 after 24 hours	51.2	0.9	17.86	23.4	5.06	76.33	20.35	-0.11
15. 12th " "	Another stool analysed fresh	49.7	0.15	18.89	22.7	0.79	83.24	23.01	..
16. 13th " "	No. 15 after 24 hours	53.7	0.13	20.06	24.1	0.64	83.28	22.48	+1.17
17. 12th " "	Another stool analysed fresh	51.4	0.14	18.63	21.8	0.74	86.60	22.8	..
18. 14th " "	No. 17 after 48 hours	48.8	0.597	21.08	25.3	2.83	83.24	22.8	+2.35
19. 12th " "	Another stool analysed fresh	54.1	0.11	19.92	23.8	0.55	83.7	23.74	..
20. 14th " "	No. 19 after 48 hours	47.0	0.58	21.89	27.3	2.64	80.34	28.22	+1.97
21. 12th " "	Another stool analysed fresh	50.1	0.18	19.31	23.4	0.92	82.5	25.88	..
22. 13th " "	No. 21 after 24 hours (paraffined and analysed)	51.2	0.18	20.5	24.6	0.86	83.37	23.81	+1.19
23. 12th " "	Another stool analysed fresh	50.8	0.096	19.67	23.9	0.48	82.31	23.26	..
24. 13th " "	No. 23 paraffined and analysed after 24 hours	51.0	0.102	20.92	25.1	0.48	83.35	22.42	+1.25
25. 12th " "	Another stool analysed fresh	55.3	0.103	18.98	23.1	0.54	82.17	21.74	..
26. 14th " "	No. 23 paraffined and analysed after 48 hours	49.7	0.407	20.17	25.3	2.02	79.71	21.91	+1.19
27. 12th " "	Another stool analysed fresh	51.1	0.19	18.08	22.9	1.06	78.98	26.34	..
28. 14th " "	No. 27 paraffined and analysed after 48 hours	50.7	1.04	17.33	25.6	6.00	67.91	24.35	-0.70
Samples of local Dhau, Government Farm, Gurdaspur.									
29. 10th February, 1912	One stool analysed fresh	50.66	0.46	15.53	18.7	2.06	83.04	15.82	..
30. 11th " "	No. 29 after 24 hours	59.5	0.67	15.16	18.2	4.41	83.2	16.90	-0.37
31. 10th " "	Another stool analysed fresh	55.7	0.90	14.74	18.0	6.1	81.83	19.27	..
32. 11th " "	No. 31 after 24 hours	59.4	0.89	14.57	18.2	6.10	80.06	15.58	-0.17
33. 12th " "	Another stool analysed fresh	51.6	0.69	13.63	17.2	5.04	79.5	18.77	..
34. 14th " "	No. 33 after 48 hours (ends cut off)	58.8	0.33	15.15	18.5	2.17	81.9	19.33	+1.47
35. 12th " "	Another stool analysed fresh	56.7	0.65	13.55	17.7	4.79	79.5	15.25	..
36. 14th " "	No. 35 analysed after 48 hours (ends cut off)	58.0	0.12	14.5	18.5	0.83	78.4	16.95	+0.95
37. 12th " "	Another stool analysed fresh	51.6	0.69	13.63	17.2	5.04	79.5	19.77	..
38. 14th " "	No. 37 analysed after 48 hours (ends not cut off)	54.9	0.25	14.28	17.8	1.75	81.14	19.24	+0.60
39. 12th " "	Another stool analysed fresh	55.7	0.65	13.55	17.7	4.79	79.5	15.25	..
40. 14th " "	No. 39 analysed after 48 hours (ends not cut off)	56.3	0.09	14.69	18.8	0.61	78.14	17.64	+1.14

Some loss in weight was bound to occur. The resulting concentration of sugar in the juice can be discounted by comparing the ratio of sucrose to total solids before and after storing. The remaining sixteen samples show an increase in sucrose varying from 2 to 2.4 per cent. This result is important, and has been followed up in a separate series of investigations to be published shortly.<sup>1</sup> It offers an explanation for the above-mentioned country practice of storing cane before crushing. It affects the results given in the tables of district cane analysis to an extent of about minus 0.34 per cent. of sucrose in 20 per cent. of the samples stored for the above period, and plus 1.1 per cent. sucrose in 80 per cent. of the samples. This error is not a serious one in view of the variations bound to occur in the method of taking small samples. Where paucity of staff did not admit of the full analysis of the bagasse at the time of crushing, this was preserved by the addition of a small quantity of chloroform to a previously weighed mass of bagasse enclosed in a stoppered bottle. This was found effective in checking enzymic hydrolysis of the sucrose or other fermentative changes for the period required to despatch these bagasse samples to the central laboratory at Lyallpur.

In collecting the samples, the Assistant in charge of the work supplied the following information :—

(1) Date of sampling : (2) tahsil and village : (3) name of grower : (4) date of sowing the crop : (5) class and description of cane : (6) class of soil on which the cane was growing : (7) an estimate of the canes attacked by borer or disease.

On receipt of the samples in the laboratory the analyst recorded the number of the sample, the average length of 10 canes, the average length of the internodes of 10 canes and the average thickness of the canes between the nodes.

These latter figures were collected as bearing on the growth of the cane and the effect of the season on this.

These figures will be found in the tables giving the average composition of the different types of cane grown in the district at pages 48-54 below.

## 2. The composition of the different types of canes grown for the seasons 1911-12 - 1915-16.

The examination of the district canes commenced in January 1911, and has been continued both in the district and at the Gurdaspur experimental station or both, up to the present season. The district samples were taken from selected villages throughout the Gurdaspur and Batala tahsils where the best cane is grown. For the practical purpose of the enquiry, it was very necessary for us to consider the best

<sup>1</sup> *Agri. Jour. India*, vol. XII, part II.

and average cane cultivated in the district, and for this reason we have not extended the enquiry to include the poorer canes of the Bet or of the Pathankot tahsil.

### *Katha or Chan.*

*Local information.* A thin reddish cane—very hardy—great tillering powers—considerable ability to withstand drought, flooding, and to a less extent frost. Ripens earlier than any other variety. Leaves are very persistent and it is consequently a difficult cane to strip. The rind is hard, and so the cane is not used for chewing. The juice is not of good colour, but is much liked for drinking as it is said to be healthy compared with *Dhau* juice, which, though a nice white colour, produces an excess of saliva in the mouth after drinking. The juice is small in quantity compared to other varieties, but contains a good percentage of sugar.

This variety is said to have arisen from the wild "Kahi" grass, which grows in swampy lands in the submontane tracts.

The *gur* from this variety is said to keep better than *gur* of other varieties. A good crop yields 30 maunds *gur* per acre.

*Distribution.* The most universally grown of any variety in the Province, it is found—

- (1) Extensively grown under *barani* (rain-fed) conditions in submontane tracts, where the rainfall, though moderate, is insufficient for other varieties.
- (2) Under well and canal irrigation in the submontane tracts some distance from the hills.
- (3) In low lands along river and canal banks and on the borders of swamps, where the absence of drainage prevents other varieties from growing. In these localities *rob* is generally made, as the crop never properly ripens.
- (4) In the canal colonies in the southern districts of the Province as it withstands the hot dry climate better than other varieties.

TABLE XX.

*Dimensions of Katha cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	1,080	220	9
Average length of cane . . . . .	4' 8.3"	4' 10.7"	4' 2"
Average length of internodes . . . . .	3.49"	3.69"	3.3"
Average thickness of internodes . . . . .	0.44"	0.45"	0.40"

TABLE XXI.

*Composition of cane in the Gurdaspur District. Variety Katha.*

Year	Month	No. of analyses for which the average has been struck	Juice per cent. (on cane)	ANALYSIS					
				Glucose	Sucrose	Total solids	Glucose ratio	Purity co-efficient	Fibre on cane
				Sucrose	Total solids				
1911-12	January	65	55.62	0.08	16.35	19.44	4.16	84.10	20.50
	February	29	56.38	0.51	17.71	20.23	2.31	87.41	20.23
	December	1	60.8	0.42	16.62	20.08	2.52	82.77	21.86
1912-13	January	12	61.9	1.27	16.37	19.91	7.75	82.22	20.64
	February	9	58.75	0.38	17.66	21.78	2.13	82.00	21.53
	November	1	56.24	2.80	12.75	18.80	21.96	67.81	21.31
1913-14	December	3	56.47	1.03	16.53	20.45	6.20	80.83	22.57
	January	6	54.92	1.40	15.33	19.36	9.13	79.18	20.11
	February	5	57.50	0.38	16.53	20.04	2.30	82.48	20.70
1914-15	November	1	60.3	0.26	14.29	17.47	1.84	81.8	21.63
	December	3	56.5	0.64	14.54	18.05	4.41	80.55	21.75
	January	3	60.4	0.46	15.40	18.79	3.00	81.09	21.24
	AVERAGE	138	57.98	0.85	15.86	19.53	5.36	81.02	21.13
	Highest	..	61.90	2.80	17.86	21.78	21.06	67.41	22.57
	Lowest	..	54.92	0.26	12.76	17.47	1.84	67.81	20.11

**Dhau of Gurdaspur.**

*Local information.* Green when unripe, the cane becomes a white colour, as its name implies, on ripening. It is thicker than *Katha* and requires a better soil and a more liberal supply of water. Occasionally found under *barani* conditions but is nearly always irrigated. It ripens later than *Katha*. Leaves strip off easily. Rind is softer than *Katha*. The sets at planting time are more prone to white ant attack than those of *Katha*. This applies to all varieties in the Province. The thicker the variety the more prone to white ant attack it appears to be. The *gur* is a better colour and the sugar made from it whiter than from *Katha*. The *gur* is reported to be inferior in keeping qualities to that of *Katha*.

*Distribution.* It is confined to irrigated land in Gurdaspur and adjoining districts. Outside of that tract it is seldom found and does not appear to thrive anywhere so well as in the Gurdaspur District.

TABLE XIX—*contd.*

No. and date of sample	Description and locality of cane	Juice per cent.	Glucose per cent.	Sucrose per cent.	Total solids	Glucose ratio	Purity per cent.	Fibre on cane	Increase or decrease on the sucrose
12. 6th March, 1912	No. 11 after 48 hours	50.4	0.38	18.9	23.9	2.01	79.07	25.8	+1.28
13. 12th " "	Another stool analysed fresh	52.4	0.14	17.97	21.6	0.78	83.1	24.63	..
14. 13th " "	No. 14 after 24 hours	51.2	0.9	17.88	23.4	5.08	76.33	20.35	-0.11
15. 12th " "	Another stool analysed fresh	49.7	0.15	18.89	22.7	0.79	83.24	23.01	..
16. 13th " "	No. 15 after 24 hours	53.7	0.18	20.06	24.1	0.64	82.28	22.48	+1.17
17. 12th " "	Another stool analysed fresh	51.4	0.14	18.68	21.8	0.74	85.69	22.6	..
18. 14th " "	No. 17 after 48 hours	48.8	0.597	21.06	25.3	2.84	83.24	22.8	+2.38
19. 12th " "	Another stool analysed fresh	54.1	0.11	19.92	23.6	0.55	83.7	23.74	..
20. 14th " "	No. 19 after 48 hours	47.0	0.58	21.89	27.3	2.64	80.34	28.22	+1.97
21. 12th " "	Another stool analysed fresh	50.1	0.18	19.31	23.4	0.92	82.5	25.88	..
22. 13th " "	No. 21 after 24 hours (paraffined and analysed)	51.2	0.18	20.5	24.6	0.86	83.37	23.81	+1.19
23. 12th " "	Another stool analysed fresh	50.6	0.096	19.67	23.0	0.48	82.31	23.28	..
24. 13th " "	No. 23 paraffined and analysed after 24 hours	51.0	0.102	20.92	25.1	0.48	83.35	22.42	+1.25
25. 12th " "	Another stool analysed fresh	55.3	0.103	18.98	23.1	0.54	82.17	21.74	..
26. 14th " "	No. 25 paraffined and analysed after 48 hours	49.7	0.407	20.17	25.3	2.02	79.71	21.91	+1.19
27. 12th " "	Another stool analysed fresh	51.1	0.19	18.08	22.9	1.06	78.98	26.34	..
28. 14th " "	No. 27 paraffined and analysed after 48 hours	50.7	1.04	17.38	25.6	6.00	67.91	24.35	-0.70
Samples of local Dhau, Government Farm, Gurdaspur.									
29. 10th February, 1912	One stool analysed fresh	56.86	0.48	15.58	18.7	2.96	83.04	15.82	..
30. 11th " "	No. 29 after 24 hours	59.5	0.67	15.16	18.2	4.41	83.8	16.90	-0.37
31. 10th " "	Another stool analysed fresh	55.7	0.90	14.74	18.0	6.1	81.88	19.27	..
32. 11th " "	No. 31 after 24 hours	59.4	0.89	14.57	18.2	6.10	80.05	15.58	-0.17
33. 12th " "	Another stool analysed fresh	51.6	0.89	13.68	17.2	5.04	79.5	19.77	..
34. 14th " "	No. 33 after 48 hours (ends cut off)	56.8	0.33	15.15	18.5	2.17	81.9	19.33	+1.47
35. 12th " "	Another stool analysed fresh	56.7	0.65	13.55	17.7	4.79	79.5	15.25	..
36. 14th " "	No. 35 analysed after 48 hours (ends cut off)	58.0	0.12	14.5	18.5	0.83	78.4	16.95	+0.95
37. 12th " "	Another stool analysed fresh	51.6	0.69	13.68	17.2	5.04	79.5	19.77	..
38. 14th " "	No. 37 analysed after 48 hours (ends not cut off)	54.9	0.25	14.28	17.6	1.75	81.14	19.24	+0.60
39. 12th " "	Another stool analysed fresh	56.7	0.65	13.55	17.7	4.79	78.5	15.25	..
40. 14th " "	No. 39 analysed after 48 hours (ends not cut off)	56.3	0.09	14.60	18.8	0.61	78.14	17.04	+1.16

Some loss in weight was bound to occur. The resulting concentration of sugar in the juice can be discounted by comparing the ratio of sucrose to total solids before and after storing. The remaining sixteen samples show an increase in sucrose varying from 2 to 2.4 per cent. This result is important, and has been followed up in a separate series of investigations to be published shortly.<sup>1</sup> It offers an explanation for the above-mentioned country practice of storing cane before crushing. It affects the results given in the tables of district cane analysis to an extent of about minus 0.34 per cent. of sucrose in 20 per cent. of the samples stored for the above period, and plus 1.1 per cent. sucrose in 80 per cent. of the samples. This error is not a serious one in view of the variations bound to occur in the method of taking small samples. Where paucity of staff did not admit of the full analysis of the bagasse at the time of crushing, this was preserved by the addition of a small quantity of chloroform to a previously weighed mass of bagasse enclosed in a stoppered bottle. This was found effective in checking enzymic hydrolysis of the sucrose or other fermentative changes for the period required to despatch these bagasse samples to the central laboratory at Lyallpur.

In collecting the samples, the Assistant in charge of the work supplied the following information :—

(1) Date of sampling : (2) tahsil and village : (3) name of grower : (4) date of sowing the crop : (5) class and description of cane : (6) class of soil on which the cane was growing : (7) an estimate of the canes attacked by borer or disease.

On receipt of the samples in the laboratory the analyst recorded the number of the sample, the average length of 10 canes, the average length of the internodes of 10 canes and the average thickness of the canes between the nodes.

These latter figures were collected as bearing on the growth of the cane and the effect of the season on this.

These figures will be found in the tables giving the average composition of the different types of cane grown in the district at pages 48-54 below.

## 2. The composition of the different types of canes grown for the seasons 1911-12 - 1915-16.

The examination of the district canes commenced in January 1911, and has been continued both in the district and at the Gurdaspur experimental station or both, up to the present season. The district samples were taken from selected villages throughout the Gurdaspur and Batala tahsils where the best cane is grown. For the practical purpose of the enquiry, it was very necessary for us to consider the best

<sup>1</sup> *Agri. Jour. India*, vol. XII, part II.



and average cane cultivated in the district, and for this reason we have not extended the enquiry to include the poorer canes of the Bet or of the Pathankot tahsil.

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This variety is said to have arisen from the wild "Kahi" grass, which grows in swampy lands in the submontane tracts.

The *gur* from this variety is said to keep better than *gur* of other varieties. A good crop yields 30 maunds *gur* per acre.

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- (1) Extensively grown under *barani* (rain-fed) conditions in submontane tracts, where the rainfall, though moderate, is insufficient for other varieties.
- (2) Under well and canal irrigation in the submontane tracts some distance from the hills.
- (3) In low lands along river and canal banks and on the borders of swamps, where the absence of drainage prevents other varieties from growing. In these localities *rab* is generally made, as the crop never properly ripens.
- (4) In the canal colonies in the southern districts of the Province as it withstands the hot dry climate better than other varieties.

TABLE XX.

*Dimensions of Katha cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	1,080	220	9
Average length of cane	4' 8-3"	4' 10-7"	4' 2"
Average length of internodes	3-49"	3-69"	3-3"
Average thickness of internodes	0-44"	0-45"	0-10"

TABLE XXI.

Composition of cane in the Gurdaspur District. Variety *Katha*.

Year	Month	No. of analyses for which the average has been struck	Juice per cent. (on cane)	ANALYSIS					
				Glucose	Sucrose	Total solids	Glucose ratio	Purity co-efficient	Fibre on cane
				(Per cent. in juice)			(Glucose × 100)	(Sucrose × 100)	
							Sucrose	Total solids	
1911-12	January	65	55.62	0.68	16.35	19.44	4.16	84.10	20.50
	February	29	56.38	0.51	17.71	20.23	2.31	87.41	20.23
	December	1	60.8	0.42	16.62	20.06	2.52	82.77	21.36
1912-13	January	12	61.9	1.27	16.37	19.91	7.75	82.22	20.64
	February	9	58.75	0.88	17.86	21.78	2.13	82.00	21.53
	November	1	56.24	2.80	12.75	18.80	21.96	67.81	21.31
1913-14	December	3	56.47	1.03	16.53	20.45	6.20	80.83	22.57
	January	6	54.92	1.40	15.33	19.36	9.13	79.18	20.11
	February	5	57.50	0.38	16.53	20.04	2.30	82.48	20.70
1914-15	November	1	60.3	0.26	14.29	17.47	1.84	81.8	21.63
	December	3	56.6	0.64	14.54	18.05	4.41	80.55	21.75
	January	3	60.4	0.46	15.40	18.79	3.00	81.09	21.24
	AVERAGE	138	57.98	0.85	15.86	19.58	5.36	81.02	21.13
	Highest	..	61.90	2.80	17.86	21.78	21.96	87.41	22.57
	Lowest	..	54.92	0.26	12.75	17.47	1.84	67.81	20.11

**Dhaura of Gurdaspur.**

*Local information.* Green when unripe, the cane becomes a white colour, as its name implies, on ripening. It is thicker than *Katha* and requires a better soil and a more liberal supply of water. Occasionally found under *barani* conditions but is nearly always irrigated. It ripens later than *Katha*. Leaves strip off easily. Rind is softer than *Katha*. The sets at planting time are more prone to white ant attack than those of *Katha*. This applies to all varieties in the Province. The thicker the variety the more prone to white ant attack it appears to be. The *gur* is a better colour and the sugar made from it whiter than from *Katha*. The *gur* is reported to be inferior in keeping qualities to that of *Katha*.

