THE EXTENSION OF AMERICAN COTTON CULTIVATION UNDER IRRIGATION IN THE WESTERN PUNJAB AND SINDH.

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Prejudice against cotton—Comparison of profits from wheat and cotton—Other factors in favour of cotton—Need of the world for more cotton—Method of increasing cotton—Growing areas—Decrease of wheat area—Financial aspect—Appendices.

Prejudice against Cotton.

The present canals of the Punjab are mainly adapted for wheat growing, since it was obviously more economical to build them to carry not much more than the minimum or winter supply, as this enabled the canals to be fairly fully utilized both in winter and summer. Water goes much further in the rabi (winter) than in the kharif (summer), and hence the cropping on perennial canal areas tends to become preponderately rabi. For example, in the Lower Chenab Canal, with a kharif supply of ten thousand cusecs, and a rabi, whose minimum is between four and seven thousand cusecs, the kharif cropping is returned as only 700,000, while the rabi is 1,600,000 acres. Even considering toria * and rapeseed as kharif crops, we still have only 1,000,000 acres of kharif and 1,300,000 acres of rabi, and of the latter, over 1,000,000 acres are wheat, while cotton is generally under 250,000 acres.

Again, perennial irrigation in the Punjab, up to twenty-seven years ago, was found almost entirely east of Lahore, and experience with the Upper Bari Doab Canal and the Western Jamna and Sirhind canals, had impressed irrigation officers with the greater reliability of wheat as compared with cotton; the latter suffering so much from rains and other calamities that it was not regarded as a safe crop.† It would appear from official papers that in 1910, there was a partial failure of the cotton crop on the Western Jamna Canal, owing to late September rains, and that a remission of Rs. 2 per acre, on a considerable area, was deemed essential.

* Toria = Brassica Campestris (oilseed).

† See notes by Ward and Sopwith on files in Irrigation Secretariat, "Failure of cotton crop in Delhi Division in 1910."

Experience in the eastern Punjab, where the rainfall is heavy as compared with western districts, is probably responsible for a great deal of the prejudice against cotton which appears to be entertained by some observant irrigation officers; but it will be apparent from a perusal of the following paragraphs that the position in the western Punjab is different.

Comparison of Profits from Wheat and Cotton.

In order to prepare the ground properly, it is necessary to compare carefully the relative profits of wheat and cotton in the new colonies,* and in this connection some figures gathered from active enquiry in the villages and published by Mr. Hamilton, the late Director of Agriculture, are instructive. The figures for wheat and cotton in a village near Buchiana in the Lower Chenab Canal are as follow :—

General cultivation expenses.

	Rs.	a.	p.
Interest at 6¼ per cent. on Rs. 150, the cost of a pair of bullocks ...	9	6	0
Bullocks will work ten years; depreciation	15	8	0
Feeding the pair of bullocks for one year ...	107	8	0
Annual cost of implements	1	8	0
Total ...	133	14	0
The cropped area under one plough is ten kilas,† therefore the cost of cultivation per kila will be	13	6	0

Wheat.

	Rs.	a.	p.
Cost of cultivation as above	13	6	0
Cost of 26 seers of seed at Rs. 3 a maund ...	2	0	0
Manuring costs nothing.			
Weeding (if there is much wild onion) six men for one day at six annas	2	4	0
Reaping	6	2	0
Winnowing wheat and stacking straw at two seers per maund, which on 20 maunds 16 seers of grain is 41 seers, worth ...	3	1	0
Blacksmith and carpenter—village menials	1	6	0
Land revenue (Rs. 6), cesses (11½ annas), and water rate (Rs. 3-12-0) ...	10	7	6
Total ...	38	10	6

* Expenses and profits of cultivation in the Punjab, by W. S. Hamilton, I.C.S., Punjab Government Printing Press.

† A kila = 1·11 acres.

	Rs.	a.	p.	Rs.	a.	p.
Total produce twenty maunds of grain, at Rs. 3 a maund ...	60	0	0			
Forty maunds of straw, at three maunds to the rupee ...	13	5	0			
Total ...	73	5	0			
Net profit				34	10	6
III.—Cotton.						
Cost of cultivation as above				13	6	0
Seed at four seers to the kila				0	5	0
Weeding is done by the cultivator with his plough and costs nothing.						
Picking ; each picker gets a tenth, equivalent to one maund, worth				8	0	0
Carpenter and blacksmith				0	6	0
Land revenue (Rs. 6), cesses (11½ annas), and water rate (Rs. 3-12-0)				10	7	6
Total ...				32	8	6
* Production of cotton, nine maunds, at Rs. 8 per maund = Rs. 72.						
Net profit ..				39	7	6

It will be seen that the net profit for cotton is Rs. 4-13-0 per kila, or Rs. 4-0-6 per acre, greater than for wheat. Similarly, even for the Tarn Taran tahsil of the Amritsar district, the extra profit per acre from cotton, in an actual village, is given as Rs. 7-10-0 in favour of cotton. The great value of these figures lies in the fact that they are the result of careful local enquiries, and represent the views of the cultivator.

This calculation has, however, the following defects, some of which are partially discussed in the publication referred to :—

(*a*) The whole of the bhusa † has been debited to the cost of feeding the bullocks, and at the same time credited to the profits of wheat growing.

(*b*) The cropped area per plough in the instance recorded is thirteen kilas, but, as only ten kilas were bearing money crops, the cost of cultivation should be borne by these ten kilas. The figure would thus be Rs. 13-6-0 per kila, and not Rs. 10-4-0, and this is high.

* Production ought to be ten maunds or cost of picking should be omitted. Profit is Rs. 8 too low.

† Bhusa is threshed wheat straw.

(*c*) A uniform cultivation figure is used, although wheat receives a great deal more cultivation than cotton.

(*d*) Yields are much too high to be taken as averages for the whole canal system, though many individual squares undoubtedly reach even higher averages.

A calculation by the writer, which has been used in lectures at the Agricultural College for eight years, and is being constantly brought up to date, is given below. This is based on extensive and careful enquiries all over the canal colonies and represents the average conditions. The cost of a pair of bullocks and one man for a day is taken at Re. 1-4-0, which should be ample, and it is also assumed that a pair of bullocks will plough an acre a day.

OUTLAY.

Wheat.

	Rs.	a.	p.
Six ploughings, at Re. 1-4-0 each	7	8	0
Seed, 24 seers	2	8	0
Sowing (ploughing and sohagaing * twice)	3	0	0
Hoeing and weeding once (contract rate) ...	2	0	0
Water rate, revenue cesses, etc. (approximate)... ...	10	0	0
Reaping	5	0	0
Threshing	3	8	0
Winnowing and stacking ...	3	0	0
Total ...	36	8	0

Cotton.

Two ploughings ...	2	8	0
Sohagaing once	0	4	0
Seed ; four seers ...	0	6	0
Sowing (ploughing, sowing and sohagaing) ...	1	8	0
Hoeing by hand ...	2	0	0
Hoeing with a plough ...	1	0	0
Picking ; an eighth share ...	6	0	0
Water rate, revenue cesses, etc.	10	0	0
Total ...	23	10	0

* Sohagaing means dragging a plank over the ground to break up clods of earth and to cover the seed.

RETURN.

Wheat.	Rs.	a.	p.	
15 maunds of grain, at Rs. 3-4-0	48	12	0	
30 maunds of bhusa, at $2\frac{1}{2}$ maunds per rupee ...	12	0	0	
Total ...	60	12	0	
Profit	24	4	0	per acre
Cotton.	Rs.	a.	p.	
6 maunds at Rs. 8-0-0 ...	48	0	0	
Total ...	48	0	0	
Profit	24	6	0	per acre.

A great many cultivators only hoe cotton once, with the plough. The yields taken are very safe ones, being low for cotton, though, perhaps, somewhat high for wheat as an average per acre, but even with these very moderate figures, it is seen that wheat scarcely holds its own even against country cotton. With American cotton the position is radically different, for the yield is more certain and practically universally higher, while the kappas (seed cotton) fetches at least Rs. 3 a maund more. The premium last year averaged over Rs. 4 per maund of kappas. At Rs. 3 premium there is an extra profit per acre of Rs. 18-2 for American cotton, while the approximate price of cotton now is Rs. 16 as compared to Rs. 3-15-0 for wheat. The area under American cotton is already 270,000 acres.

Other Factors in favour of Cotton.

There are many other factors which will have a growing effect in favour of cotton, of which the most important are connected with improvements in cultivation. To double the figures taken as an average for wheat, *viz.* to reach thirty maunds per acre, is a comparatively difficult achievement, but yields of twelve and fifteen maunds of cotton are very common. In 1916, some of the college farm tenants, by sowing in lines and interculturing, reached a yield of $23\frac{1}{2}$ maunds, and it is evident that the people are not slow to realize the advantages of better systems of cultivation from the fact that, though broadcast sowing was universal for cottons in the Punjab, already about 6,000 acres of American cotton has been sown in lines three feet

* See Appendix VI for prices of wheat and cotton since 1909 at Lyallpur.

apart, in the Lower Chenab Canal and Lower Bari Doab Canal areas this year. Cotton, as compared to wheat, offers enormous possibilities of improvement by good cultivation.