*Distribution.* It is confined to irrigated land in Gurdaspur and adjoining districts. Outside of that tract it is seldom found and does not appear to thrive anywhere so well as in the Gurdaspur District.

This cane and *Tereru* are occasionally found growing in Jullundar, Ludhiana and Ambala districts as mixture in crops of *Dhau* of *Phillour*. There is no difference made between them and they are both known as *Ghorru* and are disliked as they are said to yield very inferior juice.

TABLE XXII.

*Dimensions of Dhau cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	700	340	20
Average length of cane . . . . .	4' 6.2"	5' 0.5"	5' 0.5"
Average length of internodes . . . . .	2.89"	3.41"	3.27"
Average thickness of internodes . . . . .	0.52"	0.56"	0.38"

TABLE XXIII.

*Composition of cane in the Gurdaspur District. Variety Dhau.*

Year	Month	No. of analyses for which the average has been taken	Juice per cent. (on cane)	ANALYSIS					
				Glucose	Sucrose	Total solids	Purity		Fibre on cane
							Glucose Ratio x 100	Sucrose x 100	
(Per cent. In Juice)				Total solids					
1911-12	January	46	55.52	0.57	16.48	18.98	3.45	87.29	20.75
	February	25	55.54	0.41	16.11	19.03	2.54	84.65	19.37
1912-13	December	4	59.93	1.27	13.91	17.52	0.13	79.39	20.24
	January	16	61.61	0.88	15.81	18.96	5.57	83.28	19.04
1913-14	February	15	59.50	0.27	17.31	20.48	1.56	84.52	20.21
	November	2	59.80	3.36	11.25	14.85	3.00	66.77	18.16
1914-15	December	6	60.15	0.39	14.15	17.29	2.75	81.84	19.41
	January	6	57.34	1.10	13.98	17.37	7.87	80.48	20.17
1915-16	February	14	58.10	0.52	14.68	17.51	2.54	83.83	19.69
	November	1	61.1	0.41	13.87	16.63	2.04	83.40	16.82
1914-15	December	4	57.47	0.62	12.74	15.66	4.87	81.25	19.07
	January	3	62.2	0.41	14.55	17.43	2.81	83.47	19.87
1915-16	January	92	60.72	2.62	10.23	15.01	25.60	66.1	15.99
	AVERAGE	134	59.67	0.99	14.23	17.59	5.62	80.65	19.06
	Highest	..	62.20	3.36	17.31	20.48	25.60	87.29	20.75
	Lowest	..	55.52	0.27	11.25	15.01	1.56	66.77	15.99

*Teru or Tereru.*

Very like *Dhauku* of Gurdaspur, but with ivory markings. In Gurdaspur District, where it is very commonly found as a mixture in *Dhauku* of Gurdaspur, it is looked upon as a fairly good quality cane, and the presence or absence of markings is said to be a question of weather conditions. Sometimes a crop from typical *Teru* seed will in the next year show no ivory markings. On the whole *Dhauku* is preferred to *Teru* in the Gurdaspur District. In parts of Jullundar, Ludhiana and Ambala districts, it is found much less commonly as a mixture in "*Dhauku of Phillour*" crops. Generally the ivory markings are present, but occasionally they are absent, when the cane is identical with *Dhauku* of Gurdaspur. In both cases, however, the cane is known as *Ghorru* or *Ekkar* and is much disliked, as it is said to yield very inferior juice and the best cultivators discard it when they are cutting sets for seed. In the Samrala tahsil of Ludhiana District sometimes the markings are very heavy indeed.

TABLE XXIV.

*Dimensions of Teru or Tereru cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	80	30	2
Average length of cane	3' 8-4"	5' 2"	4' 10"
Average length of internodes	2-66"	3-54"	3-35"
Average thickness of internodes	0-53"	0-45"	0-49"

TABLE XXV.

*Composition of cane in the Gurdaspur District. Variety Teru (Tereru).*

Year	Month	No. of analyses for which the average has been struck	Juice per cent. (on cane)	ANALYSIS					Fibre on cane
				Glucose	Sucrose	Total solids	Glucose Ratio	Purity co-efficient	
				(Per cent. in juice)			Glucose x 100	Sucrose x 100	
1911-12	January	6	60-13	1-05	15-68	18-23	6-70	86-01	19-66
1912-13	November	1	58-31	1-37	13-32	18-20	10-28	82-22	21-78
	December	2	59-28	0-99	14-93	17-94	6-63	82-11	22-85
1913-14	January	4	58-76	0-95	15-18	18-26	6-63	83-02	19-84
	February	1	57-01	0-62	15-36	17-68	4-04	86-88	19-91
	AVERAGE	14	58-30	0-99	14-69	17-66	6-69	84-31	20-78
	Highest	..	60-13	1-37	15-68	18-20	10-28	86-88	22-85
	Lowest	..	56-76	0-62	13-32	16-20	4-04	82-11	19-66

**Kahu.**

A green cane, becoming a paler green on ripening, with broad leaves and tall growing habit. The thickest cane in the province from which *gur* is made. Requires better cultivation, better land and more irrigation than other varieties. Is subject to red rot. Ripens very late. Yields very heavily and gives *gur* and *shakkar* of very superior quality. Has a soft rind and is consequently largely used for chewing purposes. Is very susceptible to frost.

*Distribution.* As a chewing cane it is to be found widely distributed over the Province near towns. As a *gur*-making cane its cultivation is practically confined to the Gurdaspur District, where the conditions are fairly suitable in good and mild seasons.

TABLE XXVI.

*Dimensions of Kahu cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	190	190	8
Average length of cane . . . . .	4' 10"	5' 1-2"	4' 11"
Average length of internodes . . . . .	3-31"	3-01"	3-88"
Average thickness of internodes . . . . .	0-72"	0-65"	0-63"

TABLE XXVII.

*Composition of cane in the Gurdaspur District. Variety Kahu.*

Year	Month	No. of analyses for which the average has been taken	ANALYSIS						Fibre on cane
			Juice per cent. (on cane)	Glucose	Sucrose	Total solids	Glucose ratio (Glucose x 100)	Purity co-efficient (Sucrose x 100)	
								(Per cent. in juice)	
1911-12	January . . . . .	10	63-42	1-39	14-78	17-90	9-40	82-57	16-08
	February . . . . .	5	68-10	0-94	15-09	18-06	6-23	83-56	13-24
1912-13	December . . . . .	2	60-25	1-87	12-59	16-06	14-85	78-39	14-48
	January . . . . .	12	68-14	1-42	13-80	17-54	10-30	78-68	13-71
1913-14	February . . . . .	4	71-87	1-77	14-48	18-23	12-22	79-43	12-67
	November . . . . .	1	65-96	4-14	10-75	18-50	28-51	65-16	12-00
	December . . . . .	2	67-78	2-01	13-50	17-60	15-00	76-70	13-29
	January . . . . .	5	65-64	2-13	12-27	16-41	17-36	74-77	14-05
	February . . . . .	5	66-23	1-70	13-20	16-89	12-88	78-15	12-53
	AVERAGE . . . . .	46	66-15	1-93	13-38	17-24	14-42	77-61	13-55
	Highest . . . . .	..	71-87	4-14	15-09	18-23	28-51	83-56	15-09
	Lowest . . . . .	..	60-25	0-94	10-75	16-41	6-23	65-16	12-00

**Merthi.**

A tall growing thick cane. Very similar in general habit to *Kahu*.

*Distribution.* Found near towns in the tract where *Suretha* is grown, but, as it is grown only for chewing purposes and on a very small scale, is of little importance.

TABLE XXVIII.

*Dimensions of Merthi cane grown on the Gurdaspur Farm.*

	1912-13	1913-14	1914-15
Number of observations on which the figures are based	5	6	5
Average length of cane . . . . .	4' 6"	4' 6.5"	7' 0"
Average length of internodes . . . . .	3.9"	3.33"	4.00"
Average thickness of internodes . . . . .	0.09"	0.66"	0.66"

TABLE XXIX.

*Composition of cane on the Gurdaspur Farm. Variety Merthi.*

Year	Month	No. of analyses for which the average has been taken	ANALYSIS						
			Juice-per cent. (on cane)	Glucose (Per cent. in juice)	Sucrose (Per cent. in juice)	Total solids	Glucose Ratio	Purity co-efficient	Fibre on cane
1912-13	December . . . . .	1	67.4	2.15	12.53	17.32	17.15	72.36	13.04
	January . . . . .	2	69.2	2.02	13.96	18.20	18.77	76.70	13.46
	February . . . . .	2	71.46	2.66	15.81	17.41	16.82	90.82	12.45
1913-14	December . . . . .	2	68.03	2.68	13.21	18.24	20.30	72.42	12.08
	January . . . . .	2	66.30	2.12	14.15	17.54	14.98	89.67	12.56
	February . . . . .	2	62.82	1.04	16.74	18.50	6.21	90.48	14.64
1914-15	November . . . . .	1	60.3	2.32	8.51	12.51	27.22	68.00	16.34
	December . . . . .	2	67.3	2.38	8.61	12.74	27.40	67.60	11.76
	January . . . . .	1	69.4	1.38	12.98	16.34	10.71	79.1	13.31
	February . . . . .	1	68.9	1.35	15.14	16.34	10.27	80.4	13.06
	AVERAGE . . . . .	16	67.72	2.17	12.96	16.51	16.74	78.5	13.27
Highest . . . . .	..	71.45	2.68	16.74	18.50	27.40	90.82	16.34	
Lowest . . . . .	..	62.82	1.04	8.51	12.51	6.21	67.60	11.76	

**Kansar.**

*Local information.* A tall growing thick red cane of the *Katha* type, approaching the thickness of *Suretha*. Requires good land and more abundant water supply than *Dhau* of Gurdaspur or Phillour. It ripens late but yields heavily. A good crop is 40 maunds *gur* per acre of excellent quality.

*Distribution.* Most extensively grown in the submontane tracts where the water supply and land are specially good. Large areas under this cane are grown on canal-irrigated land in the Batala tahsil of the Gurdaspur District where it is known as *Kahu Katha*. It is also found in the submontane tahsils of Jullundar and Ludhiana districts, where it is known by the names of *Dag Chan* and *Masingen*. Has been seen growing as far south as the Chenab Colony, but this is exceptional. Dries up and becomes pithy in centre unless the water supply is very good.

TABLE XXX.

*Dimensions of Kansar cane grown in the Gurdaspur District.*

	1911-12	1912-13	1913-14
Number of observations on which the following figures are based.	240	170	5
Average length of cane . . . . .	5' 6.3"	5' 0.9 "	4' 5"
Average length of internodes . . . . .	4.15"	4.32"	3.8"
Average thickness of internodes . . . . .	0.60"	0.65"	0.59"

TABLE XXXI.

*Composition of cane in the Gurdaspur District. Variety Kansar and Katha Kahu.*

Year	Month	No. of analyses for which the average has been struck	ANALYSIS						
			Juice per cent. (on cane)	Glucose	Sucrose	Total solids	Glucose Ratio	Purity co-efficient	Fibre on cane
			(Per cent. in juice)						
1911-12	January . . . . .	15	58.48	0.60	18.67	19.51	3.60	65.40	19.75
	February . . . . .	5	57.00	0.77	17.53	20.01	4.41	67.60	21.18
	December . . . . .	1	63.40	0.63	16.08	19.10	3.91	64.37	not analysed.
1912-13	January . . . . .	8	64.54	0.99	15.96	19.32	6.20	62.60	19.19
	February . . . . .	7	65.37	0.77	17.06	21.22	4.51	69.40	18.47
	November . . . . .	1	63.68	2.71	14.05	19.00	19.30	73.04	14.84
1913-14	December . . . . .	1	62.72	1.48	14.95	18.65	9.90	69.19	23.63
	January . . . . .	5	59.61	1.57	12.75	19.26	12.31	66.20	18.28
	February . . . . .	3	62.40	1.02	17.37	20.54	5.87	64.56	19.82
1914-15	November . . . . .	1	61.5	1.20	9.83	14.34	12.20	69.50	21.70
	December . . . . .	2	60.45	0.61	12.21	18.06	5.00	76.63	18.94
	January . . . . .	2	62.65	0.54	13.04	17.61	4.14	74.95	19.50
	AVERAGE . . . . .	51	61.82	1.07	14.80	19.05	7.23	77.69	17.94
	Highest . . . . .	..	65.37	1.57	17.53	21.22	19.30	67.60	23.63
Lowest . . . . .	..	57.00	0.54	9.83	14.34	3.60	66.20	14.84	

### 3. Climatic effect on the composition of the cane juice.

An Indian crop report is always prefixed by an account of the season under review, and in a country where so much depends on the character of the summer rains, the variations introduced into the area under crop and the crop outturn by this climatic factor are extremely wide. Irrigation canals and railways have to a large extent eliminated the famines which in bygone days devastated portions of the country when the rains failed, but the simile of a shower of rain to a shower of gold still holds for North India.

Where the cane is grown under *barani* conditions, that is by rainfall alone, the crop is directly under the weather. Where the rainfall is augmented by well or canal irrigation, climatic variation can be to a large extent neutralized. In a dry hot climate like that of North India, it is very doubtful if irrigation—useful as it is—can adequately replace rain, for one has only to pass through a growing crop after rain to see the difference between its effect and that of irrigation at the same time of the year when the weather is dry. In Hawaii<sup>1</sup> it is stated that young cane requires irrigation water at the rate of  $\frac{1}{2}$ " per watering, as it gets well above ground it requires about 1 inch up to 3 or 4 months, after which it requires 1.5 inches until fully grown, when waterings 3 inches in depth are necessary. This is in a climate where the air is warm and moist and rain falls every month.

We have no such figures available for Gurdaspur, and all that can be said here is that in a dry season the cane shows very uneven growth and the system of irrigation by canal is not elastic enough at present to enable the cane grower to adjust his water supply to the crop requirements. Where irrigation from wells is practised, the water supply is more under the direct control of the farmer, but here again he is limited by the cattle at his disposal. In a dry season the crop requires much more water than in one of normal rainfall, for more water is lost by transpiration. To what extent these vary, we do not at present know. It is evident, therefore, that under the best prevailing conditions cane in the Gurdaspur District is very dependent on the summer rains. Any improvement in the elasticity of water distribution during April, May and June will be of help to the cane grower there, and so also will be any improvement in the water yield of the wells and in water-lifting methods. These latter points are receiving the special attention of the Agricultural Department at the present time and the introduction of tube wells and mechanical well lifts gives promise of excellent results.

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<sup>1</sup> Noel Deerr *loc. cit.*



But the cane crop in this district has to face other vicissitudes of climate besides variation in rainfall. Temperature also plays an important part. The cane season commences with sowing in the latter half of March, and the crop is reaped during the following December and January, but the amount of cane remaining uncut at that time is not very great. One of the peculiar practices of cane growing in Gurdaspur is the care exercised by the farmer to preserve his seed. If the winter is mild, the seed cane is left standing in the field. This seldom happens however. For the most part at the first signs of frost he cuts and buries his seed cane, otherwise the seed is spoiled.

A comparison between the seasons of 1911-12 and 1912-13 shows that more rain fell in July, August and September in 1912 and less in October, November and December than in 1911. In spite of the fact that the 1912 rainfall was some 4" below the average, it was on the whole a better season for cane, for not only was more rain received during the growing of the crop but warm dry weather prevailed during the latter part of the ripening period. In spite of the apparent better season and the more even growth and better appearance of the 1912-13 crop, the average glucose content of the canes was higher, and the sucrose and purity co-efficient lower than in the preceding season of 1911-12. The principal reason for this appears to be a period of frost to which the former crop was subjected in January 1913 which lowered the purity co-efficient of the juice for 2 weeks out of a total of 9 weeks during which the canes were under chemical examination. A close study of the figures reveals the fact that the drier winter of 1912 gave a riper cane than was obtained in 1911, and the crop would have been better all round but for this frosty period.

We shall probably find, as experience is gained, that the district is always subject to this reverse, and even in a good cane season like 1912 when a ripe cane showing even development has been grown, it will still have to face the cold of winter. In this connection a comparison between the Gurdaspur and Lyallpur canes in 1912 is of interest. This is shown in the following table.

TABLE XXXII.

Table showing the highest, lowest and average analyses of all canes examined at Gurdaspur and Lyallpur Stations in 1912-13.

	Glucose (per cent)	Sucrose on juice)	Purity co-efficient of juice	Fibre per cent. on cane
<i>Gurdaspur District.</i>				
Highest . . . . .	2.81	19.25	94.13	27.97
Lowest . . . . .	0.09	6.91	60.09	9.51
Average (on 76 samples) . . . . .	0.72	16.16	82.80	19.44
<i>Gurdaspur Farm.</i>				
Highest . . . . .	4.56	19.53	89.58	23.23
Lowest . . . . .	0.04	7.13	53.40	6.72
Average (on 105 samples) . . . . .	1.24	15.13	79.30	18.92
<i>Lyallpur Farm.</i>				
Highest . . . . .	0.95	18.95	90.5	25.85
Lowest . . . . .	0.04	12.60	74.10	11.22
Average (on 43 samples) . . . . .	0.20	15.05	82.30	20.64

In this table are shown the highest, lowest and average analyses of all canes examined at the two stations in 1912-13. From this it will be seen that the sucrose content of the best canes at Lyallpur approximates very closely to the best canes of Gurdaspur, while the worst Lyallpur canes are markedly superior to the worst in Gurdaspur. A comparison of the glucose and purity co-efficient figures shows that here again the advantage lies with Lyallpur. This not only indicates the climatic disadvantages of Gurdaspur, but emphasizes the desirability of even watering for successful cane cultivation, for we have to take into account in this comparison the marked inferiority of the Lyallpur soils to the best soils of Gurdaspur for cane cultivation and of irrigation to natural rainfall.