Again, experience has shown that American cotton is a very sure crop, even in bad years such as 1911, when country cotton suffered severely from boll-worm. Owing to its gradual flowering, as compared to country cotton, it is less damaged by rain ; in fact, frost is the only serious danger from which it is apt to suffer more than country cotton, but even in this respect past experience has been favourable.

Need of the World for more Cotton.

This need, which has been prominent in the cotton world, especially in Great Britain, since 1901, led in the following years to the formation of the British Cotton Growing Association, with a voluntary capital of £500,000, with the object of encouraging cotton growing in the Empire. The position is, that at present America is producing sixty per cent. of the world's supply of cotton, or fifteen million, out of a total of twenty-five million bales. She is already using over half of her production herself, and there is a strong movement in the Southern States to grow more food crops, which will indirectly tend to restrict the supplies of cotton available for other countries. So far the activities of the British Cotton Growing Association have only led to an increase of 100,000 bales of cotton, mostly in Africa. It is from India, especially North-West India, however, that the Empire, and even India herself, must chiefly look to progress with staple cotton in the future.

The average price of cotton in Liverpool during the last twenty years has been as follows :—

Five years *	... 1895—1899	3·76 d.
,,	... 1900—1904	5·44 d.
,,	... 1905—1909	5·78 d.
,,	... 1910—1914	7·16 d.

which plainly shows that the supply is not keeping pace with the demand. The present price in Liverpool is 18 pence per lb.

Again one-third of the trade of Great Britain is in cotton goods, hence the importance of securing supplies of raw material.

* Report of a lecture by Mr. Hutton before the Manchester Athenæum, page 11 (February, 1917).

Methods of increasing Cotton growing Areas.

This will be taken under three main heads, *viz.* :—

1. New canals.
2. Improving inundation canals by adding weirs.
3. Adding to the summer supplies of existing perennial canals.

1. New canals are beyond the scope of this paper except as regards the remarks under the third main head.

2. Adding weirs to inundation canals. American cotton should, if possible, be sown before the end of April, and certainly before 10th May. Again, it requires water at the end of September, or early in October, and these desiderata also apply, though with less force, to country cotton, but the periods referred to are the ones when inundation canals fail. The provision of weirs would solve this difficulty, and would probably incidentally contribute to a much better distribution of the water used, and to the avoidance of excessive flooding, now so common on inundation canals.

3 Increasing the size of perennial canals. To double the size of all main channels, so as to carry an enhanced kharif supply, would mean that for the winter season a small quantity of water would be flowing in a large canal, with the result that the proportion of losses would tend to be excessive in proportion to the supply, and it would, therefore, be better to have a separate canal alongside the present one.* It would be thus possible, when lining is accepted as feasible, to carry out the operation conveniently during the winter season. Increasing supplies would tend to accentuate the evils of water-logging, and might bring about the necessity of lining at least portions of main canals. Two per cent. is the extent of water-logging at present on the Lower Chenab Canal.

Lining would in any case only be necessary for the perennial portion. It is not, however, proposed to discuss the many interesting engineering questions that suggest themselves, but to confine attention to the agricultural aspect. Taking the case of the Lower Chenab Canal, and supposing the size doubled to carry an extra kharif supply, what changes in cropping would occur ? It is sometimes stated that there is no room for increased cropping in the Lower Chenab Canal, yet the cropping is only 98 per cent. of the allotted area, according to the latest

* See paper by T. A. Curry on the Lining of Canals at this Congress meeting in 1917.

returns,* while in Egypt it is often as high as 230 to 300 per cent. A double kharif supply from April to October would only add 33 per cent. at the most to the cropping area.

A typical example of present cropping, and that eventually obtainable under double kharif supply, may be considered briefly :—

	Existing cropping.	*Eventual cropping.*
Cotton ...	2½	7
Sugarcane ...	½	1
Chari and guara †	3½	5½
Maize ...	1	1
Toria ...	3	1½
Wheat ...	11	8½
Miscellaneous ...	1	...
Fallow ...	2½	...
Gram ...	1	4
Senji ‡ ...	1	2
Wheat (after maize) ...		1

Area already cropped	24½ acres
Eventually	31½ acres
Increased cultivation ...	7½ acres
Area double cropped already ...	2 acres
Area double cropped eventually	7 acres

	Rs. a. p.
Income to Government per square under existing system, excluding proprietary dues ...	186 15 2
Eventual income would be §	241 2 1

The income of the zamindar would be as follows ‖:—

	Rs.	a.	p.	
Existing system ...	1,027	0	0	per square. ¶
Proposed system ...	1,472	0	0	,,

The agricultural advantages of the proposed system would be many, and may be thus enumerated :—

(*i*). The total area under leguminous crops, *i.e.*, crops which add nitrogen to the soil, would be 11½ as

*Administration Report, Punjab Irrigation, 1916.
† Guara = Cyamopsis psoralvides.
‡ Senji = Melilotis paraviflora.
§ See Appendix No. I for details.
‖ Square = A block of land 27·8 acres in area divided into twenty-five equal parts called kilas.
¶ See Appendices II and III for details.

compared to 4¼ under the present system. This would be an immense advantage, as alluvial soils provided they can get nitrogen, are inexhaustible.

(*ii*) Excess of cereal cropping would be done away with, and a deep rooted crop, *e.g.*, cotton, would take a more prominent part, thus equalising the strain on the soil.

(*iii*) More intensive agriculture would take the place of a non-intensive system, and this always tends to improve agricultural practice all over the world. The sowing of cotton and maize in lines, with interculture, would become essential and would gradually revolutionize existing practices. It is only by interculture of the growing crop that cotton and maize can get the requisite cultivation.

(*iv*) More fodder crops are bound to be grown, and this, being superior to the wheat straw (bhusa) which is at present produced in excess, would lead to improvement in cattle feeding and breeding—one of the main obstacles to agricultural improvement at present. This would also tend to relieve the competition of the colonies for working cattle from breeding areas such as the Hissar and Dhani tracts.

(*v*) Increased intensity is not incompatible with a high duty of water as has often been impressed on the writer by A. S. Gibb and others.

In the Egyptian Delta, where the conditions now are in some aspects an extreme instance of what is proposed in this paper, the cropping is very heavy indeed, yet Egypt leads the world in the outturn per acre of cotton, the average yield being 18 to 20 maunds of kappas per acre, yielding 400 lbs. of cotton as compared to the estimate of 160 lbs. per acre on the Lower Chenab Canal. The main characteristics of Egyptian agriculture are using heavy silt-bearing water, intensive cultivation, and a very high proportion of leguminous crops, *viz.*, berseem or Egyptian clover.* This proportion is given by Fletcher as generally sixty to a hundred per cent. of the land and thirty-three to fifty per cent. of the cropped area.

Objection to increasing the kharif supply is sometimes made on the basis that the demand for water is then small and that

* "Text Book of Egyptian Agriculture" by Fletcher and Fodden, Vol. II,

where more or less cotton is grown, but the fact that there is plenty of room for more intensive cropping is patent. This is universally admitted by zamindars,* and many holders of big areas on the Lower Chenab Canal are already concentrating on a few squares.

In the Lower Bari Doab Colony, the area under cotton per square is generally seven or eight acres, but conditions there are not typical, as rabi supplies have so far been low.

All that has been said with regard to cotton in the western Punjab, applies with still greater force to Sindh, where both a better quality of American cotton and higher yields can be obtained than in the Punjab. The more extended the growth of good quality cotton, the better is the price obtained, as the cotton only then becomes known to many spinners. The development of Sindh is, therefore, of great indirect interest to the Punjab.

Finally, the writer wishes to express his indebtedness, without committing anyone to agree with him on any particular point for most of the ideas expressed in this paper to many officers of the Irrigation Department, notably Messrs. Gibb, Woods and Ward, to many zamindars with whom he has discussed these problems, and to his colleagues in the Agricultural Department.

* See Appendix V for details.

APPENDIX No. I.

Existing Cropping.

Statement showing the gross income to zemindars for every twenty-five acres of land in the Lower Chenab Canal Colony.

Crop.	Area in acres.	Outturn per acre. Maunds.	Price per maund. Rs. a. p.	Total. Rs. a. p.
Cotton (American) ...	2½	6½	10 0 0	162 8 0
Sugarcane		22	4 8 0	49 8 0
Chari-Guara	28 kanals	@ Rs. 5 per kanal		140 0 0
Maize	1	16	2 8 0	40 0 0
Toria	3	8	4 0 0	96 0 0
Wheat	11	13	3 0 0	429 0 0
Miscellaneous	1	11¼	2 12 0	31 0 0
Gram	1	11¼	2 12 0	31 0 0
Senji	8 kanals	@ Rs. 6 per kanal		48 0 0
Wheat (after maize) ...		*Nil.*		
Total ...	...	...	...	1,027 0 0

Note.—"Price of American cotton has been taken at Rs. 10 per maund and wheat at Rs. 3 per maund. Outturns are as given for next quinquennial returns."

APPENDIX No. II.

Proposed cropping (double kharif supply).

Statement showing the gross income to zemindars for every twenty-five acres of land in the Lower Chenab Canal Colony.