The ripeness of cane is judged by the ratio of sugar or sucrose to invert sugars calculated as glucose. In unripe cane there is but little sucrose and a comparatively large quantity of glucose sugars. The *glucose ratio* by which the ripeness can be gauged if we are dealing with a known cane is given by  $\frac{\text{glucose per cent.} \times 100}{\text{sucrose per cent.}}$ . In unripe cane, therefore, the *glucose ratio* is high.

As the cane ripens, the *glucose ratio* falls, and at the same time the total solids in the juice and the sucrose increase, while the amount of

invert sugars diminishes. Both grower and manufacturer aim at producing sucrose, as the other sugars, while of some commercial importance as molasses and for spirit making, are waste products so far as the making of dry marketable sugar is concerned.

In 1913 there was a fall in temperature at Gurdaspur; frosty nights prevailing from the 6th to 20th January. A large number of canes grown on the Government farm were, therefore, periodically analysed to watch the effects of this fall in temperature on the sugar contents of the juice. The following summarized results were obtained:—

- (a) There was no marked change in the amount of juice extractable by the Nahan mill as the season advanced between the limits of the experiment, December 15th to February 20th.
- (b) In all cases there was a steady increase in the total solids of the juice *and this increase was unaffected by frost.*
- (c) In most cases there was a steady fall in the invert sugars of the juice, except where the cane was affected by frost, when there was in all cases an increase in the invert sugars.
- (d) In all cases there was an increase in the sucrose content of the juice, except where the cane was affected by frost, when there was usually a decrease in the sucrose contents of the juice, either during or immediately after the frosty period.
- (e) The *glucose ratio*<sup>1</sup> and *purity co-efficient*<sup>2</sup> are both detrimentally affected by frost, but to a different extent in the different varieties of cane.

The cane varieties were classified in order of merit according to their resistance to the effect of cold, and divided into the following four groups:—

- (i) *Frost-resistant* (unaffected, or almost unaffected, by cold).
- (ii) *Semi-resistant to frost, A* (i.e., slowly affected by cold).
- (iii) *Semi-resistant to frost, B* (i.e., quickly affected by cold but quickly recovering from its effect).
- (iv) *Non-resistant* (i.e., quickly affected by cold and slowly recovering).

The canes of the district according to this classification fell into the following groups:—

$$^1 \text{ Glucose ratio} = \frac{\text{glucose per cent.} \times 100}{\text{sucrose per cent.}}$$

$$^2 \text{ Purity co-efficient} = \frac{\text{sucrose per cent.} \times 100}{\text{total solids per cent.}}$$

TABLE XXXIII.

*Classification of district canes according to the effect of cold upon the composition of the juice during season 1912-13.*

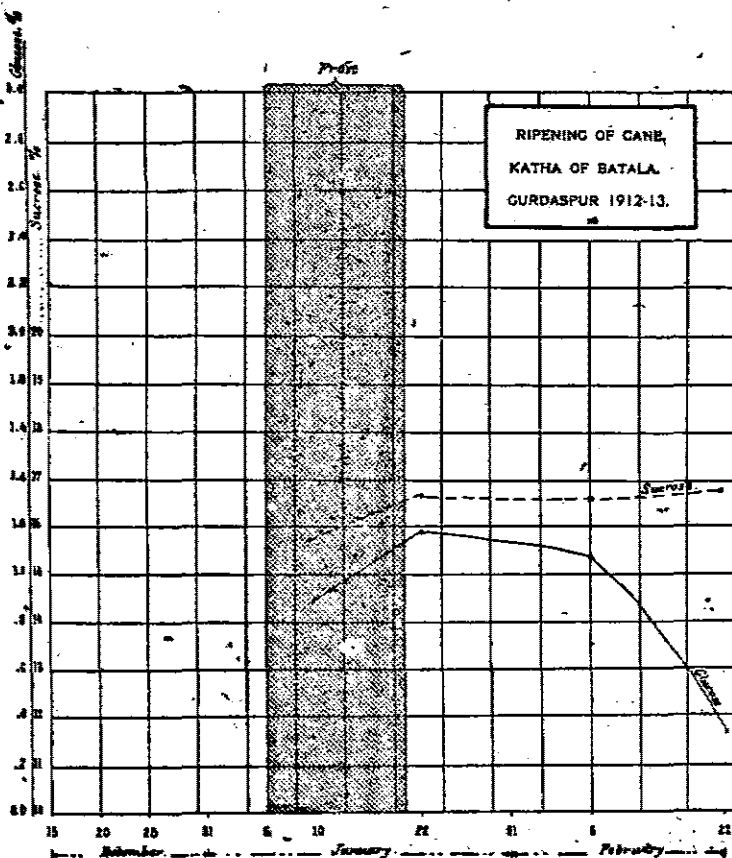
Frost-resistant	Semi-resistant to frost, A	Semi-resistant to frost, B	Non-resistant
1. Katha of Batala	2. Tereru of Batala 3. Kansar of Batala 4. Merthi	5. Kahu 6. Dhaulu	

The analytical results obtained in the case of the above varieties are given in graphic form in the following diagrams :—

DIAGRAM I.

*Effect of cold on the chemical composition of cane juice.*

*Type 1.—Frost-resistant*



The enquiry was continued in 1913-14 and 1914-15.

In the season 1913-14, the periods of extreme cold were more intermittent than in 1912-13. Frosty periods occurred from December 26th to December 30th, January 9th, January 22nd to 26th, January 31st and February 9th, while in the season 1914-15 a long cold period occurred in December (December 14—24), January 4—6th, January 13th to 16th, making the season a more severe one.

The district canes were classified according to the above method as follows :—

TABLE XXXIV.

*Classification of district canes according to the effect of cold upon the composition of the juice.*

Frost-resistant I	Semi-resistant to frost, A 4I	Semi-resistant to frost, B III	Non-resistant IV
	<i>Season 1913-14.</i>		
Tereru . . . . .	Katha . . . . .	..	Kahu
Dhauhu . . . . .	Kansar . . . . .		
Merthi . . . . .	Bodi . . . . .		
	<i>Season 1914-15.</i>		
Kanara . . . . .	Katha . . . . .		
Bodi . . . . .	Kansar . . . . .		
Merthi . . . . .			
Katha (Sept. sown)			
Dhauhu ( " )			

Besides the local canes, this enquiry was extended to include a large number of foreign varieties and the results obtained are in preparation for publication : where the whole question of climatic effect will be more fully dealt with.

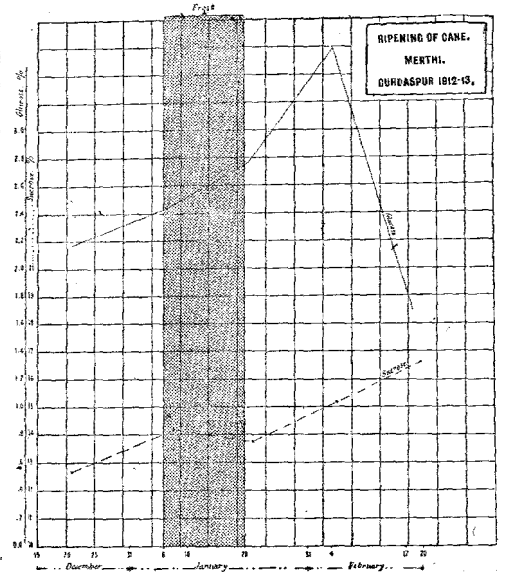
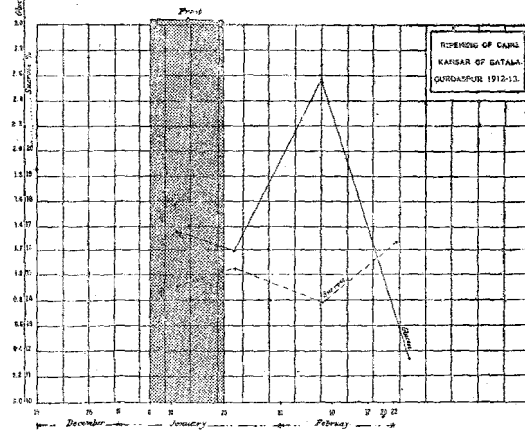
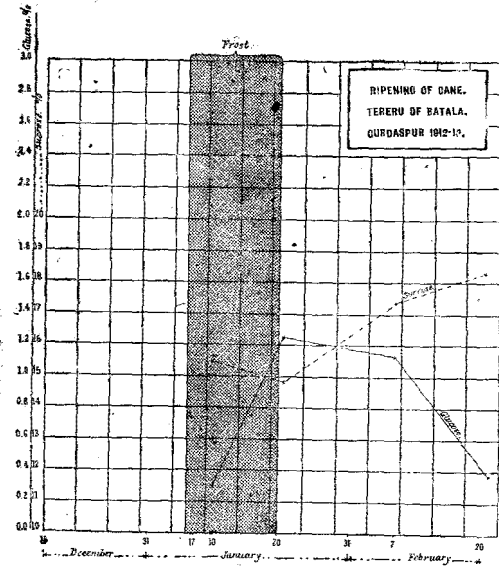
These results are of particular importance. They give us at once a key to the sugar problem in the Punjab. No matter how far we may improve cane cultivation by improved methods of tillage or by artificially enriching the soil or how far we supply the natural deficiency of water, we are still faced with this climatic factor of cold which bars the way to progress. There is one narrow opening left in this barrier and that is the selection of an improved variety of cane which is almost or entirely unaffected by the cold to which it will be subjected.

There can be little doubt that the local varieties, such as *Katha*, *Dhauhu*, *Tereru*, etc., have become hardy through long exposure to a severe climate. We do not yet know the types of cane from which these have sprung, but from existing practices in the Southern Punjab where

## DIAGRAM II.

*Effect of cold on the chemical composition of cane juice.*

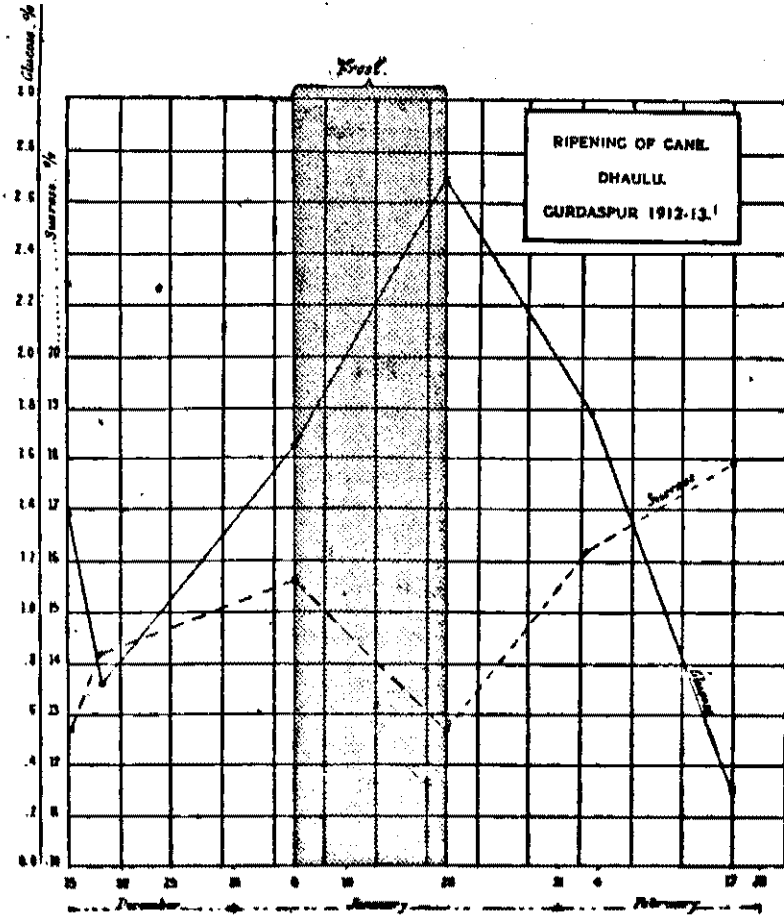
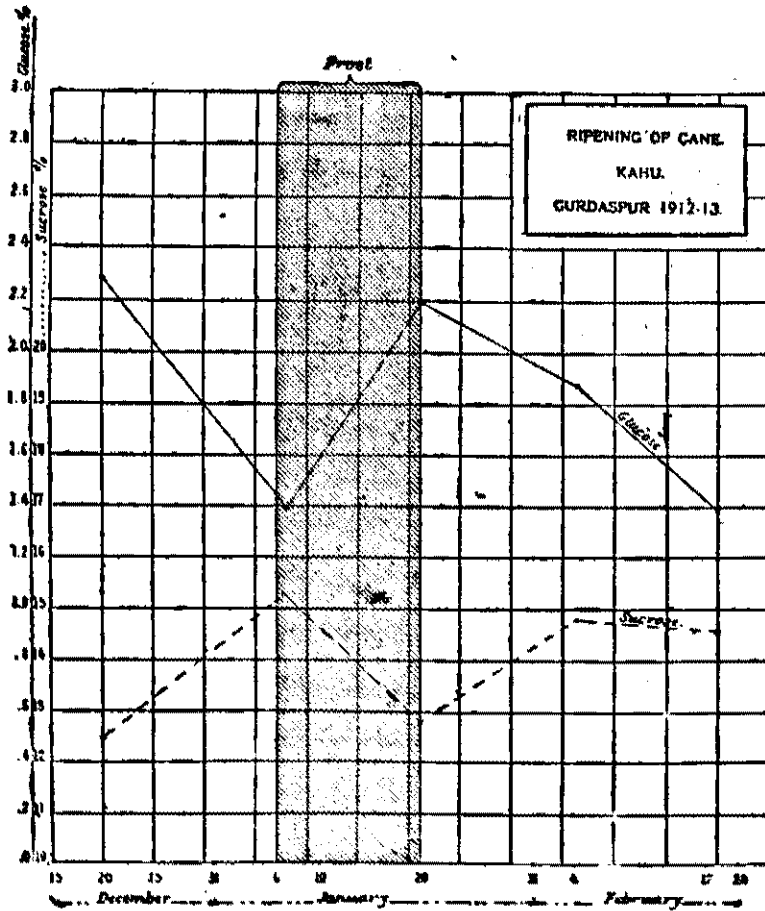
*Type 2.—Semi-resistant to frost A.*



### DIAGRAM III.

*Effect of cold on the chemical composition of cane juice.*

*Type 3.—Semi-resistant to frost B.*



the cultivators are in the habit of bringing up seed canes from further south in the United Provinces, it seems most probable that cane cultivation in the eastern portion of the peninsula originated towards the lower end of the Ganges and spread gradually north-west into the regions of greater cold. Within comparatively recent times, *Kahu*—a thick juicy cane—has been introduced into the district from the south and is evidently not yet acclimatized. The out-turns obtained in a good year, however, render this variety attractive to the cultivators who have been accustomed to hard canes of the *Katha* type, and the farmers say that though they may lose the entire crop of *Kahu* every third or fourth year, the gain in the good years recompenses them for the losses so sustained.

✓ For a discussion on the origin of sugar cane, reference may be made to Barber.<sup>1</sup>

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<sup>1</sup> Barber, C. A., "Studies in Indian Sugarcane, No. I." *Mem., Dept. of Agri., India, Bot. Ser.*, vol. VII, no. 1, introduction pages 1—5.



## CHAPTER IV.

### THE SUGAR TRADE IN THE DISTRICT.

#### 1. Total production from Gurdaspur and other districts of the Province.

I shall not attempt to deal with the sugar trade of the Gurdaspur District in anything like a comprehensive manner, for the whole problem of the Indian sugar trade has been fully discussed by Noel Paton<sup>1</sup> and the factors there set out as ruling the importation of foreign sugar into a sugar-producing country like India apply equally to the provincial or even the district problem. In a few words, these are the low cost of production in the countries exporting sugar to India as compared with the cost of production of sugar in India itself, and the ruling factors in the cost of production are yield per acre of sugar and the prevention of waste in manufacture.

In the following table I have given the area under cane for the whole of the district of Gurdaspur, as well as that produced in each tahsil for the past thirteen years as compared with that of the whole Punjab.

TABLE XXXV.

*Showing the area in acres under cane for the whole of the district of Gurdaspur as well as that produced in each tahsil for the past 13 years as compared with that of the whole Punjab.*

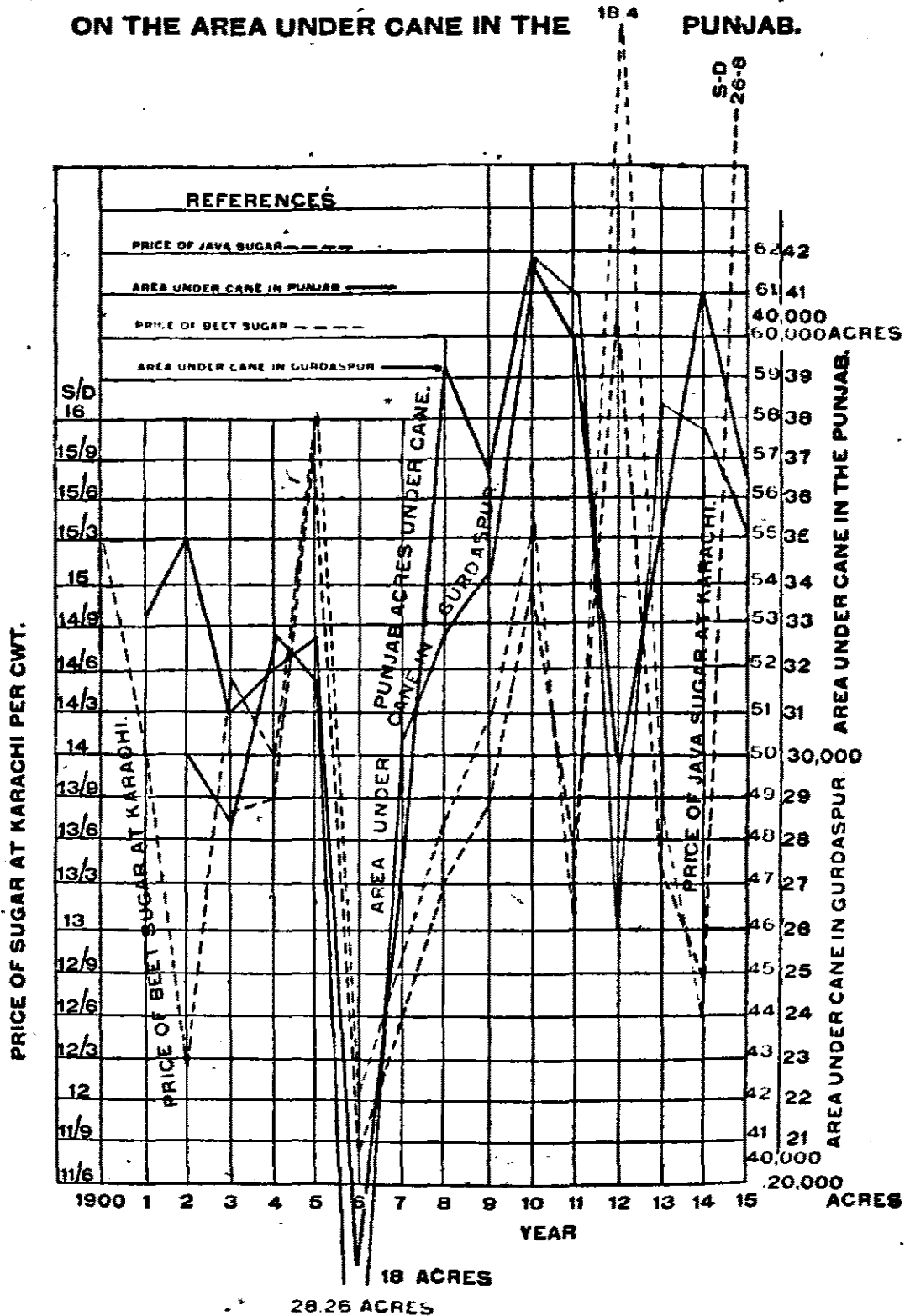
Years	TAHSILS				Total for the whole district	Total area for the whole Punjab
	Gurdaspur	Batala	Shakar-garh	Pathan-kot		
1901 . . .	16,783	18,192	9,969	4,973	49,917	334,500
1902 . . .	17,766	15,660	9,929	4,876	48,231	351,500
1903 . . .	17,552	18,366	11,500	5,194	52,612	309,400
1904 . . .	16,729	17,154	12,737	4,970	51,590	321,200
1905 . . .	9,149	6,283	10,070	2,758	28,260	325,500
1906 . . .	16,913	15,399	11,648	4,195	48,155	172,700
1907 . . .	15,662	17,182	9,835	4,323	47,002	277,700
1908 . . .	18,591	17,702	8,974	5,015	50,282	391,800
1909 . . .	21,714	19,801	13,073	5,278	59,866	365,700
1910 . . .	20,188	19,614	12,534	4,799	57,135	411,700
1911 . . .	13,556	14,887	8,613	3,169	40,225	387,900
1912 . . .	18,604	20,803	9,220	4,660	53,287	284,800
1913 . . .	20,314	19,889	9,665	4,613	54,481	360,400

<sup>1</sup> Notes on Sugar in India." Government Printing, India, Calcutta.

DIAGRAM IV.

INFLUENCE OF IMPORTED SUGAR

ON THE AREA UNDER CANE IN THE PUNJAB.



This table shows that a considerable variation takes place from year to year in the acreage under cane, not in *barani* tracts alone but also in the land under irrigation. There is, if anything, a greater uniformity in the area under *barani* cultivation, which is contrary to expectation based on the assumption that climatic variations in rainfall influence the areasown (Compare Table 1, Chapter 1, page 2, rainfall in the Gurdaspur District). We must look elsewhere, therefore, for an explanation of these variations.

During a period of ten years, 1906 to 1915, there was a variation of 28 per cent. from the normal in the area under cane in Gurdaspur, the lowest in 1911-12 being 16 per cent. below the average, and the highest in 1909-10 being 12 per cent. above the average.

Compared with that of the whole Punjab, the highest figure for the area under cane was also in 1909-10, when it was 13.7 above the average: the lowest recorded figure being in 1906-07 when it was 23 per cent. below. Next to this in the Punjab figures comes 1911-12, when the average was 18 per cent. below normal. These figures are more intelligible when cast into graphic form.

In the diagram opposite I have not only shown the area under cane, but have, as far as figures are available, included in it the average Karachi prices for beet and Java sugars.

## 2. Influence of imported beet sugar on cane cultivation in the Punjab.

As we should expect, the Karachi prices for imported sugar rise and fall with the area under cane, this being evidently a case of supply and demand; the two naturally react upon each other. So far as India alone is concerned, we may regard her demands for sugar as steadily on the increase both because of her growing population and because of her increased prosperity. The area under cane should, therefore, increase, or else if any limit has been set to this by climate, soil, or labour, the yield per acre and the efficiency of the methods of manufacture in vogue should show improvement.

It is true that the substitution of the bullock-driven iron mill has made an advance over the old wooden *belna* in the efficiency of juice extraction, but such a minor improvement is almost negligible when set against the mighty improvements effected in the mechanical methods of sugar extraction in use elsewhere. An examination of the figures shows that in the Punjab the area under cane has not materially increased during the past thirty years or so, for the area in 1884-85 was 335,454 acres, while the average for the past nine years has been 366,779 acres,

and during the latter period has frequently fallen below that of 1884. The area for the whole of India on the other hand has shown an increase. So far as can be gathered from the figures available, this increase has taken place for the most part in the United Provinces. In spite of the increased production which this increase of area under cane indicates, the ratio  $\frac{\text{export}}{\text{import}}$  has diminished in every province in the country. During the ten years preceding 1910, there was an almost steady decline in the total area under cane throughout India, which, Noel Paton calculates, was equivalent to a decreased output of 40,800 tons of potential sugar. During this period the imports had risen by 397,000 tons. At the same time the price of imported sugar has fallen from Rs. 10.1 per cwt. in 1899-1900 to Rs. 8.83 per cwt. in 1909-10, while the price of *gur* at Cawnpore has risen from Rs. 5.37 to Rs. 6.75 per cwt., and the declared export value of Madras jaggery from Rs. 4.78 to Rs. 5.4. There is only one feasible explanation for these figures, and this is that imported sugar is either regulating or helping largely to regulate the area under cane in India, for Noel Paton has shown that in the United Provinces, which produces over 50 per cent. of the reported sugar in India, the area under cane has during the ten years following 1900 contracted by some 90,000 acres, while the area under other crops had increased by nearly two millions (or 5.6 per cent. of the whole).

Turning now to the Punjab and especially to Gurdaspur, we see in the diagram given above in graphic form the rise and fall of area under cane and the prices of imported sugar at Karachi, the port for North India.

Any comparison of rainfall figures is difficult as they vary from place to place. The total rainfall for Gurdaspur itself showed a steady increase from 1908 until 1910 and a decrease from 1910 to 1913. The rainfall of any one year cannot, however, affect the area under cane for that year because sowing takes place in the spring, and the bulk of the rain falls in the months of July and August. Its effect, however, is either to improve the conditions and out-turn of the existing summer crops, or to admit of a large area of *barani* cane being sown *the following summer*. We have seen, however, that the *barani* cane area is far more uniform than is that under irrigation. The principal effect of good summer rains then is on the late sown summer and winter crops. *It does not affect the area under cane* except in an indirect manner, *viz.*, the general prosperity of the agricultural classes and a rise in demand and in the price paid for sugar.

If imported sugar can be sold in the bazaars of Northern India cheaper than an indigenous article of equal purity, this is bound to contract the area under cane there to the extent to which the imported article

can replace the natural product. If we compare the value of European beet sugar with East Indian cane sugar imported into India, we see that previous to 1900, beet sugar was commanding a higher price at the western ports than imported cane sugar. This cane sugar came principally from Mauritius. By 1903 Java sugar was competing and selling at a lower price than beet. Since then these two classes have been in competition with the balance in favour of the Java sugar.

Noel Paton sets forth in a very clear manner the strengthening effect of the Austrian cartel on the foreign sugar trade of that country, and the similarly stimulating effect of its imitation by Germany.

At certain periods the Indian import sugar market has been in the hands of a particular producing country. The above quoted prices for beet sugar at Karachi show that, up to the appearance of Java sugar there, the imports were for the most part beet sugar.

The appearance of Java sugar in 1903 introduced a competition, which from the outset has apparently always been able to undersell beet. This is borne out in the figures given for the average annual prices of beet and Mauritius sugar at Bombay, namely, that at the Western Indian ports imported cane sugar can always undersell beet. Between the years 1898 and 1907 the greater part of the sugar imported into Karachi was beet, which for the most part came from Austria-Hungary. By 1908 the imports for cane sugar had grown until the amount exceeded the beet imports. From this it appears that beet sugar sets the price of this article at Karachi and that this price is so favourable that Java sugars can compete in comfort, and are gradually claiming the bulk of the market there. Diagram IV opposite page 63, indicates that the fluctuations in the area under cane in the Punjab as well as in the Gurdaspur District are the result of fluctuations in the imports and prices of foreign sugar—both beet and cane—or in other words *between certain limits*—the limits mentioned on pages 64, and 92-95—*the area under cane in the Gurdaspur District is regulated by the amount and price of imported refined sugar*. This is an important deduction: it shows the precarious nature of the sugar trade in the district, and leads us at once to consider in what manner this external influence may be controlled. The first and what appears the simplest solution, the solution suggested by all previous students of this problem, is to increase and improve the indigenous industry until foreign sugar can no longer compete. I venture to suggest, however, that this may not prove to be economically possible in North India, either now or in the future, and we may have to achieve the result in a somewhat different manner. The facts upon which we have to base our reasoning are, firstly, that foreign sugar can be produced at such a low cost abroad—cane sugar in Java and Mauritius

and beet sugar in Austria-Hungary and Germany—that their excess products can pay freighting into India and to the Indian markets and still undersell the Indian sugar. On the other hand, we have seen the difficulties in the way of improving the cultivation of cane in the Gurdaspur District, and to what extent the climate and conditions there hinder the growth of this crop. I shall refer in the next chapter to the crops now in competition with cane in Gurdaspur. In Egypt, it has been found that cane cannot compete with cotton in Lower Egypt and the Delta, and an existing industry complete with factories and an established cane cultivation had to retire further south when the value of Egyptian cotton became known to the manufacturing world. A comparative study of the history of sugar growing and refining in Egypt is of the greatest interest and importance when considering the problem of cane cultivation in North-West India. The climate here, while unsuited for the growth of high quality cane, is admirably adapted for cotton. *Prima facie*, therefore, cotton can be improved more easily and with more certainty than can the sugarcane, and we have the example of the industry in Egypt to point the argument that even under climatic conditions equally suitable to either crop, cotton proved to be the stronger. Now the markets for Egyptian cotton are the best on the continent of Europe and in Lancashire, while the market for Egyptian sugar is in Egypt itself.

Indian cotton of the best quality will have to compete in the same markets at any rate for many years to come. It must, therefore, be produced at a lower cost as well as of high quality, if it is to pay the extra freighting and canal dues which it will have to do before it reaches the manufacturer. Such a policy is based on broader lines than the improvement of one crop. We not only aim at raising the out-turn of raw products in the country, but, what is of greater importance still, to the happiness and welfare of India, we must aim at increasing the individual comforts of her inhabitants by increasing their spending power. There has been much foolish talk about the policy of agricultural improvement being to make two blades of grass grow where only one grew before. We can achieve this by intensive cultivation but this does not always result in improving the prosperity and happiness of the classes engaged in agriculture as we can see at a glance if we compare the conditions existing in the congested districts of the Ganges valley with, say, the free farmers of Australia, of the veldt, of the pampas, or even of the canal colonies in North India. The ideal agricultural policy is to lower the cost of production so that one man can produce with less bodily labour and at less cost what it previously took two or more men to accomplish. Competition will then regulate the increase of out-turn

of raw produce. If this is accepted, then the climatic factor becomes more and more important and we shall float with the stream rather than row against it.

It does not follow from this that the Punjab must abandon its existing cane industry forthwith and be content to purchase sugar from abroad. India is a big country and there are many places in it where the sugarcane finds a natural home. It is in these places where the cane naturally flourishes that efforts should be made to secure that portion of the Indian market which is or has been up to recently in the possession of the manufacturers of Java, of Austria-Hungary, or of Germany. It is possible to find parts of India where Indian sugar can be produced at a less cost than the price at which foreign sugar has to be sold in India, and it is to the sugar zones in India that Government attention should first be directed in any efforts which may be made to improve this industry and render it independent of foreign influence. As for the existing sugar industry in the Gurdaspur District, and that similarly existing in other parts of the Punjab, we should for the time being limit the effort and money devoted to improving it to checking waste in the existing processes of crushing and boiling, to introducing better canes selected specially with reference to their adaptability to the rigorous climate of Northern India, and to improving the cultivation and yielding power of the land. Apart from this, we should concentrate the main attention of the Agricultural Department in improving those crops more particularly suited to the climate and soil and for which there is a large and growing foreign demand such as cotton, wheat, oilseeds, pulses, etc. The future of the cane industry so far as Northern India is concerned, can be safely left to competition. Southern, Central and Western India will in the course of time produce all the sugar required in Northern India in exchange for the commodities grown there, and at a less cost than it can be produced in the Punjab. Under such natural and healthy competition, cane, which is to be regarded as foreign to the Punjab, will gradually be replaced by other and more remunerative crops. The present high value of cane in Northern India is anomalous. The industry established itself in the days when India possessed no means of inter-communication save roads and those of the worst description and it derives support to-day largely from a sentimental regard for raw country sugar on the part of a portion of the Indian public, and from the fact that sugar boiling provides the farmers with a very pleasant occupation at a cold and idle part of the farming year. This is borne out by an examination of the trade figures for sugar products within the district itself. Gurdaspur is, as we have already stated, the largest producer and grower of sugar in the Province; we should, therefore, naturally expect to find

that there is a large amount of sugar exported from the district and little or no sugar beyond refined sugar imported from outside.

### 3. Exports of sugar products.

In Table XXXVI I have given a copy of figures supplied by the North-Western Railway for the outward land sugar traffic as booked at the various stations on the Amritsar-Pathankot line, which runs through the whole length of the district. From the table, it will be noticed that the bulk of the trade lies in the Gurdaspur and Batala tahsils, the latter predominating.

TABLE XXXVI.

*Showing the outward traffic (in maunds) of sugar booked from North-Western Railway stations in the Gurdaspur District for the years 1911 to 1914.*

Name of station	1911-12			1912-13			1913-14		
	Refined sugar	Raw sugar	Gur, rab, or molasses	Refined sugar	Raw sugar	Gur, rab, or molasses	Refined sugar	Raw sugar	Gur, rab, or molasses
Pathankot . . . . .	205	244	549	16	748	426	8	507	705
Sarna . . . . .	..	24	159	..	14	11	2	18	101
Jakhlan . . . . .	..	..	..	..	..	..	..	..	..
Permanand . . . . .	..	..	..	..	..	..	..	..	..
Dina Nagar . . . . .	195	281	3,236	..	194	1,179	4	108	1,768
Sohal . . . . .	..	1,451	6,367	..	781	5,520	..	902	9,584
Dhariwal . . . . .	204	777	5,471	..	1,020	2,435	4	772	4,873
Gurdaspur . . . . .	111	3,358	37,005	..	6,011	35,947	43	5,244	47,277
Batala . . . . .	298	14,444	143,013	14	46,656	106,900	6,523	25,950	155,077
<b>TOTAL . . . . .</b>	<b>1,008</b>	<b>20,579</b>	<b>200,800</b>	<b>30</b>	<b>55,424</b>	<b>152,623</b>	<b>6,569</b>	<b>33,601</b>	<b>219,275</b>

### 4. Nature of sugar imports.

In Table XXXVII are given the recorded imports of sugar and *gur* for the years 1903 to 1912 compiled from Government records in the office of the Deputy Commissioner, Gurdaspur.



TABLE XXXVII.

Statement showing the imports (in maunds) of sugar and gur for the years 1903-04 and 1911-12.

Year	BY RAIL			BY RIVER			BY RAIL	BY RIVER	Total of Gur, rab, etc.	GRAND TOTAL
	Refined	Unrefined	Total	Refined	Unrefined	Total	Gur, rab, etc.	Gur, rab, etc.		
1903-04 . . . . .	13,40,562	6,77,877	20,18,439	10,420	..	10,420	10,59,279	..	10,59,279	30,07,138
1904-05 . . . . .	12,01,953	8,09,514	20,11,467	20,830	..	20,830	10,79,156	..	10,79,156	31,11,453
1905-06 . . . . .	21,60,086	8,42,119	30,02,205	25,820	..	25,820	24,57,726	..	24,57,726	54,85,751
1906-07 . . . . .	22,65,050	8,83,845	31,48,895	20,020	..	20,020	18,05,560	..	18,05,560	44,83,475
1907-08 . . . . .	23,25,050	8,78,097	31,98,147	41,340	..	41,340	18,75,780	..	18,75,780	46,15,267
1908-09 . . . . .	20,55,712	7,84,706	28,40,418	38,960	..	38,960	18,62,069	..	18,62,069	42,41,447
1909-10 . . . . .	19,98,285	10,21,230	30,19,515	42,180	..	42,180	12,84,767	..	12,84,767	43,46,462
1910-11 . . . . .	24,90,640	8,47,100	33,37,740	36,950	..	36,950	11,82,846	..	11,82,846	45,57,596
1911-12 . . . . .	19,12,098	15,43,674	34,55,772	34,230	..	34,230	17,87,196	..	17,87,196	52,77,798

SUGAR AND SUGARCANE IN THE GURDASPUR DISTRICT

The very large amount of imported sugar varying from 30 to over 50 lakhs of maunds of sugar is evidently very largely in excess of the sugar exported. That is to say, that in this, the largest sugar-producing district of the Punjab, the consumption of sugar is largely in excess of the production. This is very interesting because it indicates in yet another manner that the industry is decaying because it is not keeping pace with the growing demand for sugar.

Examining this trade in rather more detail, we find that in the year 1885 (*Assessment Report of the Gurdaspur District* by L. Dane, 1890) the export of sugar was considerably in excess of the imports, and that in the five years following the ratio of  $\frac{\text{Import}}{\text{Export}}$  gradually increased. The importation of sugar into Gurdaspur at that time was probably the result of better trade conditions for sugar there than in the adjoining districts.

TABLE XXXVIII.