Crop.	Area in acres. Maund.	Yield per acre. Maunds	Price per maund. Rs a. p.	TOTAL. Rs. a. p.
Cotton (American) ...	7	6½	10 0 0	455 0 0
Sugarcane	1	22	4 8 0	99 0 0
Chari-Guara	44 kanals	@ Rs. 5 per kanal		220 0 0
Maize	1½	16	2 8 0	60 0 0
Toria	1½	8	4 0 0	48 0 0
Wheat	8½	13	3 0 0	331 8 0
Miscellaneous	...	...	...	..
Gram	4	11¼	2 12 0	123 12 0
Senji	16 kanals	@ Rs. 6 per kanal		96 0 0
Wheat (after maize) ...	1	13	3 0 0	39 0 0
Total ...	...	..	...	1,472 4 0

Note.—" Price of American cotton taken at Rs. 10 per maund and wheat at Rs. 3 per maund."

APPENDIX No. III.

Showing water rate and land revenue, etc., of existing and eventual cropping.

1	2	3	4	5	6	7	8	9	10	11	12	13
				Land revenue, Malikana, and cesses.					Land revenue and cesses.			
Serial No.	Name of existing crop.	Area in acres.	Water rate.	Land revenue.	Malikana (Proprietary dues).	Cesses.	Total.	Total of columns 4 and 8.	Land revenue.	Cesses.	Total.	Total of columns 4 and 12.
			Rs. a.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs a. p	Rs. a. p	Rs. a. p.
1	Sugarcane...	½	3 12	1 12 0	0 6 0	0 4 4	2 6 4	6 2 4	1 12 0	0 4 4	2 0 4	5 12 4
2	Cotton ...	2½	9 6	8 12 0	1 14 0	1 3 1	11 13 1	21 3 1	8 12 0	1 3 1	9 15 1	19 5 1
3	Maize ...	1	3 12	3 8 0	0 12 0	0 8 8	4 12 8	8 8 8	3 8 0	0 8 8	4 0 8	7 12 8
4	Chari and Guara.	3½	8 12	12 4 0	2 10 0	1 14 2	16 12 2	25 8 2	12 4 0	1 14 2	14 2 2	22 14 2
5	Toria ...	3	11 4	10 8 0	2 4 0	1 9 11	14 5 11	25 9 11	10 8 0	1 9 11	12 1 11	23 5 11
6	Wheat ...	11	41 4	38 8 0	8 4 0	5 15 0	52 11 0	93 15 0	38 8 0	5 15 0	44 7 0	85 11 0
7	Miscellaneous	1	3 12	3 8 0	0 12 0	0 8 8	4 12 8	8 8 8	3 8 0	0 8 8	4 0 8	7 12 8
8	Gram ...	1	2 8	3 8 0	0 12 0	0 8 8	4 12 8	7 4 8	3 8 0	0 8 8	4 0 8	6 8 8
9	Senji ...	1	3 12	3 8 0	0 12 0	0 8 8	4 12 8	8 8 8	3 8 0	0 8 8	4 0 8	7 12 8
											Total ...	186 15 2

APPENDIX No. III—*concluded.*

1	2	3	4	5	6	7	8	9	10	11	12	13
				Land revenue, malikana, and cesses.					Land revenue and cesses.			
Serial No.	Name of eventual crop.	Area in acres.	Water rate.	Land revenue.	Malikana.	Cesses.	Total.	Total of columns 4 and 8.	Land revenue.	Cesses.	Total.	Total of columns 4 and 12.
			Rs. a.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1	Sugarcane ..	1	7 8	3 8 0	0 12 0	0 8 8	4 12 8	12 4 8	3 8 0	0 8 8	4 0 8	11 8 8
2	Cotton ...	7	26 4	24 8 0	5 4 0	3 12 5	33 8 5	59 12 5	24 8 0	3 12 5	28 4 5	54 8 5
3	Maize ...	1 1/2	5 10	5 4 0	1 2 0	0 12 11	7 2 11	12 12 11	5 4 0	0 12 11	6 0 11	11 10 11
4	Chari and Guara	5 1/2	13 12	19 4 0	4 2 0	2 15 5	26 5 5	40 1 5	19 4 0	2 15 5	22 3 5	35 15 5
5	Toria ...	1 1/2	5 10	5 4 0	1 2 0	0 12 11	7 2 11	12 12 11	5 4 0	0 12 11	6 0 11	11 10 11
6	Wheat ...	9 1/2	35 10	33 4 0	7 2 0	5 2 0	45 8 0	81 2 0	33 4 0	5 2 0	38 6 0	74 0 0
7	Gram ...	4	10 0	14 0 0	3 0 0	2 2 6	19 2 6	29 2 6	14 0 0	2 2 6	16 2 6	26 2 6
8	Senji ...	2	7 8	7 0 0	1 8 0	1 1 3	9 9 3	17 1 3	7 0 0	1 1 3	8 1 3	15 9 3
											Total ...	241 2 1

APPENDIX No. IV.

Cropping over 140 per cent.

Kharif.	Rabi.	Kharif.
1 Fallow ...	1 Toria ...	1 Cotton.
1 Fallow ...	1 Toria and Gram ..	1 Cotton.
3 Fallow ...	3 Wheat ...	2 Chari. 1 Fallow.
2 Fallow ...	2 Wheat ...	1 Cotton. 1 Fallow.
3 Maize ...	3 Wheat ...	3 Chari.
4 Chari ...	4 Grams ...	4 Cotton.
3 Cotton ...	3 Senji ...	1 Sugarcane. 2 Maize.
1 Sugarcane ...	1 Fallow ..	1 Cotton.
6 Cotton ..	6 Fallow ...	1 Maize. 5 Fallow.
1 Chari ...	1 Fallow ...	1 Cotton.
25	25	25

Kharif crops .. 18 acres.
Fallow ... 7 „

Rabi crops ... 17 acres.
Fallow ... 8 „

Toria. ..	Toria and Gram.	Wheat .	Wheat ...	Wheat.
Cotton ...	Cotton ...	Chari and Guara.	Chari mixture.	Fallow.
Wheat ...	Wheat ...	Wheat ...	Wheat ...	Wheat.
Cotton ...	Fallow ...	Chari mixture.	Chari mixture.	Chari mixture.
Gram ...	Gram ...	Gram ...	Gram ..	Senji.
Cotton ...	Cotton ...	Cotton ...	Cotton ..	Sugarcane.
Senji ...	Senji ...	Fallow ...	Fallow ...	Fallow.
Maize ...	Maize ...	Cotton ...	Maize ...	Fallow.
Fallow ...	Fallow ...	Fallow ..	Fallow ...	Fallow.
Cotton ...	Fallow ...	Fallow ...	Fallow ...	Fallow.

APPENDIX No. V.

Possible cropping with increased kharif supply of water.

Cotton	8 Kilas.	On large holdings under direct cultivation.
Sugarcane	2½ ,,	
Chari-Guara	2 ,,	
Maize	1½ ,,	
Miscellaneous	1 ,,	
	15 Kilas.	
Cotton	8 Kilas.	Large holdings cultivated by tenants.
Sugarcane	1 ,,	
Maize	2 ,,	
Chari-Guara	4 ,,	
	15 Kilas.	
Cotton	7 Kilas.	Zemindars with one square under direct cultivation.
Sugarcane	3 ,,	
Maize	2½ ,,	
Chari-Guara	2½ ,,	
	15 Kilas.	
Cotton	8 Kilas.	
Bajra	3 ,,	
Chari-Guara	3½ ,,	Jangli zemindars.
Sugarcane	½ ,,	
	15 Kilas.	
Cotton	5 Kilas.	
Sugarcane	2 ,,	
Maize	2 ,,	Light soils.
Chari-Guara	5 ,,	
	14 Kilas.	

APPENDIX No. VI.

Minimum and maximum prices of wheat and cotton at Lyallpur since 1909-10.

Year.	Minimum.		Maximum.	
	Wheat.	Cotton.	Wheat	Cotton.
	Rs. a. p.	Rs. a p.	Rs. a. p.	Rs. a. p.
1909-10	...	7 1 0	...	8 8 0
1910-11	2 9 6	8 14 0	3 1 6	10 10 0
1911-12	2 11 0	8 2 0	3 5 6	9 3 0
1912-13	2 14 6	8 5 9	3 4 0	10 13 0
1913-14	2 14 0	7 0 0	3 4 0	8 7 6
* 1914-15	3 2 0	4 6 0	5 3 0	5 0 6
1915-16	3 4 0	7 6 0	3 7 6	8 0 6
1916-17	2 14 0	8 14 0	4 2 0	11 8 0
†1917-18	3 9 0	‡10 [illegible] 0	4 2 0	‡12 0 0

Prices are as supplied by Ralli B[illegible]s' Agency, Lyallpur.
* Temporary fall in price of cotto[illegible]d rise in wheat due to the war.
† Up to September 1917.
‡ Price of forward buying of country cotton.

DISCUSSION.

MR. FAULKNER, in the unavoidable absence of Mr. Roberts, introduced the paper by saying that the facts of the case as regards cotton cultivation had altered in recent years. In the first place, there had been a general rise in the price of cotton, which was now extremely high, and this was not mainly due to the effect of the war, but to the discrepancies between the world's supply and demand, and it was believed that the price of cotton would continue to remain very high at least for some time after the war. In fact there was nothing which one could now foresee, which would cause the price of American cotton to fall very low. The conditions in the Punjab had also been altered by the introduction of American cotton, because it was in many ways a safer crop than the country variety, which was the poorest class of cotton in the world. The lowest grade of any commodity inevitably suffered first in any fall in prices; but American cotton was just within the limit which could be sold in every market of the world, and consequently commanded a surer price. It was also a safer crop than the country variety, which was more liable to damage from rain and insect pests. As a result of these facts the area under American cotton in the canal colonies was rapidly increasing, but with existing water supplies it could not increase beyond a comparatively small figure; after that, further increase could only follow an increase of water supply in the kharif.

In the paper it was suggested that it was possible and profitable, from the agricultural point of view, to grow an increased area of cotton, provided that water was available at the critical times; that such an increase would lead to a sounder system of farming and to an increase in the area under fodder crops which would lead to improvement in the class of cattle and to a great increase in the supply of farmyard manure. If more kharif area were grown it must mean more fodder crops, as these were short period crops.

An attempt had been made in the tables attached to the paper to show the return which might be attained by the farmer and by the State if the canal kharif supply could be increased. The first part of Appendix No. III presented a general idea of the existing cropping in the Lower Chenab Colony, while the second part was an indication of what Mr. Roberts considered could be done with an increased kharif supply. Appendix No. IV was merely an indication of possible cropping to about 140%, with

an increased kharif supply, with a table showing the cropping of each field separately, while Appendix No. V showed the actual existing kharif cropping in certain selected villages on different canals.

RAI BAHADUR LALA GANGA RAM said that the paper was a conclusive reply to a remark which fell from the lips of both the Chief Engineers of the Punjab Irrigation Branch at the last wheat conference, namely that, although the existing canals were generally speaking not capable of giving an increased supply in the kharif season, yet wherever this was possible, there was no demand for more water in that season. Mr. Roberts had done a great service to the agricultural community in showing that there was a demand for more water, and he thought that a further demand could be created by introducing new crops and new methods of using the coarse cereals which should be grown in the kharif season. The mistake was originally made in announcing that the annual irrigated area on the Lower Chenab Canal should be in the proportion of three-fifths in the rabi crop and two-fifths in the kharif crop. Last year's annual Administration Report showed, however, that the rabi area was responsible for 71·23 per cent. of the whole. Mr. Faulkner had pointed out the advantages to the cultivator in growing more fodder crops, but there was one further advantage, which had not been mentioned. The requirements of farming were so great that all the manure available was not sufficient for the requirements of the land, but green manuring could not be introduced as an additional source of replenishment without more water in the kharif season. It was generally assumed that in order to keep up the strength and vitality of the soil it was better to let it lie fallow for some time. This was a mistake, as fallow land deteriorated unless it was ploughed up at intervals.

Intensive cultivation and more manure were the really essential things and the pressing economical needs of the country. He had recently published some statistics in a pamphlet which he thought proved that only enough cereals were being produced in the country for the bare existence of the population, and the only possible source of supply of food stuffs to meet the future increase in the population lay either in intensive cultivation or in increased yield, and it followed, therefore, that an increased supply from the canals should be given in the kharif when the water was available in the rivers. Mr. Roberts had

taken the amount of straw as double the grain obtained, but he had never obtained more than twenty-five per cent. in excess of the grain.

MR. QUINN-YOUNG thought that Mr. Roberts had based his arguments on a questionable assumption. There was no prejudice for or against cotton cultivation in the minds of canal officers, nor had any disfavour been shown towards the cultivation of this crop. Moreover to say that the Punjab canals were built on a wheat basis was to introduce a novel idea, which was as open to challenge, as it would be to allege that there were unalterably fixed duties. There had been but past experience to go upon. On some canals wheat was the chief crop, on others rice, and so on. Averages were struck, and so many acres per cusec were allotted, and this was taken as the designing symbol for the capacity of the canal, but in the course of time the distributaries, and even the main canals, were remodelled to adopt themselves to new duties, when current practice showed this to be necessary. For instance, on the Upper Chenab Canal some channels were modelled on a rice basis of a hundred acres per cusec at the outlet head, but where sugarcane was the predominating crop a lesser duty was taken in the course of time, no doubt, there would be a reconsideration of duties.

Reference had been made to the partial failure of the cotton crop on the Western Jumna Canal in 1910, but such failures had occurred on all canals; for instance in 1915 there were heavy cotton failures on the Lower Chenab Canal. On the Western Jumna and Sirhind canals, cotton failed because of the dust-storms, but it was the people (and not the canal officers) who put forward this reason for not growing more cotton. On the other hand the *soondi* caterpillar destroyed wheat, sarson and gram wholesale, yet there was no prejudice claimed against the cultivation of these crops.

Mr. Roberts also stated that his object was to induce the increased growth of cotton "because the world had need of it," but surely the world could also do with more wheat: if the area under cotton was to be extended, why should it be at the expense of wheat? Neither were luxuries; in fact both were essentials. The figures quoted by Mr. Roberts showed that the British Cotton Growing Association had made very slow progress since 1901, and it would be impossible to look for quicker progress from the conservative Punjabi. As long as the simple wants of the cultivator were met, he would be

prejudiced in favour of wheat, but when either the intensity of population or the extension of luxuries demanded it, he would raise more valuable crops. If the world needed more cotton after the war, no doubt East and West Africa, Uganda and the Sudan would meet the demand, for there they had no inherited customs to contend against. That there was money to be made from the cu' vation of food crops in preference to cotton was evidenced y the fact mentioned by Mr. Roberts that "the cotton states merica were more favourably inclined to food stuffs." If thi re so in America, how could it be brought home to th imple Indian that cotton was more profitable than wheat ?

Turning to the various means of meeting the demand for more cotton, he thought that the new canals, now under consideration, would irrigate areas more suitable for wheat and gram than for cotton. The improvement of inundation canals, by adding weirs to the rivers, could only be undertaken if it were going to be remunerative, whether the crops to be grown were cotton or wheat, while, as regards proposals for lining canals, he thought that the cost would be enormous and the engineering difficulties extremely great. It did not appear possible to go in for more intensive cultivation unless more manure was forthcoming : "green manuring" was scarcely practised at all, in spite of the nominal charge for the water used. Conditions in Egypt were very different, for the Nile silt was very fertilising, whereas the silt from the Punjab rivers was often deleterious. If it were not for the enriching quantities of the Nile silt, there could not be the cotton or other crops at present so lavishly produced in Egypt.

MR. J. D. BEDFORD presented some statistics extracted from official publications, showing that Mr. Roberts's contention that there was insufficient water was not borne out by facts. The statistics referred to the Western Jumna, Sirhind, Upper Bari Doab, Lower Chenab, and Lower Jhelum canals. The canals of the Triple Project were not included, as they had not yet been fully developed. One statement gave the full supply discharge and the average monthly discharges for a period of eleven years, and during this period it was only on very rare occasions that the average supply of any month approached the designed supply. Column 10 of the statement showed that, at a moderate estimate, if the existing capacity of the Lower Chenab Canal were utilized to the utmost, 2,600,000 more acres of cotton might have been sown, and in the same period 850,000 acres of cotton could

have got seven waterings if it had been sown, and that some area less than 2,600,000 acres and more than 850,000 acres could have got six instead of seven waterings. A similar state of affairs existed on all the other canals. The second statement showed that the Western Jumna Canal, although smaller than the Lower Chenab Canal, grew more cotton.

These statistics clearly indicated that it was necessary to look elsewhere for the reason for the slow development of cotton cultivation. The author would agree with him that the area under wheat was almost entirely dependent on the supply of moisture available at sowing time. The zemindar, from past experience, knew that, if the winter rains failed, he would not have sufficient water to mature all his wheat, and so he gambled on rain. The zemindar would not gamble similarly where cotton was concerned, as past experience had shown him that, even under favourable circumstances as regards water, cotton was a risky crop, so that to increase the area under cotton, the crop must be made more secure by combating the several blights that attacked it ; and, at the same time, the zemindars must be educated up to the standard of cotton cultivation.

Another reason for the slow increase of cotton might be that, in the past, the zemindar had been generally made to understand that only a certain percentage of his area was to be irrigated, on pain of having his outlet reduced, and this might often mean that he would have to choose between an acre of wheat and an acre of cotton, and, wherever this choice had to be made, there was lit' doubt that cotton would come second. The statistics cl showed that there was no shortage of water at the cotton ing time. The only period of the year where there was likely be some shortage was when the maturing of cotton synchroni d with the sowing of wheat and toria. This was the only period when the extra water was likely to be used, but to what purpose would the zemindar put this extra water ? To the maturing of cotton or to increasing his gamble on wheat and toria ? Experience led one to believe that a second canal alongside the present Lower Chenab Canal would increase the wheat and toria crops far more than the cotton crop.

Statement showing the average discharges from April to October on certain canals as compared with the authorized full supply discharge.