*Rail-borne traffic for the carriage of sugar through the Gurdaspur District in the year 1885 (Assessment Report, 1890, by L. Dane).*

Tahsil	EXPORT		IMPORT	
	Quantity in maunds	Value (rupees)	Quantity in maunds	Value (rupees)
Gurdaspur . . . . .	70,700	1,76,750	1,092	2,730
Batala . . . . .	99,540	3,31,800	4,650	15,500
Pathankot . . . . .	3,780	9,450	1,344	3,360
Shakargarh . . . . .	(No railway station in the tahsil.)			
TOTAL . . . . .	174,020	5,18,000	7,086	21,590

TABLE XXXIX.

*Rail-borne traffic for the carriage of sugar through the Gurdaspur District, average of five years 1884—88.*

Tahsil	EXPORT		IMPORT	
	Quantity in maunds	Value (rupees)	Quantity in maunds	Value (rupees)
Gurdaspur . . . . .	52,218	1,30,545	1,795	4,488
Batala . . . . .	169,558	5,65,187	6,403	21,342
Pathankot . . . . .	12,918	32,295	3,923	9,808
Shakargarh . . . . .	(No railway station in the tahsil.)			
TOTAL . . . . .	234,692	7,28,027	12,121	35,638

TABLE XL.

Showing the total recorded rail-borne traffic in maunds of sugar and sugar products in the Gurdaspur District in 1907 and 1908 (Gurdaspur Assessment Report by F. Kennaway, 1910).

Year	RAW SUGAR		REFINED SUGAR		GUR, SHAKKAR JAGGERY AND MOLASSES	
	Export	Import	Export	Import	Export	Import
1907	1,522	23,252	7	13,086	278,573	33,021
1908	2,207	35,081	501	16,750	299,457	33,112

TABLE XLI.

Showing the ratio of import to export of all rail-borne sugar products in Gurdaspur District for the years 1884-88, 1907-08 and 1911-12.

Year	Export Maunds	Import Maunds	Imports to exports
1884-88	234,692	12,121	0.05
1907	277,102	69,359	0.25
1908	302,165	84,943	0.28
1911-12	320,387	5,243,568	16.36

Within the last 30 years or so, the exports of sugar have not increased to anything like the same extent as the imports. For whereas in 1884-85 the ratio  $\frac{\text{import}}{\text{export}}$  was 0.05 : 1, in 1911-12 the ratio rose to 16.36 : 1.

We have already seen that the area under cane cultivation has not changed greatly within this period—it fluctuates from year to year, but on the average remains fairly constant. This being the case, and because we have no reason to believe that the out-turn of sugar produced per acre has increased to the extent shown by the increased exports by rail (from 234,692 maunds in 1884-85 to 320,387 maunds in 1911-12), we are forced to the conclusion that this increase is due for the most part to the re-exportation of imported sugar or, if this is not the case, then the increase is indirectly due to imported sugar releasing a larger and larger amount of locally produced sugar for export by replacing the consumption within the district.

The greater part of the exports is in the form of raw sugar, gur and jaggery; the amount of refined sugar going out of the district being very small. On the other hand there has been an enormous increase in the importation of refined sugar. This all bears out the contention that imported refined sugar is an important factor in regulating the area of cane grown.

### 5. Prices : Factors governing the fluctuation of prices of sugar products.

In 1883 Harcourt (*ibid*) reported that there was no foreign competition in the sugar trade of this district. Foreign sugar—of what kind we do not know—but to the extent of some 7,000 maunds was imported into the district in 1885 two years later.

TABLE XLII.

*Prices prevailing in 1883 for the sugars manufactured in the district (Harcourt report [ibid])*

Class of sugar product	Average wholesale price	Average retail price
Coarse sugar, gur . . . . .	16½ seers per rupee	16 seers per rupee
Shakkar . . . . .	1½ " " "	11 " " "
Refined Talouncha khand . . . . .	6½ " " "	6 " " "
Khand . . . . .	4½ " " "	4 " " "
Sugar manufactured at the Sujanpore refinery—		
Sugar No. 1 . . . . .	} 10 per cent. less than retail prices }	Rs. A. P. 14 8 0 per maund.
" No. 2 . . . . .		12 12 0 "
" No. 3 . . . . .		11 4 0 "
Small whole grain . . . . .		13 4 0 "

The average price of *gur* between 1884-85 in Gurdaspur and Pathankot according to Dane (*loc. cit.*) was 16 seers per rupee, and in Batala 12 seers per rupee; the latter figure is probably low or the two former figures high, because a close comparison of *gur* prices in Batala with those in Gurdaspur shows the latter to be always slightly higher as we should expect, seeing that Batala tahsil produces far more sugar than Gurdaspur.

The following two tables show the prevailing current prices of *gur* in these two tahsils from 1905 to 1914 month by month. The total average for the last ten years has been 8.04 seers per rupee in Gurdaspur and 8.7 seers per rupee in Batala. Within the last 30 years, raw sugar has risen there in value to an extent of 100 per cent. Even allowing for the decreased purchasing value of the rupee as in the ratio of  $\frac{24}{10}$ , we still find that the value of raw sugar in the last ten years was nearly 55 per cent. higher than it was in 1883.

TABLE XLIII.

Statement of current prices of gur in Gurdaspur in seers per rupee from 1905 to 1914.

Year	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		Average
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	
1905	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	8	8	..	8	7	7.6
1906	6½	5½	5½	6	5½	..	5½	6	6	..	6	..	6	..	6	..	6	..	6	6	6	..	8	10	6.4
1907	8	9	10	10	10	..	10	..	9	..	8½	8	8	..	8	..	8	7	7	7	7	..	7½	..	8.3
1908	7½	7½	7½	7½	7½	..	7½	..	7½	7	7	..	7	..	7	..	7	7½	8	..	8	..	9	..	7.5
1909	9½	8½	8½	9½	9½	..	9	8	8	7½	8	..	8	..	8	7½	8	..	8	..	7	..	8½	10	7.9
1910	10	10	10	10	10	..	10	..	9	..	8½	..	8½	..	8½	..	8½	..	8½	..	8½	9	10	..	9.2
1911	10	..	10	..	10	9	8	..	8	..	8	..	8	..	7	..	7	..	7	..	7	..	8	7	8.0
1912	7	..	7	..	7	..	7	..	7	6	6	..	6	..	6	..	6	..	6	..	6	7	9	10	6.8
1913	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9	..	9.0
1914	9	..	10	..	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9.7
AVERAGE FOR 10 years.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8.04

SUGAR AND SUGARCANE IN THE GURDASPUR DISTRICT



We can only account for this by the increased prosperity of the district resulting in a greater demand for sugar, which has been met almost entirely by imports from outside the district.

This indicates the early stages of a decay of the industry foretold earlier in this chapter. *Gur* (which is the form of sugar still most commonly used) is evidently produced cheaper in the south than it can be made in Gurdaspur where the cost of its production is regulated by the value of the other raw stuffs grown in the district. These have evidently increased in value to a greater extent than has the sugarcane, hence the gradual invasion of this stronghold of the Punjab cane industry by foreign sugar, and by foreign I mean anywhere outside the district of Gurdaspur.

We shall see this importation of foreign sugar into the district increase in the future and I anticipate in the course of time a shrinkage in the area under cane. There need be no cause for alarm, provided at the same time we see that the value of the exports from this district and the area under other crops show a steady and corresponding increase. It is evident to me that the fight for the sugar trade of India will have to be borne by those parts of the country which fall naturally in the sugarcane zone, that is, where the cane has not to face the climatic disadvantage to which it is subjected in the Punjab and especially in the Gurdaspur District.

## CHAPTER V.

### IMPROVEMENT OF THE EXISTING INDUSTRY.

#### 1. Low yields of cane : A consideration of the various causes contributing to this result.

Many of the economic limits to the improvement of the cane industry in the Gurdaspur District have been indicated in the preceding chapters. Some of these limits are beyond control at present, others are under partial control, while the remainder constitute what we might term immediately remediable defects in the industry. I will try and follow this classification in the following pages, though such a classification is of necessity purely arbitrary—what are to-day regarded as limitations beyond human control, may in a few years' time when more exact knowledge is available, be possibilities, and to-day's probabilities be tomorrow's certainties. Such a classification will serve as a useful point to take off from, in considering how far the existing industry can be improved. Perhaps the first and most apparent defect is the low yield of cane obtained throughout the district. In spite of the time which has elapsed since cane appeared—so far back that we have no positive record of how long ago it is since this first took place—the farmer has not yet succeeded in achieving an improvement of the crop at all comparable with the improvements effected among other cane-growing peoples elsewhere : and indeed we have very good reason to believe that cane has degenerated rather than improved. This is not because the crop has received little or no attention from the Punjab peasant, for the proverbs of the people are rich in reference to the many details of land preparation and treatment essential to the growing of a good crop of cane. The variations in yield even within the district itself show that better cane can be grown than is generally the case, and more of it per acre. The insistence of the agricultural proverbs such as given in the foot-note <sup>1</sup> shows to what extent this depends on suitable soil conditions, and these proverbs are but typical of many others to be heard

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<sup>1</sup> *Punjab Agricultural Proverbs* edited by Maconochie.

Page 93—Atthais báh, giyárah páni, nau khod. Jab dekhe ganne ka lod. (If you plough 28 times, water 11 times and weed 9 times, you may look for good sugarcane.)

Page 96—Máh Phágan ki khori, sher ki jhori. (Ploughing in Magh and Phágan is like the scratch of a tiger, i.e., very effective.)

Page 98—Mail de, sor raja kiya de. (The Raja cannot give what manure gives to the soil.)



throughout the district. We are not justified, therefore, in assuming that the backwardness of the industry is due to lack of attention on the part of the farmer. To what then can we attribute the general unsatisfactory condition of the crop? Apart from the climate, I believe it is largely due to the poor implements at his disposal, and this is particularly effective in a crop like cane which makes such heavy demands upon the soil. The Punjab peasant can in all justice be said to have solved the greater part of the agricultural problems capable of solution by the means at his disposal. The Indian farmer is just beginning to obtain implements and tools of steel, and we have only to look at the history of American agriculture—to take one example only—to see what cheap steel has done for farming in that country. With better transport facilities, better and cheaper implements will gradually find their way into every Punjab village. This is one of the main lines of improvement being now advocated by the Punjab Agricultural Department and with the best of results. The effect of this will be better out-turns in all crops due to better methods of tillage—deeper ploughing and a more effective use of the power available to the farmer. This constitutes one of the first, greatest, and most effective improvements available, and will operate advantageously on all crops.

On the more economical use of water, I have at present little more to say than has been already stated above in Chapter I. The cultivators using well irrigation for cane, having to raise this water themselves, practise every reasonable economy in its use and in the prevention of undue losses by evaporation from the soil. The prevention of waste of water by weeds or by unsatisfactory methods of tillage is part of the regular propaganda of the Agricultural Department, and, whenever possible, implements are being introduced to facilitate this objective.

*Draining.* There is a considerable amount of land in the district which could be improved by draining; land which at present is either unfit for cane or only grows the poorest quality. This aspect of the agricultural improvement might well engage the attention of the irrigation expert, for the excess of water so recovered would be of great value in the arid tracts further west. At present land is lying waste in Gurdaspur because of excess of water, while not far away there is land equally valueless on account of insufficient water. A more even distribution should be possible with beneficial results.

Among other improvements in the growing of the cane, which are unlikely to yield immediate results, may be mentioned improvements in the varieties of cane grown, and the restoration of the full fertility of the partially exhausted soils of the district by the application of artificial manures.

As regards the first of these, viz., the introduction of improved varieties of cane, reference may be made to tables given below in which is given a record of the cane variety trials carried out at the Gurdaspur Experimental Farm during the past four years. These experiments have so far failed to indicate a foreign cane as hardy as the indigenous canes of the district, and the extended use of these canes would, therefore, have to include arrangements for bringing in fresh seed from further south every few years. I question whether this is likely to be remunerative and hesitate to recommend it at this stage. If, in the course of further study of these and other canes, we find one hardy enough to withstand the rigorous climate of Gurdaspur and better in yielding powers and in purity and richness of juice than the indigenous varieties, we should of course at once proceed with its distribution to the zemindars, but there seems no immediate hope of achieving this. If frost-resistant canes of high quality can be easily produced by breeding or by selection this would have been done long ago in Louisiana where there is an old established sugar industry. The unstable condition of the industry there may be gauged, however, from Table II. taken from a report in the *Indian Trade Journal*, vol. XXXIV, no. 438, page 308-09, dated August 20, 1914.

TABLE XLV.

Cane variety trials, Gurdaspur, 1912-13.

Name of variety	Date of sowing	Actual weight of cane reaped	Actual weight of juice obtained	Actual weight of gur obtained	Weight of cane per acre	Weight of juice per acre	Weight of gur per acre	Agricultural notes
		Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	
Dhauhu . . . . .	20th March, 1912 . .	146 25	85 30	11 32	439 35	257 10	35 16	Deep ploughed 8"
Suretha . . . . .	Ditto . . . . .	62 4	39 20	6 20	398 25	253 22	41 20	Harrowed 3 times. 750 mds. of farmyard manure per acre. Watering . 4 Hoing . 3 Harrowing . 1  Ordinary ploughing with Rajas. 3 Harrowing . 3  450 mds. of farm- yard manure per acre. Watering . 3 Hoing . 3 Harrowing . 1
Dhaura of Azamgarh . . . . .	Ditto . . . . .	38 21	22 4	2 27½	548 16	314 24	41 33	
Cawnpuri . . . . .	Ditto . . . . .	18 20	9 30	1 28	443 10	227 24	40 29	
Lal, hard . . . . .	Ditto . . . . .	19 20	11 30	1 10	542 17	316 10	40 21	
Keora of Benares . . . . .	Ditto . . . . .	34 25	17 30	2 28	602 33	309 1	47 0	
Merthi . . . . .	Ditto . . . . .	15 5	9 20	1 16	366 1	286 5	42 14	
Chin . . . . .	Ditto . . . . .	64 14	34 20	5 38	479 35	257 11	44 8	
Patarki Mango . . . . .	Ditto . . . . .	9 39	5 10	0 31	439 37	223 36	33 31	
Tereru of Batala . . . . .	Ditto . . . . .	16 37	7 10	1 15	680 5	278 19	52 32	
Katura . . . . .	Ditto . . . . .	4 13	2 4	0 11	456 2	220 38	23 37	
Barhai . . . . .	Ditto . . . . .	39 2	22 0	3 22	547 32	303 25	49 32	
Katha of Batala . . . . .	Ditto . . . . .	23 8	13 5	2 20	351 8	199 30	38 2	
Kansar of Batala . . . . .	Ditto . . . . .	31 10	16 10	2 38	570 30	305 37	53 25	
Dhanlu . . . . .	24th March, 1912 . .	783 3	409 15	53 33	324 8	181 2	26 0	

SUGAR AND SUGARCANE IN THE GURDASPUR DISTRICT.

TABLE XLVI.

*Cane variety trials, Gurdaspur, 1913-14.*

Name of variety	Area harvested in square yards	Weight of cane.	Weight of juice	Weight of gur	Weight of shakkar	Weight of cane per acre	Weight of juice per acre	Weight of gur per acre	Percentage of juice to cane.	Percentage of gur to juice	Percentage of gur to cane	Percentage of shakkar to juice
		Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.				
Dhault of Bham . . . . .	1,493	117 0	54 0	9 12	..	379 11	175 2	30 6	46-16	17-22	7-83	..
Katha of Batala . . . . .	1,493	80 12	38 30	7 10	..	260 13	125 25	23 30	48-24	18-70	9-02	..
Terern of Batala . . . . .	1,614	112 31	59 20	9 10	0 21	360 21	190 8	31 10	52-72	16-37	8-66	17-6
Kansar . . . . .	1,504	69 29	37 20	7 25	..	224 15	120 27	24 22	53-78	20-33	10-93	..
Kahu . . . . .	1,499	83 33	45 20	7 20	..	270 26	150 6	24 9	55-47	16-12	8-94	..
Lal, hard . . . . .	1,501	88 37	43 0	8 30	..	226 30	138 26	28 9	48-35	20-34	9-83	..
Reera of Benares . . . . .	1,522	90 18	51 0	0 22	7 27	287 25	162 7	26 6	56-37	18-33	9-09	16-98
Buretha . . . . .	1,507	74 10	38 10	7 31	..	238 19	122 33	24 39	53-31	20-32	10-82	..
Barha . . . . .	1,513	76 1	37 0	6 27	..	243 8	118 14	21 14	48-66	18-04	8-78	..
Dhaura of Asamgarh . . . . .	1,522	96 37	47 0	..	8 7	308 9	149 18	26 0	48-49	..	8-43	17-39
Behar . . . . .	205	16 31	7 0	1 10	..	396 2	165 11	29 20	41-72	17-85	7-45	..
Mango . . . . .	209	11 15	5 0	1 0	..	263 16	115 32	23 6	43-95	20-00	8-79	..
Matki Mango . . . . .	214	13 27	7 0	1 13	..	309 11	153 12	29 39	51-18	18-93	9-59	..

Chin . . . . .	207	16 7	6 20	1 14	..	378 8	151 89	31 23	40-18	20-77	8-39	
Betakali of Dumraon . . . . .	260	12 4	5 5	..	0 33	209 14	92 9	14 34	42-36	..	0-31	10-00
Katara . . . . .	174	5 38	3 10	0 12	0 10	105 20	90 16	15 26	54-02	17-85	0-45	10-00
Matna . . . . .	430	22 6	12 30	2 20	..	244 8	140 23	27 23	57-50	10-00	11-28	..
Merthi . . . . .	230	16 38	6 35	1 16	..	356 27	144 27	26 12	40-56	18-18	7-37	..
Manch of Basali . . . . .	270	14 25	6 0	1 10	..	258 16	107 22	22 16	41-52	20-83	8-54	..
Deol Suretha . . . . .	228	18 38	10 0	2 5	..	411 12	217 1	46 5	52-77	21-25	11-21	..
Paterki Mango . . . . .	265	15 7	8 20	0 10	1 10	277 6	165 10	27 16	50-05	10-66	0-88	17-71
Bodi . . . . .	217	24 17	11 0	1 32	..	544 31	245 14	40 7	45-03	10-36	0-21	..
Dhaura Kanar . . . . .	262	25 20	13 20	2 10	..	471 3	249 0	41 22	52-04	10-06	8-82	..
Dhanu Suretha . . . . .	280	23 36	13 20	2 0	..	413 5	233 14	34 23	50-47	14-61	8-36	..
Kanara . . . . .	218	20 20	0 0	1 20	0 11	458 10	190 32	38 23	48-58	20-00	8-41	18-38
.. selected . . . . .	68	3 31	2 10	0 18	..	288 28	160 6	32 1	59-6	20-00	11-02	..