1	2	3	4	5	6	7	8	9	10	11
Name of Canal.	Year.	April.	May.	June.	July.	August.	September.	October.	Extra cotton that might have been sown. Acres.	Extra cotton that could have got seven waterings if sown. Acres.
Western Jumna Canal. Authorized full supply discharge being 6,301 cusecs.	1915-16	4,048	4,454	4,476	4,771	4,945	4,769	4,54.	225,300	135,600
	1914-15	4,912	4,638	5,291	3,690	2,377	5,814	4,031	-	48,700
	1913-14	3,955	3,491	3,940	2,463	5,115	5,189	2,781	281,000	111,200
	1912-13	3,010	3,288	3,845	5,119	3,008	4,433	5,258	329,100	104,300
	1911-12	4,459	5,127	3,419	5,163	6,311	5,275	3,393	184,200	...
	1910-11	2,034	3,128	4,510	3,474	3,374	3,061	3,260	426,700	179,100
	1909-10	2,702	3,037	3,779	2,121	3,706	986	3,896	359,900	211,500
	1908-09	2,585	2,435	3,414	2,947	...	2,199	4,046	386,600	225,500
	1907-08	3,493	5,123	5,529	4,711	2,768	4,178	2,878	280,800	77,200
	1906-07	3,610	4,856	3,540	4,403	3,178	3,814	3,828	269,100	144,500
	1905-06	3,990	4,406	4,997	3,595	5,350	4,704	3,480	231,100	95,100
										1,382,700

Sirhind Canal with an authorized full supply discharge of 8,000 cusecs.	1915-16	5,093	3,869	3,360	4,881	7,055	7,298	7,310	413,100	65,000
	1914-15	4,685	6,787	5,891	3,814	4,583	5,542	4,537	331,500	121,300
	1913-14	5,288	4,901	5,274	3,079	6,739	8,222	6,361	309,900	...
	1912-13	4,335	7,232	7,977	5,284	4,412	7,359	7,465	366,500	2,300
	1911-12	3,670	3,986	3,266	6,025	7,381	7,369	7,786	433,000	21,400
	1910-11	3,983	2,894	3,252	2,561	3,575	6,299	6,144	512,600	170,100
	1909-10	4,898	5,721	4,344	2,307	4,308	3,059	6,095	310,200	190,500
		5,560	5,866	7,284	5,226	2,451	4,810	6,239	244,000	71,600
	1907-08	5,752	5,114	4,505	5,069	2,553	7,326	6,991	288,600	67,400
	1906-07	5,513	5,344	5,156	5,691	5,265	4,099	7,408	265,600	59,200
	1905-06	6,966	6,323	5,869	5,180	4,784	6,157	7,028	167,700	97,200
	Totals ...	...	...	...	..	...	...	...	3,640,700	866,000

1	2	3	4	5	6	7	8	9	10	11
Name of Canal.	Year.	April.	May.	June.	July.	August.	September	October.	Extra cotton that might have been sown. Acres.	Extra cotton that could have got seven waterings if sown. Acres.
Upper Bari Doab Canal with an authorized full supply discharge of 6,500 cusecs.	1915-16	4,031	3,437	6,352	6,401	5,964	5,987	3,451	306,300	29,900
	1914-15	4,977	6,067	6,343	3,742	4,418	4,715	4,606	152,300	15,700
	1913-14	5,033	6,089	4,992	5,008	4,045	5,246	3,149	146,700	
	1912-13	4,994	6,175	5,862	5,886	3,901	5,973	3,567	150,600	32,500
	1911-12	3,941	5,560	5,602	6,094	6,090	6,016	4,068	255,900	40,600
	1910-11	4,079	5,667	5,713	4,902	3,578	5,142	4,620	242,100	78,700
	1909-10	3,748	5,156	6,187	4,994	5,594	2,471	4,672	275,200	31,300
	1908-09	4,699	5,802	6,485	5,057	2,279	3,216	3,847	180,100	1,500
	1907-08	3,386	5,133	5,215	6,074	4,546	6,053	3,348	311,400	42,600
	1906-07	2,835	5,821	5,287	5,821	5,944	3,462	5,282	366,500	55,600
	1905-06	4,947	5,409	5,587	5,555	6,381	4,299	4,178	155,300	11,900
							...	...	2,542,400	381,400

Lower Chenab Canal with an authorized full supply discharge of 10,930 cusecs.	1915-16	7,648	8,892	8,786	7,740	9,364	9,242	9,471	334,200	191,300
	1914-15	10,081	9,584	9,791	8,736	9,001	9,879	9,851	140,600	90,900
	1913-14	9,511	6,621	8,153	7,869	7,318	9,242	9,017	436,900	147,900
	1912-13	9,682	9,618	10,577	9,646	9,030	9,829	8,997	137,200	41,300
	1911-12	9,377	8,671	9,026	9,079	9,923	10,144	10,350	231,900	64,000
	1910-11	9,568	8,837	9,062	9,048	10,967	8,481	10,092	215,300	2,300
	1909-10	10,598	8,495	8,417	6,825	8,521	8,025	10,051	249,500	39,200
	1908-09	9,190	10,087	10,082	8,286	8,601	8,863	9,493	180,000	90,300
	1907-08	9,975	8,564	8,429	9,605	9,119	10,051	9,642	242,600	3,900
	1906-07	9,381	8,686	9,430	9,369	9,827	8,358	10,430	230,400	56,000
	1905-06	10,255	8,867	8,948	9,072	9,726	8,970	10,317	212,300	67,300
	Totals ...	...	...	...	...	...	...	...	2,610,900	845,000

1	2	3	4	5	6	7	8	9	10	11
Name of Canal.	Year.	April.	May.	June.	July.	August.	September.	October.	Extra cotton that might have been sown. Acres.	Extra cotton that could have got seven waterings if sown. Acres
Lower Jhelum Canal with an authorized full supply discharge of 4,000 cusecs.	1915-16	3,163	3,118	3,203	3,246	3,576	3,758	3,757	93,700	24,200
	1914-15	3,406	3,062	3,151	3,177	2,553	3,605	3,542	93,800	39,500
	1913-14	3,437	2,793	3,248	2,989	3,278	3,035	3,511	129,700	48,900
	1912-13	3,010	2,684	3,278	3,491	2,902	3,518	3,809	131,600	19,100
	1911-12	3,128	2,649	3,247	3,266	3,756	3,586	4,002	135,100	
	1910-11	3,393	3,012	3,170	2,593	2,733	3,299	3,713	98,800	
	1909-10	3,391	2,737	3,021	2,816	3,104	3,586	3,571	24,300	[illegible]
	1908-09	3,767	3,415	3,500	2,971	2,215	1,884	3,352	58,700	23,300
	1907-08	3,412	2,748	2,916	3,359	2,923	3,727	3,818	125,900	18,200
	1906-07	3,370	3,135	2,701	2,865	2,970	2,624	3,662	86,500	23,800
	1905-06	3,016	2,604	2,848	2,530	2,785	2,395	3,152	139,600	84,000
	Totals ...	...	...	...	...	...	...	...	1,107,800	361,900

Note.—The figures of average monthly discharge have been taken from "Statistics of Irrigation, Water Distribution, and Working of Distributaries of the Canals in the Punjab" for various years.

Column 10 was obtained as follows:

The sowing season for cotton is April—May. The actual average discharge in April *or* May, whichever is less, is deducted from the designed full supply discharge. This gives the water available, and it has been assumed that a hundred acres of cotton can *be sown* (not matured) with one cusec per month, so that multiplying the water available by 100 gives the average of cotton that could have been sown.

Column 11 was obtained by deducting the largest monthly average from the designed full supply discharge, when the difference multiplied by 100 gives the acreage of cotton that could have got seven waterings.

*Cotton crop assisted on various Canals.**
1905-06 *to* 1915-16.

Canal.	Year of maximum crop.	Maximum area. (Acres.)	Total for eleven years. (Acres.)	Average for eleven years. (Acres.)
Western Jumna Canal ...	1905-06	323,669	2,320,665	210,969
Sirhind Canal (Both branches)	1913-14	84,039	439,867	39,979
Upper Bari Doab Canal ...	1913-14	234,989	1,565,105	142,282
Lower Chenab Canal ...	1914-15	261,819	1,840,848	167,349
Lower Jhelum Canal ...	1913-14	105,168	612,148	55,649

LALA WAZIR CHAND CHOPRA thought that the problem of increasing the area under cotton, or, for the matter of that, of any other non-food stuff, was not so much a question of irrigation facilities, as one of improving the agrarian and agricultural conditions of the country Mr. Roberts had referred particularly to the Western Punjab and Sindh, but to understand the problem it was necessary to consider the whole of India. According to the statistics collected by Rai Bahadur Lala Ganga Ram in his recently published pamphlet entitled "The Agricultural Problem of India", the annual requirements of the country in food stuffs amount to 71 million tons, as against the total normal produce of 76 million tons. Further, these figures were obtained when 89 per cent. of the land was under the cultivation of food stuffs. These relations should more or less hold good for each part of the country, and it would be noted that the margin between consumption and produce was not large. In congested districts, the holdings were small, and as an example he took the Gujrat district, where the size of the holdings were only five acres in two tahsils, and seven acres in the third. In such small holdings it w natural for the proprietor or tenant to raise as much food stu was possible by sowing nearly the whole area. In the Gu district, 100 per cent. of the whole area was under cultivatic nnually and the proportion

* *Note.*—These figures are taken from "Statistics of Revenue, Expenditure and Working of the Canals in the Punjab from the year 1887-88" printed in 1914.

of kharif crops was 35 per cent. of the whole. Before irrigation started the areas under various classes of crops were as follows :—

Food stuffs	74 per cent.	(of which 39 per cent. was wheat.)
Fodder	... 9	,,
Sugarcane	... 1	,,
Oil seeds	... 3	,,
Cotton	... 2	,,
Miscellaneous	... 11	,,

It would be noted that nearly three-fourths of the area was under food stuffs ; five-sixths was under food stuffs and fodder combined ; whilst only one-fiftieth was under cotton. Such were apparently the natural requirements under present conditions ; and if the area under cotton were to increase, it could only be at the expense of the area under food stuffs. As already shown, the present margin of extra food stuffs was small, and before any alteration could be made in the relative areas under the various crops it would be necessary for conditions to be changed so that—

(*a*) The yield per acre of food stuffs would be increased

(*b*) Such soils as were not suitable for canal irrigation might be made so, after an investigation as to what crops could be grown on them.

(*c*) Holdings should be increased to an economic size, so that the individual cultivator could look at the question from the aspect of market prices, which was Mr. Roberts's point of view.

According to Mr. Roberts, American cotton should be sown before the end of April, which meant that waterings would be required in February and March, and further waterings were required in September and October, but unfortunately these periods were just the ones before the rivers rose in the spring on the one hand, and when they fell to below canal capacity on the other. Increasing the capacity of the canals to take in water, which was seldom available, would, therefore, scarcely improve the prospects of an extension of cotton.

MR. NICHOLSON drew attention to the fact that the author started his paper by presuming there was a prejudice against cotton, referring to the " prejudice against cotton which appears to be entertained by some observant irrigation

officers", from which it was clear, that Mr. Roberts was charging irrigation officers with prejudice, and this he wished to refute. The author stated that the Punjab canals were adapted for growing wheat, as they did not carry much more than the minimum or winter supply of the rivers, but the author, who was a resident of the parish of Lyallpur on the Lower Chenab Canal, might not be acquainted with the other canals of the province; and appeared to be generalizing from the particular case with which he was acquainted. The Lower Chenab Canal started in quite a small way as an inundation canal, and developed in accordance with the demands that arose; it was not a pre-conceived scheme to grow wheat, nor was its present capacity only slightly in excess of the minimum or winter supply of the river.

Taking statistics for the canals of the province as a whole, it would probably be startling to the author to hear that the total capacity of the perennial canals was five times the minimum discharge of the rivers from which they drew their supply. A diagram was put forward shewing (*a*) the percentage of the full supply capacity of the various canals run in the rabi and kharif on a ten year average, (*b*) the percentage of the gross area, within irrigation limits, irrigated during the rabi and the kharif on the various canals on this same ten year average, (*c*) the percentage of the gross area, within irrigation limits, of wheat and cotton irrigated in the rabi and kharif respectively on a five year average. In addition to the ordinary rectangular axes, radial axes were given, which enabled further information to be obtained by an inspection of the diagram These radial axes shewed the proportion between the conditions plotted on the *x* and *y* axes; thus the kharif supply utilized on the Upper Bari Doab Canal was double that of the rabi supply utilized, whereas the Lower Jhelum Canal utilized 1·1 times as much water in the rabi as in the khar[illegible] Again, the Upper Bari Doab irrigated 1·2 times as mu[illegible] area in the rabi as in the kharif, whereas the Lower Jhelu[illegible]anal irrigated three times the area in the rabi that it did in [illegible] kharif. Again, the Upper Bari Doab Canal irrigated 1·5 tir[illegible]s as much wheat as cotton, whereas the Lower Jhelum Canal irrigated nine times as much. A further set of axes at forty-five degrees was given, which enabled further information to be read off; thus the mean supply in both crops of the Lower Jhelum was 76 per cent. of the full supply. The total irrigation of both crops on the Lower Jhelum Canal was 51 per cent. of the gross area within irrigation

limits. The total area of wheat and cotton irrigated on the Lower Jhelum Canal was 31 per cent. of the gross area.

Plotting, on such a diagram as this, figures for various canals, gave at a glance a clear comparison between the conditions existing on, and the working of, the various canals. An inspection showed that the Upper Bari Doab, Lower Chenab and Lower Jhelum Canals all utilised very similar amounts of water in the kharif. The Western Jumna Canal utilised less, as that river had a small catchment in the snows, and the canal could only be sure of getting its full supply when the monsoon broke. The Sirhind Canal, to which the speaker had the honour to belong, was the worst canal of all: it only utilized ·48 of its full supply in the kharif, although there was always ample water in the Sutlej. This was reflected in the fact that the Sirhind Canal did the least area of kharif irrigation, and was far and away the worst canal as regards cotton cultivation, which was only one twenty-fourth of the wheat area. If barley, of which a large area was grown on the Sirhind Canal, were treated as a cereal equivalent to wheat, the proportion was much worse. If Mr. Roberts thought that there was not enough water available in the canals, and that owing to this cotton cultivation was restricted, there was the Sirhind Canal, on which the very conditions existed for which he was crying out. He would find a warm welcome awaiting him on the canal and no prejudice against cotton in the minds of the irrigation officers there, so it only remained for him to get the cultivators to take up cotton cultivation, in which endeavour he would receive the whole-hearted assistance of the irrigation officers, and probably far more water than he could utilize. There was no doubt but that cotton and wheat were antagonistic crops, since the canal that had the highest cotton duty had the lowest wheat duty; duty being taken as the area irrigated per cusec of full capacity at the canal head. Thus, on the Western Jumna, with a wheat to cotton area of 1·1 to 1·0, the wheat duty was thirty acres against a cotton duty of twenty-seven acres; on the Lower Chenab, with a wheat to cotton area of 4·9 to 1·0, the wheat duty was ninety acres, and the cotton fought for water at the time of common demand. Water was required for cotton sowing when it was also required for the last watering of wheat, and it was required for wheat sowing when it was also needed for the last watering of cotton, and both these times were the critical periods in the rivers, when they were rising and falling, and could not give a full supply to the canals.

Mr. Roberts's proposal to double the capacity of the Lower Chenab Canal, at a cost of four crores of rupees, would little avail his purpose, and it would be far sounder to spend half that amount in storing water in the hills in order to keep the canal running its full supply during the two critical periods.

There were several important points controlling the extension of cotton cultivation. On the Sirhind Canal, in the lower reaches, the zemindars had large holdings, and could grow their full area of wheat in the rabi and make sufficient profit to keep them in comfort, and they did not desire to undertake strenuous work in the hot weather in the cultivation of cotton, when they made quite sufficient to keep them in what they considered complete luxury. Higher up on the Sirhind Canal the holdings were smaller, and the cultivators had to make the most out of their small holdings. They found that out of a small area, by cultivating cotton, which involved personal labour, they could make more profit. To encourage cotton growing, lower down the Sirhind Canal, extravagant habits should be developed in the cultivators, and they would then have to take up cotton cultivation to enable them to meet their heavier expenses.

Mr. Roberts laid great stress on Egypt as being an example for the Punjab to copy. The figures for Egypt were approximately :—

Total crops	7,500,000	acres.
Wheat and barley ...	1,650,000	,,
Cotton	1,650,000	,,

The proportion of wheat to cotton was the same as that now existing on the Western Jumna Canal. The total of wheat and cotton was about 44 per cent. of the total cropped area in Egypt and on the Western Jumna Canal it was about 50 per cent.

The difference betweet 44 per cent. and 50 per cent. was due to the fact that in Egypt a large area of about 1,400,000 acres of clover was grown.

MR. C. A. H. TOWNSEND ...ector of Agriculture, thought that Mr. Roberts's paper w... ...ost valuable and suggestive. He was particularly in agre...ment with what was said as regards the larger growth of leguminous crops and the increased possibilities of "green manuring," because it was well known that the out-turn of all crops in the Chenab Colony (the

oldest canal colony) was not what it used to be when the land was virgin. This state of affairs could only be remedied by the cultivation of leguminous crops and an extended use of green manuring. The application of artificial manures must be put out of consideration for many years to come. The weak point of the proposal was that already pointed out by Mr. Quinn-Young, namely, the decrease in the area under wheat involved in it. The great bulk of opinion, with which he agreed, held that the supply of food grain produced in the world would be, for at any rate some years after the war, considerably less than the demand. There would undoubtedly be a great and increasing demand for cotton, but a man could wear his clothes over and over again, whereas he could not eat his food more than once. It was true that Mr. Roberts had said that the decrease in the out-turn of wheat would be met by an increase in the area under gram, but he himself thought that the price of the latter was entirely artificial, being due to the large amounts exported to the Mediterranean areas as fodder for the forces of the allies. Apart from that, he doubted whether the Englishman, who consumed much of the wheat exported from the Punjab, would, for many years, eat gram in its place. In conclusion, he welcomed the paper as attracting attention to a most important subject.