TABLE XLVII.

Cane variety trials, Gurdaspur, 1914-15.

Name of variety	Area harvested in square yards	Weight of cane		Weight of juice		Weight of gur		Weight of shakkar		Weight of cane per acre		Weight of juice per acre		Weight of gur per acre		Weight of shakkar per acre		Percentage of juice to cane	Percentage of juice to gur	Percentage of gur to cane	Percentage of shakkar to juice	Percentage of shakkar to cane
		Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.								
Lal, hard . . . .	771	50 29	29 28	4 8	1 1	318 17	190 13	32 27	33 12	58-55	17-54	10-43	17-83	10-12								
Kanara . . . .	985	51 33	32 0	..	5 19	254 26	157 10	..	26 36	63-74	..	..	17-11	10-66								
Bodl . . . .	889	70 22	38 0	..	5 39	384 4	206 35	..	32 32	53-86	..	..	15-72	8-46								
Dhauri of Bham . .	545	47 6	25 0	..	3 27	418 6	222 0	..	32 25	55-02	..	..	14-70	7-8								
Kahu . . . .	782	98 6	59 56	7 19	..	676 21	370 23	46 10	..	64-28	12-48	8-02	..	..								
Reora of Benares .	864	106 13	62 32	4 26	4 12	595 25	351 34	53 29	45 31	59-06	15-28	9-02	13-23	7-64								
Kansar . . . .	1,074	98 3	61 15	9 15	..	441 39	275 26	42 10	..	62-57	15-27	9-55	..	..								
Morhli . . . .	1,100	97 9	61 35	7 39	..	427 31	272 10	35 4	..	63-64	12-88	8-2	..	..								
Surotha . . . .	778	71 29	41 21	6 39	..	446 8	258 13	43 15	..	57-89	16-79	9-7	..	..								
Dhaura of Azamgarh .	549	43 14	21 39	..	3 18	426 10	193 29	..	30 17	45-45	..	..	15-69	7-13								
Tereru . . . .	1,060	93 32	53 26	7 20	0 9	423 12	242 38	35 9	26 12	57-19	14-38	8-22	15-0	8-57								
Chin . . . .	1,072	93 14	54 38	8 25	..	421 18	243 4	38 38	..	58-85	15-69	9-24	..	..								
Matki Mango . . .	1,107	94 26	59 10	9 0	..	413 33	259 4	39 14	..	62-59	15-19	9-51	..	..								

Katha of Batala . . . . .	904	60 7	84 16	5 26	..	822 7	184 7	30 10	..	57-16	16-42	9-36	..	
Katara . . . . .	441	30 8	17 27	0 18	2 2	861 18	103 30	29 2	27 5	58-52	15-0	8-78	18-97	8-16
Dotakali of Dumraon . . . . .	509	45 30	25 16	..	3 20	486 1	241 21	..	34 28	55-52	..	..	14-37	7-97
Patarki Mango . . . . .	395	41 27	20 18	0 39	1 37	509 14	249 37	37 18	34 20	49-07	15-0	7-36	18-18	6-78
Barhal . . . . .	560	46 32	25 28	2 22	1 13	404 19	222 5	38 36	32 29	54-01	15-27	8-37	14-72	8-09
March of Basati . . . . .	520	61 10	38 0	4 11	..	560 16	301 37	39 5	..	52-38	12-05	6-98	..	..
Mansahi of Dumraon . . . . .	409	55 7	38 0	0 16	4 7	585 7	320 3	43 1	44 21	59-31	18-33	8-0	18-01	8-32
Bohar . . . . .	810	36 23	22 0	3 5	..	570 26	343 19	48 32	..	60-10	14-20	8-55	..	..
Sunnabille . . . . .	535	62 38	36 30	5 32	..	569 19	332 10	52 19	..	58-38	15-78	0-21	..	..
Mango . . . . .	823	111 18	55 0	4 15	3 20	655 18	323 18	47 6	45 12	49-32	14-58	7-19	14-0	6-01
Deul Surotha . . . . .	1,130	108 21	64 8	0 20	..	464 38	274 37	41 26	..	59-15	15-15	8-06	..	..
Dhours . . . . .	1,102	116 38	70 9	8 2	..	513 26	308 17	35 14	..	60-35	11-46	6-38	..	..
Kinar . . . . .	1,049	66 19	41 1	4 23	..	306 28	180 11	21 4	..	61-71	11-15	6-33	..	..
Dhault Local . . . . .	2,098	208 30	118 30	14 0	..	481 23	274 18	32 12	..	56-09	11-74	6-7	..	..
.. Surotha . . . . .	240	24 11	14 18	1 37	..	489 21	201 10	38 33	..	59-58	18-32	7-33	..	..
Katha (cross-drained) . . . . .	225	11 30	7 10	0 30	..	252 9	155 34	19 14	..	61-33	12-41	7-50	..	..
Dhault (winter sown) . . . . .	265	20 5	11 38	1 20	..	381 30	220 33	24 10	..	50-38	12-55	7-45	..	..
Dhault (cross-drained) . . . . .	714	64 24	39 0	4 24	..	437 36	264 15	31 7	..	60-37	11-70	7-12	..	..

TABLE XLVIII.

*Cane variety trials, Gurdaspur, 1915-16.*

Name of variety	Area harvested in square yards	Weight of cane	Weight of juice	Weight of gur	Weight of cane per acre	Weight of juice per acre	Weight of gur per acre	Percentage of juice to cane	Percentage of gur to juice	Percentage of gur to cane
		Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.			
Sonabohi . . . . .	771	60 28	48 0	5 30	437 16	369 36	36 4	61.70	13.38	8.25
Bohar . . . . .	840	95 30	62 2	8 21	561 24	357 20	40 4	64.8	13.74	8.90
Burotha . . . . .	840	59 1	40 20	4 30	540 4	358 12	28 26	68.61	12.25	8.42
Lahri . . . . .	2,148	126 22	86 24	12 10	805 24	105 4	23 4	63.86	14.41	9.20
Dhaura of Asamgarh . . . . .	974	84 26	40 25	6 0	421 32	231 28	20 33	54.93	12.86	7.07
Reera of Benares . . . . .	888	60 1	30 5	4 20	327 8	213 8	25 30	65.18	12.08	7.54
Mango . . . . .	810	58 18	31 5	4 10	348 20	186 0	26 12	53.97	14.14	7.54
Dodi . . . . .	2,280	146 12	86 10	10 7	810 24	188 4	21 24	58.95	11.80	6.95
Patahri mango . . . . .	2,280	208 18	119 25	13 20	442 28	263 36	20 6	57.36	11.48	6.69
Katha . . . . .	610	45 7	25 30	4 7	358 20	204 12	28 5	56.99	16.21	9.24
Katha . . . . .	898	77 11	46 20	5 19	416 16	261 12	29 20	62.75	11.20	7.09
Katara . . . . .	1,060	65 18	45 25	5 27	298 32	208 16	27 2	69.76	12.98	9.08
Kanara . . . . .	1,060	144 23	86 10	9 24	359 12	214 4	24 18	59.56	11.42	6.803
Tereru . . . . .	212	17 20	10 5	1 7	404 28	231 8	26 58	57.12	11.61	6.628
Chia . . . . .	206	18 17	10 20	1 18	432 36	252 20	24 2	56.34	13.49	7.27
Kansar . . . . .	112	6 5	2 29	0 18	351 8	161 0	19 18	46.22	12.08	5.428
Nargori . . . . .	72	4 6	2 22	0 14	278 26	171 16	22 2	61.45	12.72	6.425
Khari . . . . .	108	6 0	4 32	0 20	276 24	221 8	22 2	79.94	16.42	4.22



TABLE II.

*Sugar industry in Louisiana, 1911-13.*

Year	No. of factories	Average yield of cane per acre	Average sugar made from acre cane	PER MILL AVERAGE		Average length of the campaign in days
				Sugar made	Cane milled	
		Short tons	Pounds	Short tons		
1911 . . .	188	19	2,200	1,877	31,315	..
1912 . . .	126	11	1,500	1,219	17,163	30
1913 . . .	153	17	2,300	1,913	27,542	45

This supposition is borne out by the system in vogue in the Southern Punjab of bringing in seed cane every few years from the United Provinces. The experience of the local farmers has evidently taught them the advantage of this and the impossibility of establishing a good hardy cane by acclimatization without the cane undergoing degeneration. In 1913 five hardy varieties of cane were planted in the autumn in order to see if the young plants could survive the winter better than the mature canes, and so secure a more certain harvest by lengthening the growing season. The experiment was a failure and only *Katha* and *Dhauhu* varieties survived. The out-turns of *gur* were :—

*Katha*—19 maunds and 14 seers per acre.

*Dhauhu*—28 maunds and 19 seers per acre.

The analyses of the Gurdaspur soils quoted in Chapter I indicate the impoverished nature of the land there and the probability of improvement by the addition of artificial manures. The use of artificials, however, is by no means a simple matter. If it is to be effective and remunerative, it is necessary first to work out by field trial the best combination of manures required by the soil. This is always done, and the chemical analysis of soil will not do more than point the way and indicate the more glaring deficiencies. Every year there is more and more evidence accumulating that a biochemical analysis as well as a chemical analysis is required to assist in forming an opinion about the cropping qualities of the soil, but at the present time the biochemical methods at our disposal are extremely scanty and there is a lack of data. In order to secure the required information on the manurial needs of the Gurdaspur soils manurial experiments were commenced at Gurdaspur in 1915. It is too early yet to pass any opinion on these as several years' results will be required before this can be done, but the out-turns obtained are given below :—

TABLE L.

Statement showing the results of manurial experiments with sugarcane (Local Dhaul) in F. No. 2, 1915-16.

No. of plot	Harvested area in square yards	Treatment	Weight of cane	Weight of juice	Weight of gur	Weight of cane per acre	Weight of juice per acre	Weight of gur per acre	Percentage of juice to cane	Percentage of gur to juice	Percentage of gur to cane
			Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.			
1	866	Untreated . . . . .	71 15	44 24	5 17	398 35	249 8	80 13	62-47	12-16	7-6
2	1,006	Lime=2,000 lb. per acre; Ammonium sulphate=200 lb. per acre.	81 23	58 29	6 31	393 4	232 24	32 24	71-83	11-53	8-29
3	1,047	Untreated . . . . .	91 26	55 23	8 8	423 23	256 36	37 35	60-64	14-75	8-94
4	897	Potassium sulphate=200 lb. per acre; Superphosphate=200 lb. per acre.	86 17	53 20	6 15	466 12	238 23	34 16	61-90	11-91	7-37
5	1,047	Lime=2,000 lb. per acre; Ammonium sulphate=200 lb. per acre; Potassium sulphate=200 lb. per acre; Superphosphate=200 lb. per acre.	86 23	48 5	6 9	400 12	222 20	23 31	55-59	12-93	7-19
6	1,047	Potassium sulphate=200 lb. per acre; Superphosphate=200 lb. per acre.	84 9	53 20	7 25	389 20	242 32	35 15	62-33	14-57	9-08
	1,047	Untreated . . . . .	83 26	56 0	7 23	411 4	258 35	26 30	62-93	14-20	8-94

8	1,047	Lime=2,000 lb. per acre; Ammonium sulphate=200 lb. per acre	71 1	46 20	6 30	329 20	216 0	31 8	65-27	14-52	8-473
9	1,047	Untreated . . . . .	80 32	51 19	7 31	415 12	238 4	35 38	57-33	15-10	8-60
10	1,047	.. . . .	86 30	44 6	7 20	401 8	204 4	34 27	50-89	15-00	8-04
11	1,047	Lime=2,000 lb. per acre; Superphosphate=200 lb. per acre	07 20	58 20	8 18	450 32	270 20	39 3	00-01	14-44	8-57
12	1,047	Untreated . . . . .	80 30	48 20	6 34	374 16	224 12	31 27	60-80	14-13	8-46
13	1,047	Potassium sulphate, 200lb. per acre; Ammonium sulphate, 200lb. per acre	80 31	54 20	6 23	415 8	252 0	30 36	60-70	12-29	7-48
14	1,047	Lime=2,000 lb. per acre; Potassium sulphate=200 lb. per acre; Ammonium sulphate=200 lb. per acre; Superphosphate=200 lb. per acre	88 4	50 10	6 29	407 16	232 16	31 4	57-03	13-39	7-03
15	1,047	Potassium sulphate=200 lb. per acre; Ammonium sulphate=200 lb. per acre	76 3	45 23	6 30	351 32	211 12	31 8	60-06	14-77	8-87
16	1,047	Untreated . . . . .	79 0	30 30	5 33	365 12	183 32	27 20	50-31	14-27	7-53
17	1,047	Lime=2,000 lb. per acre; Superphosphate=200 lb. per acre	92 10	48 18	7 15	427 28	224 0	34 4	52-37	15-23	7-03
18	1,047	Untreated . . . . .	07 30	54 0	8 3	452 23	240 23	37 14	55-10	14-06	8-25

SUGAR AND SUGARCANE IN THE GURDASPUR DISTRICT

TABLE LI.

*Analysis of the Gurdaspur farm canes, 1915-16. Manurial experiments.*

No.	Date of sample	Description and locality of cane	Juice						
			Juice per cent.	Glucose per cent.	Sucrose per cent.	Total solids	Glucose ratio (Glucose x 100) Sucrose	Purity co-efficient (Sucrose x 100) Total solids	Wine on cane
1	10th January, 1916	Dhault, unmanured Plot 18, Field 2, Government Farm, Gurdaspur	58.91	0.49	15.17	18.40	3.23	82.47	19.33
2	Ditto	Ditto	61.67	1.33	12.72	16.59	10.44	76.68	18.59
3	12th January, 1916	Dhault, unmanured Plot 9, Field 2, Government Farm, Gurdaspur	57.98	0.43	15.59	18.54	2.79	84.09	16.41
4	Ditto	Ditto	57.19	1.54	12.78	16.84	12.02	75.90	11.99
5	Ditto	Ditto	62.99	2.83	5.45	11.07	51.84	49.36	10.07
6	21st January, 1916	Dhault, unmanured Plot 1, Field 2, Government Farm, Gurdaspur	60.66	2.93	5.02	10.64	53.37	50.05	14.60
7	Ditto	Ditto	56.67	2.72	10.78	15.66	25.24	68.85	16.68
8	Ditto	Ditto	58.04	2.66	11.78	16.52	22.55	71.29	17.06
9	13th January, 1916	Dhault fully manured (with N+K+P+Ca), Plot 14, Field 2, Government Farm, Gurdaspur	59.73	1.11	15.11	19.08	7.35	79.21	20.08
10	Ditto	Ditto	63.87	2.97	4.91	10.81	60.53	46.26	14.69
11	Ditto	Ditto	59.20	0.85	10.90	19.66	5.32	80.83	20.01
12	Ditto	Ditto	58.64	3.09	8.88	14.20	34.98	62.56	18.24
13	17th January, 1916	Dhault fully manured (with N+K+P+Ca), Plot 5, Field 2, Government Farm, Gurdaspur	58.86	3.39	10.96	15.73	30.92	71.12	17.83
14	Ditto	Ditto	53.96	4.41	5.18	11.83	85.02	43.82	14.73
15	Ditto	Ditto	67.47	3.95	5.96	12.04	66.18	49.55	10.64
16	Ditto	Ditto	64.28	3.32	6.49	12.09	51.25	53.67	12.50

TABLE LI—concl'd.

Analysis of the Gurdaspur farm canes, 1915-16. Manurial experiments.

No.	Date of sample	Description and locality of cane	JUICE						
			Juice per cent.	Glucose per cent.	Sucrose per cent.	Total solids	Glucose ratio (Glucose x 100) — Sucrose	Purity co-efficient (Sucrose x 100) (Total solid.)	Fibre on cane
17	14th January, 1916	Dhault, manured with nitrogen and potash, Plot 13, Field 2, Government Farm, Gurdaspur	60.75	3.62	7.42	12.49	48.75	50.40	17.49
18	Ditto	Ditto	61.28	3.21	10.08	16.01	29.25	68.61	17.11
19	Ditto	Ditto	62.33	2.64	9.83	14.76	26.81	66.64	13.86
20	Ditto	Ditto	64.86	2.30	12.00	16.70	19.14	71.88	15.52
21	20th January, 1916	Dhault, manured with nitrogen and lime, Plot 2, Field 2, Government Farm, Gurdaspur	64.45	2.55	8.36	12.77	30.54	65.48	16.39
22	Ditto	Ditto	62.70	2.68	10.14	14.69	26.38	69.02	10.95
23	Ditto	Ditto	65.52	2.17	11.28	15.39	19.23	73.28	13.19
24	Ditto	Ditto	63.06	2.73	9.74	14.34	28.56	67.97	12.68
25	10th January, 1916	Dhault, manured with phosphorus and potash, Plot 4, Field 2, Government Farm, Gurdaspur	62.02	2.41	10.93	15.18	21.95	72.96	19.38
26	Ditto	Ditto	63.06	4.07	8.76	14.76	46.51	59.34	13.47
27	Ditto	Ditto	57.73	1.46	13.48	17.06	10.83	78.91	21.13
28	Ditto	Ditto	61.72	3.29	10.13	15.53	32.53	65.19	16.40
29	16th January, 1916	Dhault, manured with phosphorus and lime, Plot 11, Field 2, Government Farm, Gurdaspur	52.67	1.35	14.77	18.72	9.12	78.01	21.52
30	Ditto	Ditto	65.00	3.42	7.70	13.39	44.44	57.54	11.87
31	Ditto	Ditto	59.14	3.43	7.36	12.90	46.65	56.62	16.35
32	Ditto	Ditto	55.89	4.43	11.56	16.72	38.33	60.16	20.68

From the appearance of the crop and from the analysis of the juice, it was evident that excessive vegetative growth and consequent retardation of ripening had taken place. This may have been due to too much manure or to its application at the wrong time. I am inclined to think that the latter was the case, and that the manure should be put in with the crop immediately preceding cane so as to ensure that the young cane gets the greater part of the benefit to be derived from it. The growing season is so short in this district that any lengthening of the growing period will be detrimental. This is probably one reason for the local custom of avoiding excessive manuring of cane lands. The successful use of artificials is likely to be a delicate and difficult operation, and we do not yet know where the limitations lie. In the case of cane, climate will probably prove to be the chief restriction because of the danger attending late ripening.

A considerable amount of further information will have to be sought in field trials in this direction before we can recommend a suitable method of artificially correcting the manurial deficiency of the Gurdaspur soils. In the meantime better methods of cultivation, giving a deeper soil in which to grow the crop, will be effective.

For the information of growers of cane in Northern India, who are interested in this manurial experiment, I give below a sketch of the ground plan of the experiment.

1 U.	4 K.P.	7 U.	10 U.	13 K.N.	16 U.
2 N. Ca	5 K.P. N.Ca	8 N. Ca	11 P.Ca	14 P.Ca K.N.	17 P. Ca
3 U.	6 K.P.	9 U.	12 U.	15 K.N.	18 U.

U = Unmanured.

P = Superphosphate 200 lb. to the acre.

Ca = Lime 2,000 lb. per acre.

K = Potassium sulphate 200 lb. per acre.

N = Ammonium sulphate 200 lb. per acre.

The plots are 1,047 square yards each except plots Nos. 1, 2 and 4 which are 866, 1,006 and 897 square yards respectively in extent and are each separated by a ditch and two rows of cane. In the experiment given above, the manure was applied at the time of sowing. In the next season the manure will be applied with the preceding maize crop in the

rotation maize *senji*—sugarcane—wheat. Other experiments have been tried at Gurdaspur, such as surrounding the cane fields on three sides with a ditch 3 feet in depth to ensure adequate drainage and aeration. The advantages have not so far been apparent. The Java system of planting and of preparation of the land for planting is likewise under trial, but so far there are no results to report.

## 2. Extension of area under cane.

There is more cane grown in Gurdaspur than in any other district in the Province, as may be seen by reference to Table XXXV, page 62, Chapter IV. Of the submontane districts of the Punjab, Gurdaspur enjoys the best irrigation facilities and this is certainly one of the principal reasons why so much cane is still grown there. It is found growing practically in every village in the district, and is still considered by the zemindars to be the most remunerative crop grown. It is said to pay the revenue of the district. Under existing conditions, the area under cane cannot be extended without unduly interfering with the rotations at present in vogue. The possibilities of increasing the area under cane will be regulated by the water supply available and by the labour which can be got for harvesting.

The canal-irrigated lands probably grow as much cane as there is manual labour for its management, and any extension would therefore necessitate either the importation of labour or the reorganization of the existing labour and the introduction of labour-saving devices and machinery. The industry is not in a sufficiently flourishing condition to support this, nor is there any immediate prospect of it becoming so. Wherever water can be cheaply raised by the Persian wheel, cane is already grown. To increase the area under cane by increasing the irrigation facilities means improvement in the existing system of well irrigation. An increased supply of irrigation water is a sound proposition, whether it is to be used for cane or other crops, and steps are being taken to sound the water resources of the district, to improve the wells and to cheapen the supply of water for farm lands by a better and cheaper system of water-lifting. We look to the subsoil water of the Gurdaspur District to supply us with all the additional water required, rather than to an increase in the supply of canal water, as this could only be given at the expense of other districts further west and would moreover only tend to increase the area of waterlogged lands. In this respect Gurdaspur by virtue of its geographical position is well served and there is an abundance of water within easy reach of the surface.

In this connection, it may be noted that, in the Punjab, canal irrigation has resulted in a considerable rise of subsoil water table, so much

so indeed that in certain tracts there is danger of the land becoming waterlogged owing to seepage water escaping from the canals. An interesting experiment is being made by the Irrigation Department at Amritsar where the water table has risen to within six feet of the surface. In this experiment, electric power generated from canal water power is being used for irrigation by pumps—the distribution of canal water over the area now under pump irrigation being either entirely or partially discontinued. The experiment is an important one and will be watched with great interest by agricultural specialists, as well as by irrigation engineers and by Government, as, if successful, it will solve one of the greatest problems in North-West India. In examining the possibilities of increasing the area under any one crop, we have to consider the other crops in competition.

### 3. The crops in competition with cane.

As might be expected, the area under cane in such a district as Gurdaspur is subject to considerable seasonal variation. I have shown in Chapter IV that the variation appears to be controlled by external influences, one at least of which, and one of the most important, being the price of foreign sugar at the Punjab seaport (Karachi).

In planting cane or other crops, the farmer is naturally guided to some extent by the ruling market prices of his produce, and he will sow as much as he can of the crop which promises to give him the best return for his outlay in land, labour and capital: this can react but slowly to market prices, however, a considerable time must elapse between seed time and harvest and in a conservative country like India, this all tends to keep down the price and value of raw produce. The depression of prices is maintained by the comparatively high railway freightage rates and by the fact that the district exports only raw material, and has to import all, or practically all, the manufactured products used there. In this respect, it is a small competitor with the rest of India and the world, and is not in a position to make its influence felt. Any change will, therefore, be slow.

I have summarized the crop returns for the 12 years ending 1913 for the four tahsils of the Gurdaspur District in Tables V—VIII, Chapter I, pages 10-12. These results are given in graphic form in diagrams V to VIII.

These graphs show that there is a considerable variation from year to year in the area under the different crops, and that there is no apparent relationship between the amount sown, that is to say, if the area under cane declines there is no equivalent increase in the area under cotton or rice,



DIAGRAM V.

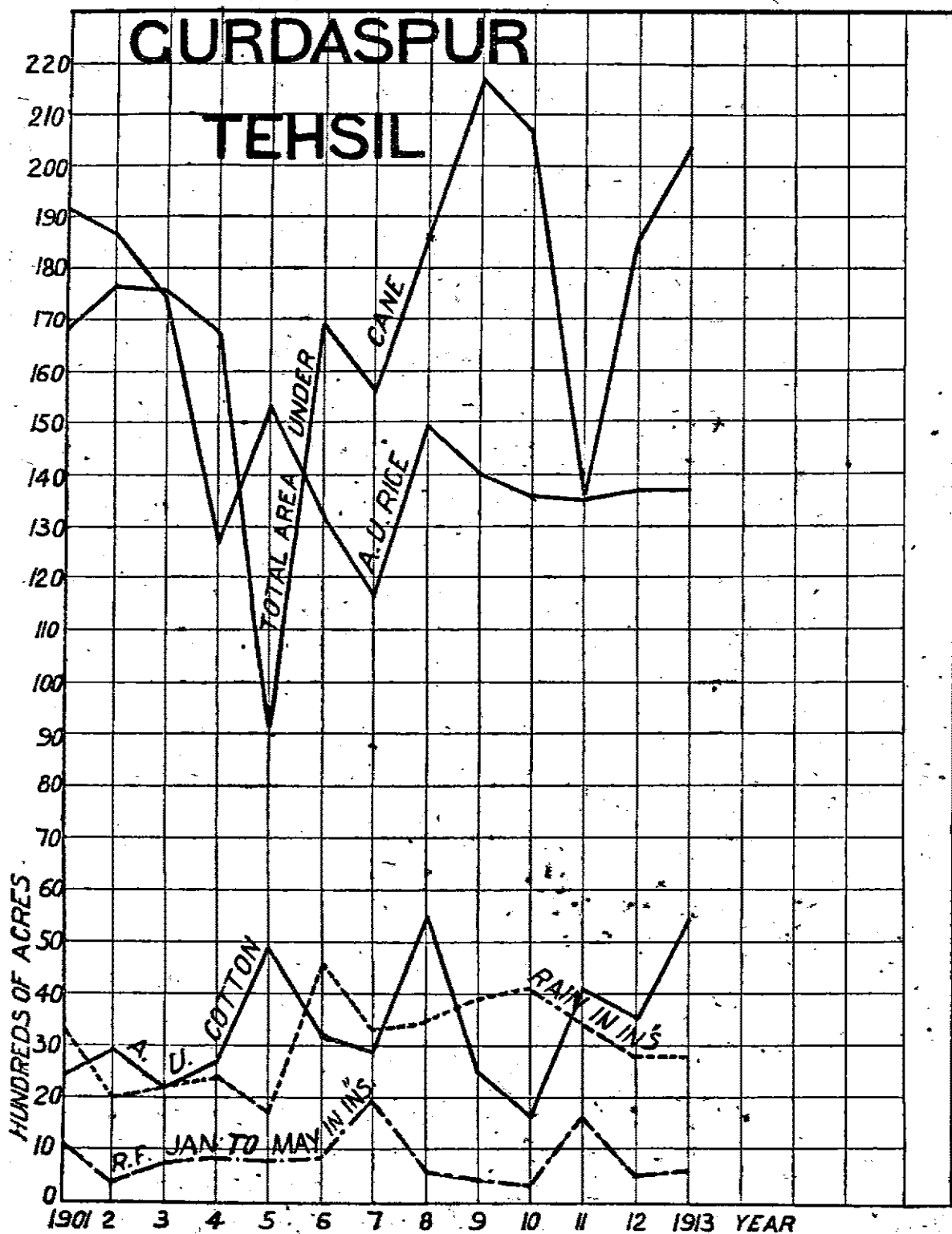


DIAGRAM VI.

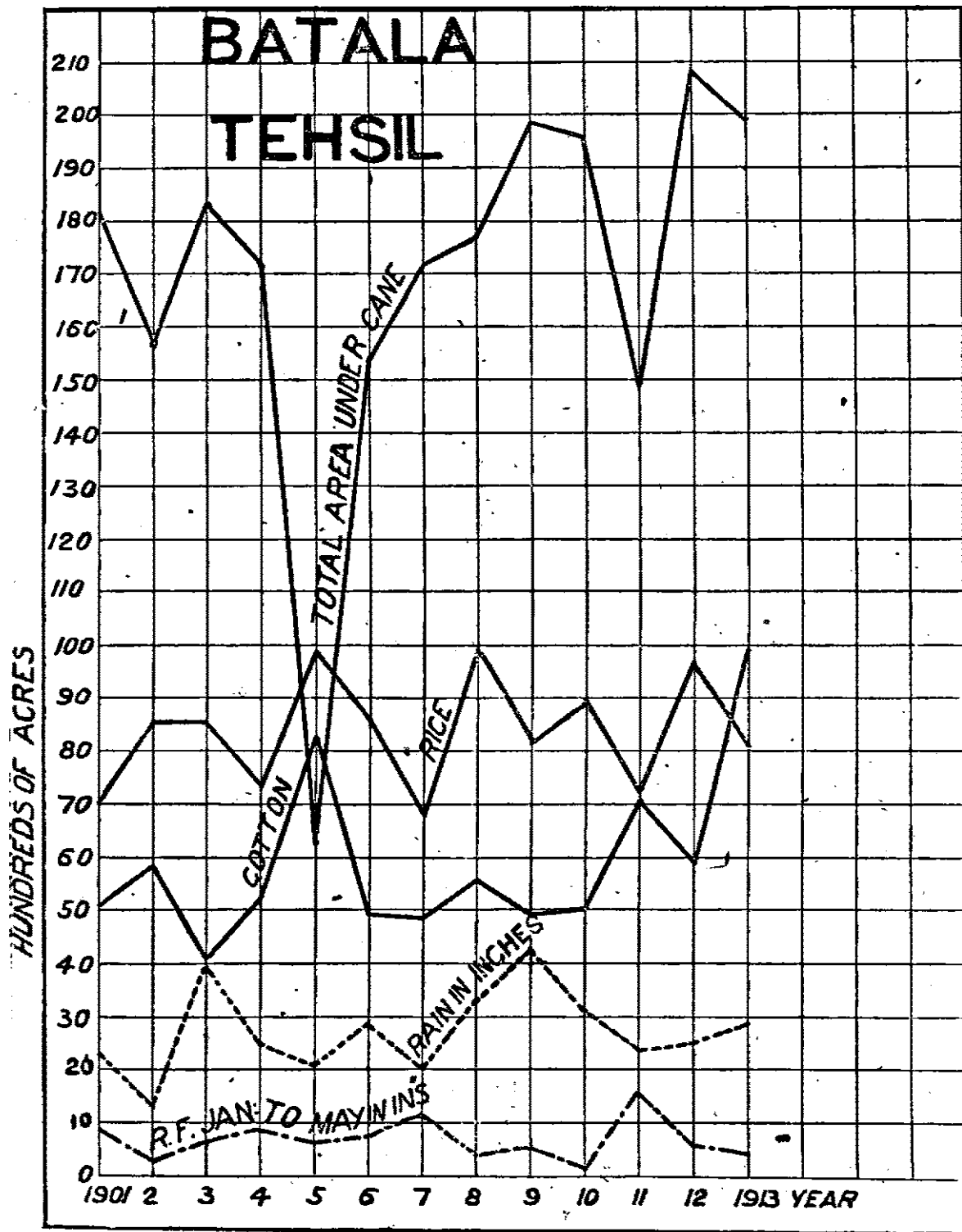


DIAGRAM VII.

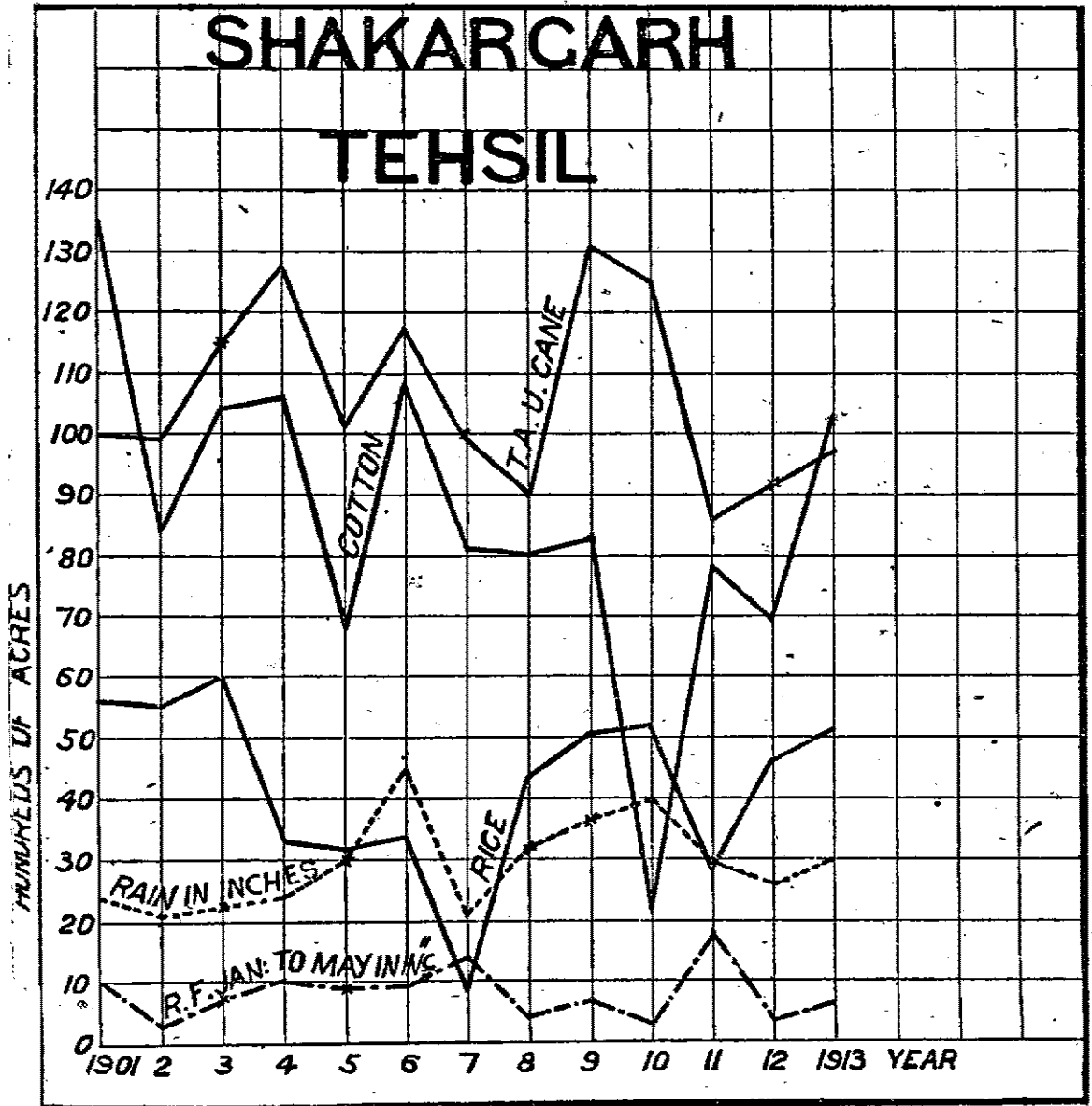
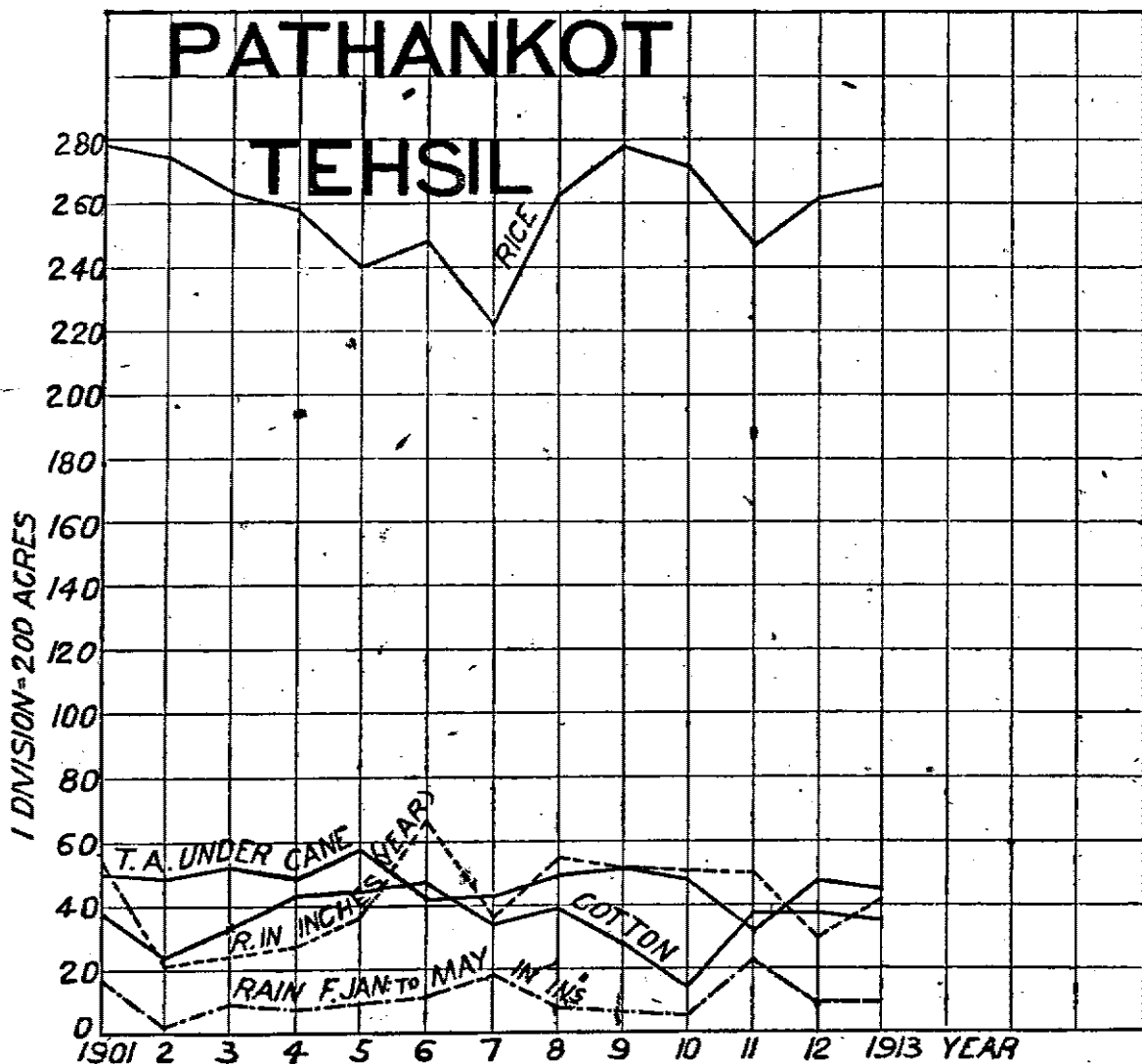


DIAGRAM VIII.