LALA WAZIR CHAND said that prejudice against cotton existed, not only amongst canal officers, but amongst the cultivators themselves, because they did not consider cotton to be a safe crop, and because climatic conditions were not favourable. He quoted a writer in *Indian Engineering*, who stated that the successful cultivation of cotton in the Punjab was largely a matter of chance; if the rains were deficient the bollworm destroyed the crop, whilst if the rains were heavy, the yield suffered. In fact, only one year out of two was a successful cotton year. He thought that the Agricultural Department had not been entirely successful in their fight against the bollworm, and could not be always relied upon. It had yet to be proved that American cotton was a safe crop. It had only been extensively grown for a few years, and even in this short period the yield differed considerably year by year. He considered that once its safety was established the cultivators themselves would take to it extensively and this would lead to an increased demand for water in the kharif, which he had no doubt, would be met.

MR. ASHFORD thought that it was necessary to enhance the area under both wheat and cotton. The Punjab had done a great deal in that direction by the development of its irrigation system during the last ten years ; and it was apparent that the only way to increase both the crops was by increasing the total acreage, which was brought under the several crops. There were two very important factors : first, the supply of water, and then the method of cultivation. Hitherto, the means of cultivation had been practically limited to ploughing by bullocks, but it was quite obvious that the number of bullocks could not be increased to meet an emergent situation. In Great Britain, when the position became acute, the problem was not faced by an effort to breed larger numbers of horses to till the land, but by the adoption of mechanical means, and by arranging to manufacture a large number of mechanical devices for the cultivation of the land, and if this province was to take a prominent part in the increased production of the wheat and cotton, which the world demanded, it could only be done by adopting mechanical means of cultivation, though there would be many difficulties to be encountered. Mechanical means of cultivation could only be used successfully on fairly large areas, while the individual holdings in many cases were small, so that if an increased area was to be cultivated, new land must be opened out in plots of sufficient size to justify the use of mechanical methods, or else arrangements must be made for the union of a number of small areas into larger ones for the purpose of such methods of cultivation, by co-operation or otherwise. The Punjab had another serious drawback. which might adversely affect it in this matter, namely, a scarcity of fuel. That this was serious had recently been forcibly brought home to all users of fuel by the practical impossibility of getting it, and consequently it would appear that the Government ought to develop the oil-fields at Attock, so as to place cheap fuel in the hands of cultivators for use in tilling the ground and pumping water If it were left in the hands of private firms their first consideration would be profit to themselves and the users of the fuel would have to pay a rate but little below that of imported fuel. Canal falls could also provide power for pumping water, as was now done at Amritsar. If these things were properly tackled, it should be possible to bring mechanical means to the aid of cultivators both for watering the soil and for cultivation.

MR. WOODS thou ht that Mr. Nicholson had misunderstood the general trend r Mr. Roberts's paper. He felt that Mr. Roberts had pres ed his paper, not in a tone of criticism of the work done by Irrigation Department, but of friendly advice in the directi of future improvements, and he had no doubt that that advice would be found useful in due course.

He agreed with Mr. Roberts that more use should be made of the summer flow of the Punjab rivers, which was relatively far more abundant than the winter flow, and richer in fertilizing matter, whilst the summer crops were relatively far more valuable than the winter crops, and promised the cultivator a larger margin of profit. Throughout the world, where artificial irrigation was practised, it was found advantageous to irrigate chiefly the more profitable crops, such as fruit, flowers, vegetables, alfalfa, cotton, whilst wheat cultivation on a large scale was practised chiefly in countries where land was cheap, and where the crop could be matured by rainfall alone.

He thought Mr. Roberts was mistaken in supposing that the control of rivers by weirs, for the sake of inundation canals, would be sound policy. These canals irrigated chiefly low-lying lands, which could be conveniently irrigated by the natural flow from the rivers. To forego that convenience would be a waste of the economic resources of the country, whilst to prevent the river from spilling over the low lands would involve much expense in protective embankments, an expense which it would not be justifiable to incur in order to deprive the country of the natural economic resources above mentioned. He thought Mr. Roberts was also mistaken in supposing that the absorption losses from two canals of a certain capacity would be less than those from a single canal of double that capacity.

With reference to Mr. Quinn-Young's remarks about the figure of duty, *viz.*, two hundred acres per annum, or eighty acres for the summer crop, or any other figures which might be used as a guide to design, he thought those were merely matters of detail. The great point to secure was to give the canal an ample capacity, and thereafter it might be trusted to attain the best proportional duties in summer and winter respectively, suitable to local conditions. In the Chenab and Jhelum rivers, there was usually a certain volume of flow available in the months of March, April, September

and October over and above the off-taking capacity of the existing canals ; and by enlarging the capacity of these canals it would be possible to utilize more of the available flow of the rivers at the critical seasons, especially at the beginning and end of each agricultural season, when the crops of one season were being watered simultaneously with the sowing of the crops of the following season. This opened up, however, a problem that was not confined to a mere question of volume of water in the canals. It was governed also by questions of available labour supply, and of the settled agricultural habits of the cultivators. Still, it might reasonably be hoped that economic forces would cause the cultivators to improve their habits when they discovered that there was money in the improvement.

MR. E. S. LINDLEY, referring to Mr. Roberts's statement that "the summer demand depends on what is given in April and May," thought this might refer merely to the possibility of shortage of supply, but the remarks of Rai Bahadur Lala Ganga Ram and of Mr. Faulkner showed that there was an impression abroad that canal officers made it difficult to extend kharif cultivation, because they restricted the supply at that time.

If a service could be given that enabled every irrigator to turn a tap on or off as he wished, the canal officer would be as much pleased as the irrigator ; but this was not possible. When demand slackened, water-courses were not cleared to take their full supply, and some outlets were even closed. This meant that full supplies could no longer be run, and the running of reduced supplies meant that channels tended to silt unduly, and zemindars, who did not really want water, wasted it freely rather than close their outlets, because they feared that any closure would be taken as an admission of too liberal supply, and lead to reduction, whilst absorption losses continued to feed the water-table at almost the normal rate. These points might, up to a certain degree, be ignored for the sake of giving the new policy a start ; but when running a diminished supply, there was less command at all off-takes, and by a too ging and lenient policy in extending flow irrigation to high nds, a condition had come about that much of the canal system could work at only very little below full supply levels.

When a supply was reduced on account of lack of demand, it was not merely the setting of the opinion of the canal officer against

the contrary opinion of an agriculturist which must be allowed due weight ; but such reductions were made because dangerously high supplies were reaching distributary tails, and it was a matter of actual experience that such reductions were too often effected only after the excessive supplies had caused breaches.

MR. W. P. SANGSTER noted that Mr. Roberts's paper contained three methods for increasing the area under cotton, all of which involved an increase in the supply of water, but he regretted that the Agricultural Department had not yet devised some scheme for utilising more fully the existing supplies. The statistics supplied by Mr. Bedford clearly showed that all the available supply was not used ; for instance, the average supply utilised on the Lower Jhelum Canal was only 74 per cent. of its full capacity, as illustrated in the following figures, where the average daily supply in the northern branch of the canal during each month was expressed as a percentage of the maximum carrying capacity of the branch :—

	Kharif		*Rabi*
April ...	66	October ...	93
May ...	80	November ...	85
June ...	66	December ...	74
July ...	76	January ...	47
August ...	63	Feburary ...	76
September ...	92	March ...	76
Average percentage for kharif		...	73
Averge percentage for rabi		...	75

In the face of these figures, he could see no necessity for enlarging the capacity of the canal.

MR. FAULKNER said that he must thank Mr. Woods for his remarks in regard to the prejudice alleged to be held by canal officers against cotton, as he was sure that it was not intended to suggest that there was an unreasonable prejudice. As a matter of fact it was reasonable at the time to design the canals mainly with the object of growing wheat. Further, the question appeared to him to be, not so much one of wheat against cotton, but of one cold weather crop as against two crops—one in the cold weather and another in the hot weather—so far as this was possible, and if water could be made available it seemed more natural that larger areas of crops should be grown in the hot weather. The growing of more kharif crops would in the main mean more fodder crops, but part of the increase would consist of cotton. Some decrease in the

wheat area was inevitable, but it was believed that more gram would be grown. It might be true that more wheat was wanted in India, but it was a fact that the bulk of the crop in the western canal colonies was exported out of India, but after the war it was likely that there would be a larger trade in gram than in the past. Most of the criticism was founded on the idea that the canal was built to suit the system of cultivation. Canals may have been built in the past to suit the existing systems of cropping, but he thought it a truism to say that on the Lower Chenab, Lower Jhelum, and Lower Bari Doab colonies the cultivation nowadays was made to suit the water supply. Several of the criticisms were based rather on experience with the canals in the eastern Punjab than in the west. He had not so much experience of the eastern Punjab as of the western part of the province, and the extension of cotton crops advocated in the paper referred principally to the western Punjab.