In the graph showing the acreage under the chief crops in Batala, which is the tahsil growing the largest amount of sugar, we see first that the yearly variation in cane, which is the principal crop, is very great. Of the two other main crops, rice and cotton, we should infer from the comparatively uniform acreage under rice that this crop is grown largely for consumption in the district and is therefore only a minor competitor to cane. Cotton on the other hand has shown a more or less steady increase. This cotton is in direct competition with cane and must be reckoned as a crop of major importance.

In the Gurdaspur tahsil where there is also a large amount of cane grown, we see that rice is much more directly in competition while cotton, though on the increase, is still very variable. The Shakargarh tahsil perhaps provides the best example of this competition between crop and crop. Cotton is evidently a crop of major importance in this tahsil and the wide variation in the amount sown shows that the farmer's attention is more on the cotton market than on sugar. The area under cane does not vary to the same extent as in Batala or Gurdaspur.

In the Pathankot tahsil which is the portion of the district nearest to the foot-hills, rice is the principal crop; all the cane grown is evidently for local consumption. A small amount of cotton is grown, but the area under this crop is comparatively uniform.

In no case does there appear to be any relationship between the amount of any crop sown and the rainfall either annual or of the spring rains. This is interesting and not altogether unexpected. We can only explain it by the assumption that in the tahsils of Batala, Gurdaspur, Shakargarh and Panthankot there is usually sufficient water either from canals, wells or rain to ensure the sowing of the crop. We are not concerned in this enquiry with the yields or what proportion of the crop comes to maturity, that obviously depends on the season, but *the amount sown is the real index of the zemindars' forecast of comparative crop values.* From these figures it appears that in the south and west of the district, cotton is in direct competition with cane and the area under this crop will probably increase. Near the hills, rice is the chief crop by reason of the abundance of water in the hot season, and such cane as is grown, is evidently for local consumption only.

When deciding on the crop to be sown the farmer will naturally be influenced by the value of the produce. But besides this, he has also to consider the outlay in labour, manure and money. This cost varies considerably with the crop and is widely different in different parts of the Province.

Below is given an abstract in tabular form of Hamilton's estimate of the expenses and profits of cultivation in the Punjab.

TABLE LII.

Showing cost of cultivation and profit in growing ordinary crops in the Punjab.

Crop	District	How irrigated	Interest on capital outlay on bullocks and implements	Cost of production	Value of produce	Profit per acre	REMARKS
			<i>Rs. a. p.</i>	<i>Rs. a. p.</i>	<i>Rs. a. p.</i>	<i>Rs. a. p.</i>	
Wheat . . .	Lyallpur (Buchiana)	Canal	10 4 0	35 8 6	73 5 0	37 12 6	} Cost of production and value of produce are per acre. } Cost of production and value of produce are per <i>ghumoon</i> .*
Cotton . . .	Do.	Do.	10 4 0	29 6 6	72 0 0	42 9 6	
Wheat . . .	Amritsar (Tarn Taran) Tahsil	Do.	10 2 0	31 11 0	73 5 0	50 6 0	
Cotton . . .	Do.	Do.	10 2 0	24 1 0	72 0 0	58 0 0	
Wheat . . .	Sharakpur fahell .	Well .	16 0 0	42 8 0	70 0 0	36 8 0	} Cost of production and value of produce are per acre.
Do. . . . .	Gujranwala Tahsil .	Do. .	22 3 0	44 7 0	78 11 0	29 4 0	
Sugarcane .	Gurdaspur . . . .	Canal	13 12 0	54 1 0	96 0 0	50 0 0	} Cost of production and value of produce are per <i>ghumoon</i> .
Do. . . . .	Do. . . . .	Do .	13 13 0	63 8 0	96 0 0	39 4 0	
Sugarcane, variety <i>Pounda</i>	Hansi . . . . .	Do.	19 11 0	226 13 0	270 0 0	69 0 0	Both the cost of production and value of produce are per <i>pecca</i> bigha.

Unfortunately these estimates do not give any account of the cost of growing cotton and the profits derived from it in the Gurdaspur District but an estimate is given for Tarn Taran tahsil in the Amritsar District which is adjacent to Gurdaspur.

The profits of cotton in Tarn Taran compare very favourably with those derived from cane cultivation in Gurdaspur under canal irrigation. Another point in favour of the cotton crop is the smaller outlay in capital and cost of production than is required in the case of cane. This will prove a powerful incentive to cotton growing with the Punjab peasant, who, like the small farmer throughout the world, is never overhanded with spare cash.

It would appear from this paragraph that I am advocating the growth of cotton and rice in lieu of cane in the Gurdaspur District, whereas this bulletin is mainly one about cane. I do not intend this; the point I wish to make clear is that there are other crops in competition with cane, and that there is every likelihood of these displacing cane unless this is very materially improved. I have shown elsewhere that I have good reason to believe that the Gurdaspur climate is not suitable for the growth of an improved variety of cane which can only be regarded, therefore, as a foreign crop. This being so, I venture to forecast that cane cultivation will decline there, and its place will be gradually taken

\* A *ghumoon* = 0.926 acre.

by other more suitable crops which will ultimately prove to be more remunerative. This becomes more clear when we compare the interest returned in profits from the sale of the produce on the capital invested in growing it. Thus for example, the interest yielded by cotton is over 100 per cent., for wheat just under 100, and for sugarcane from 24 per cent. upwards, the highest being only 86 per cent., and this latter in all probabilities is an abnormal figure.

#### *Yield per acre the ruling agricultural factor in the industry.*

The yield of cane obtained in the district has been very fully discussed in Chapter I. We have seen there that the estimated average for the district is somewhat above 10 tons of stripped cane to the acre. Higher yields than this can be, and are, obtained, but in forcing up the outturn the law of diminishing returns will apply as it does in the case of all agricultural products. The yield of ten tons may be a low average, but I am inclined to think that it is about the yield at which the zemindar gets the highest interest on his capital outlay. In other words he has pretty well reached the limit with the implements, manure, soil and water at his disposal and in the climate in which he has to work. Any marked increase over this average must mean more than average favourable conditions in one or other of the above. Otherwise more and more capital will have to be employed in obtaining increased yields.

In Table LII for example, with a capital outlay of Rs. 58 per acre in Gurdaspur, the return was 86 per cent. ; with an outlay of Rs. 77 it was 52 per cent. ; while with an outlay of Rs. 246 on *Pounda* cane the return on the capital invested was only 24 per cent. This is a point of vital importance to the small farmer, and for this reason it is useless and impossible to compare the conditions of the industry in Gurdaspur with that of other cane-growing countries on the yield per acre alone. That the out-turn of cane in Gurdaspur is below that of most other sugar-growing countries is certain, and it is only the isolated position of the district, the heavy freightage rates, and the fact that India is producing less sugar than she consumes, which enables the farmer in Gurdaspur to continue to grow cane on a large scale.

#### **4. Curtailment of the losses taking place in the manufacture of sugar.**

The losses which take place in the manufacture of sugar by country methods in the district are very great and there is scope for immediate improvement.

The principal losses take place in (a) crushing and (b) boiling. The estimates I have given for the losses in crushing in Chapter II are certainly

very much below those normally taking place in the villages. Hulme considers that the extraction effected by the ordinary country mill is about 56 per cent. or in other words not a very great improvement on Lehman's estimates (*loc. cit.*).

Two methods suggest themselves for the curtailment of this loss. The first is its reduction by better machinery, to be owned and run by the farmer, just as he owns or hires the bullock-driven crushing mill to-day. The other method is more complicated—it involves the use of machines of higher power and greater cost than could be managed by any ordinary farmer and would need special management.

The first of these two methods is being tried in the United Provinces by the Agricultural Chemist, and consists of the use of a mill capable of crushing 12 to 15 maunds of cane per hour and driven by an oil engine of from 5 to 7 B. H. P. and costing about Rs. 500.\* The mill gives an expression of 55—59 per cent. with *Ukh* canes and 62—66 per cent. with *Pounda* canes. This is better than the village mill as ordinarily used in the United Provinces, but not equal to a Nahan 3-roller mill driven by bullocks. This latter is not however within the means of the ordinary cultivator.

The second method is under trial in the United Provinces by the Sugar Engineer to the Government of India, Mr. Hulme. At Nawabganj a factory costing Rs. 50,000 and capitalized at Rs. 80,000 (Rs. 30,000 being set aside for the pre-payment of the cane) has been erected. This is capable of milling 30 maunds per hour at 22 hours per day for 91 days or about 60,000 maunds of cane in the season. In the opinion of the designer this is the smallest sugar boiling plant that can be economically used. It makes both white sugar as well as ordinary country *gur*. It does not use vacuum evaporating pans but only Wertzels pans.

By the courtesy of the Director of Agriculture, Mr. Hailey, and of Mr. Hulme, I had an opportunity of inspecting this factory in February last. It appears to be a valuable experiment, but all the problems capable of solution by it have not yet been solved. The principal difficulty experienced has been in obtaining a sufficient supply of cane to keep the factory fully employed. This difficulty will always be experienced with any similar factory unless the factory either owns a portion of the adjacent sugar land, sufficient to supply at least  $\frac{1}{2}$  of the season's consumption, or else the farmers growing the cane must have an interest in the factory itself to act as an inducement to them to supply the factory with as much cane and at as low a figure as possible. One cannot lay down any hard and fast rule as to which is the better method, for the system effective in one district or province may not be so in another.

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\* *Proceedings of the Board of Agriculture in India, 1916, page 93.*



Speaking of the Punjab and the sugar growing conditions which exist there as I have seen them, I believe the latter system of co-operation between grower and sugar boiler is the most promising, and if successful, will not only effect a considerable saving in the terrible waste now taking place but will also set free the farmer's cattle as well as the farmer himself for other work more directly connected with the farm.

At Nawabganj the factory makes 3 grades of white sugar obtaining a molasses by-product. It was estimated to yield 6 per cent. of sugar on the cane crushed at an average price of Rs. 13 per maund and 5 per cent. of molasses at an average value of Rs. 2-8 per maund. These figures have not been realized in the present working season (1916) owing to losses in the factory and the sale of part of the sugar in an unrefined state. The actual return of refined sugar on the cane crushed was only 3-6 per cent.

The efficiency of the mills is 83-3 per cent. on 19 crushing and using different types of cane and the return of *gur* is about 11 per cent. of the weight of cane. The following is the result of 3 days' working at Nawabganj. :—

Date	Weight of cane crushed	Weight of juice	Weight of <i>gur</i>	Percentage of <i>gur</i> on cane
	Mds. Srs.	Mds. Srs.	Mds. Srs.	Per cent.
9th January, 1916 . . . . .	221 33	151 25	25 12	11-39
10th January, 1916. . . . .	188 30	127 30	23 26	12-51
7th January, 1916 . . . . .	171 20	109 5	18 0	10-05
AVERAGE . . . . .	..	..	..	11-30

The cost of production is about Rs. 5-4 per maund of *gur* when the cost of cane is R. 0-5-3 per maund, this being the price actually paid for cane at Nawabganj. The price of *gur* varies. According to Noel Paton (*loc. cit.*) the average price of *gur* in 45 districts was :—

	Rs.
1906 . . . . .	5-53 per maund.
1907 . . . . .	5-04 "
1908 . . . . .	5-39 "
1909 . . . . .	5-95 "
1910 . . . . .	5-98 "

In Lyallpur and Gurdaspur districts, the price of *gur* this year (1916) is about Rs. 5 per maund.

The price paid for cane at Nawabganj is high—better cane can be purchased in parts of Bihar at R. 0-4-0 per maund. At Sujapur in the Pathankot tahsil, there is an old established sugar factory which buys the cane in advance and pays from Rs. 20 to upwards of Rs. 40 per acre, the average out-turn of which is about 200 maunds. Taking Rs. 30 as the average price per acre paid this costs on the field R. 0-2-5 per maund of cane, and at the factory, after paying carting charges at R. 0-0-9 per maund, gives R. 0-3-2 per maund.

On the other hand Dyer's scheme for making *gur* in the Gurdaspur and Amritsar districts at Chinna, Batala, and Amritsar, using steam driven mills, broke down because he could not purchase enough cane to keep the mill working even at R. 0-6-0 per maund.

##### 5. Cost of production of the cane and the price at which it could be supplied to a factory.

Hamilton<sup>1</sup> has estimated the cost of production of cane on canal irrigated lands in the Gurdaspur District at about Rs. 50 per acre (exclusive of charges for sugar boiling). Unfortunately he gives no figure for the rent value of the land, and this somewhat detracts from the value of his figures. At Rs. 50 per acre and with a yield of 300 maunds of cane, this gives the cost of growing the cane at R. 0-2-9 per maund; add carting charges at the rate of 20 maunds per cart for 15 days at R. 1 per day—we get a carting charge of R. 0-0-9 per maund of cane.

The rent of the land is difficult to estimate—this is sometimes taken as half the value of the crop grown—the owner supplying seed and sometimes other things also. It is difficult to deduct a rental value for this system, since cane only occupies a portion of the land ( $\frac{1}{3}$ rd in the ordinary rotation followed, see Chapter I), less remunerative crops being grown on the other parts at the same time. Moreover, the tenant gets fodder crops in the *kharij* season of which the landlord takes no share. Land is let on a money rental in some places, but the value varies very much. The land commanded by canal irrigation for example is very much more valuable than that which has to be irrigated from wells. I have taken Rs. 15 per acre as an average figure for the rent value of land in Gurdaspur. I am fully aware that there are many farms on which cane is grown which command a higher figure than this, but on the other hand there are many others which can only realize much less, just as is the case with the out-turn of cane per acre. This figure for rent value of the land gives a rental charge of R. 0-0-10 per maund of cane grown (taking 300 maunds as the yield per acre). The

<sup>1</sup> *Expenses and profits of cultivation in the Punjab*, Punjab Government Press, 1916.

total cost of producing the cane and landing it at the factory is estimated as follows :—

	Rs. A P.
Cost of growing . . . . .	0 2 9 per maund of cane.
Rent of land . . . . .	0 0 10           "
Carting . . . . .	0 0 9           "
TOTAL	0 4 4 per maund.

Since this is more than the price paid at the Sujapur factory, we can only conclude that, in the Pathankot tahsil at least, the cost of growing the cane is *much less than the above estimate*. These figures are only approximately correct, and their value lies in the proof they afford that the cultivator can grow and deliver his cane at a central crushing and boiling mill at a price which will yield a margin of profit both to him and to the mill-owner.

Factories of the type at Nawabganj offer a partial solution of the problem of present waste. I do not think that a factory of this type will be able to stand competition from a large refinery but it will take some years before such refineries can come into existence in sufficient number to seriously affect the price of sugar in India, and in Northern India particularly the day is far distant when sugar factories will be seen. In the meantime any system, which is an improvement on that at present in vogue, will be of assistance in increasing the out-turn of raw sugar and rendering the country more independent of the imported products. We have only to turn to the reputed losses shown in Chapter III, to see what a large margin there is for improvement in this direction—probably a larger margin than there is for the improvement of the cane itself in Northern India.

The estimates I have given in Chapter III are certainly less than is actually the case in the villages, for the milling and boiling on which these estimates of losses are based, is far better than in the villages. I shall not deal here in detail with improvements which can be effected in the boiling of the juice, as it will make this account of the Gurdaspur sugar industry too bulky and would serve no useful purpose. Improvement can only be effected by the use of better machinery and by skilled labour, both of which are beyond the reach of the present farmer unless the above system of co-operation can be secured. The type of machinery which would be used, may be seen by reference to an account of the Nawabganj<sup>1</sup> factory.

<sup>1</sup> "A note on the improvement of the indigenous methods of sugar and gar making in the United Provinces, being a report of the Government experimental sugar factory at Nawabganj" by Mr. Hulme. Allahabad Government Press, 1916.

From the table No. XLI on page 71, Chapter IV, it will be seen that the excess of imports over exports in the *gur* trade of the district was 49,23,181 maunds in 1911-12. The area under cane in the district is about 50,000 acres with an average out-turn of about 24 maunds of *gur* to the acre. In order to check this importation of *gur*, therefore, it will be necessary to either quadruple the area under cane or raise the yield per acre to four times its present value if the internal consumption of sugar is to be met locally. We cannot materially increase the area under cane, for this would disturb existing agricultural conditions, nor is there any likelihood of increasing the yield per acre to anything like this figure. There is, however, some room for improvement in the manufacture of *gur* itself, in checking losses in crushing and boiling and, while there is so much cane grown in the district, an effort should be made to minimize these losses. This will be a real improvement and a boon not only to the Gurdaspur farmer but to the sugar consumer throughout India.

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