MR. ROBERTS, in further reply to Rai Bahadur Ganga Ram, wrote that fifty per cent. more bhusa than grain would be a safe figure. The same proportion as given by Mr. Hamilton had been maintained, so as to put the case for wheat as strong as possible. Landlords rarely got their full share of bhusa, as they did of grain, and this probably accounted for the Rai Bahadur's low estimate. The point raised regarding green manuring was very important. The paper dealt with the tract west of a line from Hissar to Lahore, where conditions for cotton cultivation differed enormously from tracts east of that line. The canals were, however, designed on the experience gained on older canals, which was inevitable. Rice was generally grown on special soils, and required copious watering for a strictly limited and comparatively short period, whereas cotton competed with all kharif crops, all of which would increase if more water were available. The failure of cotton in 1915 was not serious, and the area under cotton went up in 1916. The area under American cotton in 1915 was 70,000 acres, and in 1916 it was 125,000 acres, most of the increase being on the Lower Chenab Canal. The Punjab would produce this year nearly twice the quantity of staple cotton produced annually by the British Cotton Growing Association in Africa and elsewhere. The area under American cotton in 1918 was estimated at 400,000 acres.

Regarding food crops in the southern states of the United States of America, it might be noted that cotton was practically the only crop in large tracts there, and formed from seventy to ninety

per cent. of the cropped area in sc e parts. Food stuffs and cattle were imported on a large sca Such conditions were not economically sound in the long ru and the campaign for growing more food stuffs in the south v run by the state and not by cotton growers, who in fact oppose it, but were gradually being converted to the longer view. Green manuring cost the cultivator Rs. 30 per acre at present, as the green manure replaced another crop, but this practice would certainly increase if more water were available.* It was a mistake to think that the silt of the Punjab rivers was not fertilizing. It had already transformed the character of certain soils, and the effect in binding sandy soils had been enormous, though the coarse silt deposited in water courses, at certain periods, was of course of little value.

There were many reasons for the average monthly discharge of canals falling below the full supply, such as a lack of water in the river, floods in the river necessitating a closure to prevent silting the canal, rain, and lastly, lower demand ; and unless these factors were weighed, figures taken from official statistics were misleading and often worthless. It was also assumed by Mr. Bedford that American cotton could be sown throughout April, but this was not the case, except on the Lower Bari Doab Canal, where sowings could safely go on until 10th May, especially in the Khanewal Sub-Division. Late sowings caused the crop to be caught by cold in November and December, and sowings should generally finish by 20th April, when the winter or rabi supply of water was short. It was a common occurrence for cultivators to water their wheat in early April, and the author had often seen wheat being watered as late as 6th and 7th April in years of short supply. The first crops to claim water after wheat were sugarcane and sometimes early fodders, so that the period for sowing American cotton was in some years very restricted. This was noticeably the case in the spring of 1916 and 1917, whereas in 1918 supplies were ample. Again, in discussing the extra quantity of cotton that could have been grown and watered seven times, once a month watering was assumed, but this was far from being the case, as the need for watering in May and June was small, while on the other hand it was very great in the flowering and fruiting season in August and September. It was in the latter period also that fodder crops were grown to compete with cotton, as rain was then expected. It was quite correct to say that cotton was more exacting with regard to water than wheat but

* See paper by author in Agricultural Journal for July 1913.

this was generally true of all kharif crops. Nature in that season was working at high pressure, and hence was more severe in her demands. It was possible to grow double the weight of fodder in ten weeks in summer than could be grown in twenty weeks in the rabi. From the point of view of duty, therefore, kharif crops would compare badly with rabi crops, but the margin for improvement was far higher in their case than with rabi crops.

Gujrat was not, and never would be, an important cotton tract and hence Lala Wazir Chand Chopra's example was not applicable. The colonies grew on the average ten per cent. cotton, though many individual zemindars grew twenty per cent. or more, and it was a curious fact that where cotton formed a high proportion of the cropped area, *e.g.*, in Berar, Northern Bombay and Madras, holdings were large, but on the other hand where food stuffs were grown to excess, sub-division tended to increase and the level of living to keep low.

Regarding supplies being too short in spring and autumn to justify increasing the size of canals, there would seem to be some misconception. The shortness of supply in spring was only serious with regard to American cotton for the reasons given above. It, however, was not necessary to water in February and March. A good deal of American cotton actually followed wheat. Cotton received very little cultivation as compared with wheat, and was not a high class crop, as appeared to be held by many critics. It was in September and October that the pinch might be felt, though cotton after September withstood drought very well indeed, but it should not be difficult to store water for use in October if necessary.

The Lower Chenab Canal, as regards the proportion of kharif and rabi supplies, occupied a medium position between the Lower Jhelum and the Lower Bari Doab, the difference in the latter being greater and in the former less. As Mr. Nicholson pointed out, the Lower Jhelum actually used 1·1 times as much water in the rabi as in the kharif. The Agricultural Department did not claim succes n growing American cotton on the eastern canals, and hence h of the criticism was irrelevant. It might be noted, howev that large kharif supplies were available on the Sirhind whe ain was plentiful, and the cultivator would not use canal wate in years of good rainfall as he did in years of poor rainfall, or under the conditions of the tract discussed in the paper, where the rainfall was small and often

negligible. Rainfall complicated the pr n enormously in the eastern Punjab, and until some crop uld be introduced which necessitated sowing in April and ay, conditions must remain irregular in these tracts.

Cotton and wheat were not antagonistic to the extent believed, and they only clashed seriously in October. Even if they were grown in the same season the cultivator would give preference to the one which paid him best, other conditions being equal, and the water supply limited this free choice in the tracts at present growing American cotton. Any comparison of the duty of cotton on the Western Jumna with that on the Lower Chenab Canal was misleading for two reasons, *viz.*, some cotton was grown in the tract of the Western Jumna without any irrigation at all, indicating comparatively small demands to supplement rainfall, and secondly, the country cotton grown there scarcely clashed with wheat at all even in October; so that the low wheat duty was due to some other cause than cotton. There was a great deal in the point regarding storing of water in the hills, and the feasibility of using it at the end of the kharif to make the latter secure, should be seriously considered. Mr. Nicholson's point regarding large and small holdings on the Sirhind Canal seemed contrary to Lala Wazir Chand Chopra's argument. Cotton was not a high class crop, and he was unable to explain the fact mentioned by Mr. Nicholson but there would appear to be a very large scope for agricultural work in the Sirhind tract.

Regarding Egypt, the figures given were approximately correct, except that the clover or berseem area was over 1,500,000 acres, and in addition 560,000 acres of beans were grown. The total cultivated area was just over 5,000,000, and the cropped area over 7,500,000 acres, *i.e.*, half the area was double cropped. An important fact, often ignored, was that berseem, though counted as one crop, gave from three to five heavy cuttings, and as each cutting was equivalent to a crop, the proportion of cropping ran very high indeed. The commonest rotation in Egypt was clover and cotton in the first year, followed by beans or wheat and Indian corn in the second year.

If two lakhs more acres of wheat, and two lakhs less of cotton were grown in the colonies, any attempt to bring about present conditions would have met the same criticism as regards decreasing the wheat production. There was far too much wheat grown in the colonies to form a basis of sound

agriculture. What had to be considered was whether the best and fullest use was being made of the inexhaustible fertility of the alluvial soils of the colonies, both from the point of view of the capital involved in the soil, and the resources of water in the rivers. Wheat straw was one of the poorest fodders, and hence cattle rearing was very backward in the Punjab colonies, and large numbers of the best cattle were bought annually from breeding tracts outside, thus raising the price for the rest of the Punjab. Properly developed, the colonies should not only be self-supporting, but should be able to export good working animals, thus forming a basis for agricultural progress in other parts of the Province.

Judging from pre-war costs, it was only in exceptional circumstances that steam-cultivation could compete with bullock power for agricultural operations, but large tracts in Sindh offered advantages for power cultivation, as there was a shortage there of cattle and human beings.

Regarding the control of inundation canals by weirs, the subject was of course too technical for him to express any final opinion. He would only note that a large amount of water went to waste in the beginning and end of the inundation season, which might thereby be utilized. The factor of safety would also come in, and cultivators could arrange their cropping with the certainty of the canal opening on a certain date, whereas this was now impossible. He had not stated that the absorption losses would be less in two canals than from one of double the capacity—the reverse would certainly be the case. He felt he had exaggerated the scarcity of water in the spring. In years of short rainfall, the pinch was severely felt in August and September as far as cotton was concerned. Cotton was successfully grown at Lyallpur with no watering after sowing, from April till July. The crop demanded copious supplies of water from July to September, while in the latter month and also in August toria required water, and if rainfall were small or the canal often closed, owing to river floods, the cotton crop was damaged. He understood that the re-designing of head-works now in progress would materially improve conditions in this respect

He hoped Mr. ‘ gster did not wish to imply that the whole of the difference bet en the actual and the full capacity of the northern branch of he Lower Jhelum was due to slack demand. The agricul. al staff at Lyallpur had to run a big

college and to carry out experimental work as well constantly increasing district work, but he could assure Mr. angster that, with the co-operation of the Irrigation Department, they would in time effect marked improvements in the utilization of supplies, and much more besides.

Finally, he wished to express his thanks to the Congress for the tone in which criticisms had been made, as he realised perhaps better than any of the critics, the shortcomings of the paper. The suggestions and criticisms made would be of use and encouragement in the further investigations now being carried out at Lyallpur on this very wide and important question.