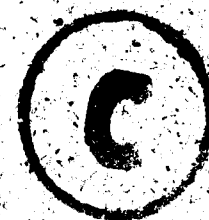


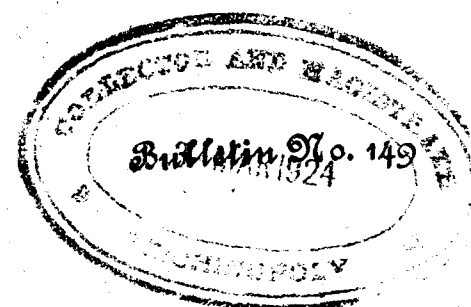
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Agricultural Research Institute, Pusa

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Agricultural Chemist to Government, Punjab, Lyallpur,

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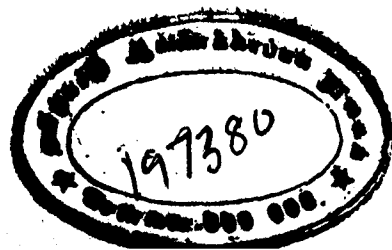
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PREFACE

The experiments recorded herein were started at Lyallpur and Gurdaspur by Mr. B. H. Wilsdon, Late Agricultural Chemist to Government, Punjab, with the assistance of M. Mukand Lal, and have been continued after Mr. Wilsdon's departure in 1921 and embody the results obtained from their commencement up to the summer 1922.

It is worthy of note that even now in the fifth year of the trials the green manured plots show marked superiority over the controls and artificials, and although the carting of green manure is not a paying concern if we consider the increased yield at the end of the first year alone, yet it is so when we balance up the successive increases for several years. These trials will be continued till the various figures show a return to uniform level.



A Study of the Factors Operative in the Value of Green Manure.

(Received for publication on 6th March 1923.)

The practice of green manuring has received very general attention in India and in many parts is becoming a common agricultural operation. Much remains, however, to be done in elucidating the rationale of the method, and there appears to be a considerable difference of opinion as to the factors which are operative in the reactions of the crops to the treatment. In general it may be stated that there are two schools of thought which differ in the emphasis which is placed on the various factors operative. On the one hand, we have those who fix their attention on the nitrogen factor alone and the influence of the green manure on the biological reactions which determine the fluctuation of nitrogen and nitrates in the soil. On the other, many workers lay stress on the more or less physical effects of the organic matter which is added, such for instance as would result in the improvement of the moisture and nutrient holding power of a sandy soil, or the effect on the hydrogen ion potential of the soil solution with a possible parallel influence on the solubility of soil phosphates. It will thus only be possible to obtain a clear idea of the value of green manuring under differing circumstances of soil and climate by tracing the action of every factor which may contribute to increased fertility.

Hutchinson has proposed that, in order to bring about the fermentation of a green manure under the most favourable conditions, the green manure shall be cut and carted to a suitable place where it can be fermented under controllable conditions. In this way it is hoped to leach out the nitrates so obtained with the irrigation water applied to the field after the fermented manure has been dug in. The effect of the treatment is definitely restricted to the application of soluble nitrogen. Apart from the economic aspects of the proposition one must consider the effect on the nitrogen balance in the soil treated and the soil on which the green manure is grown.

It is clear that a study of all the factors must be made on different types of soil. The following are probably the most important.

(1) *The nitrogen factor—*

- (a) Symbiotic fixation with the leguminous crop.
- (b) Fixation by azotobacter or similar organism and possibly by anaerobic bacteria under the stimulus provided by the carbohydrates added with the green manure.

- (c) Denitrification induced by the fermentation of the green manure.
- (d) Possible development of a BACTERIAL toxin as suggested by Hutchinson.

(2) *Physical factors*—

- (a) Improvement of moisture holding power.
- (b) Improved retention of plant nutrients.
- (c) Possibly improved aeration.
- (d) Change in soil aeration with possible increased solubility of phosphates.

(3) *Agricultural factors*—

- (a) Applicability under Barani (rain-fed) and irrigation conditions.

The plan of work which has been in progress at Lyallpur during the last four years and at Gurdaspur has been designed to test the above factors in the following way. Experiments in which green manure has been carted and dug in have been duplicated as far as possible on sandy and heavy soils. Applications of artificials have been made on other plots in amounts similar to those produced by the fermentation of the green manure. Although insufficient data have so far been obtained to throw light on all the factors enumerated above, the results obtained enable a preliminary survey of their relative importance to be made which may not be without interest to other workers in the subject. The progress of the experiment is detailed each year in part 2 of the Annual Report of the Punjab Agricultural Department. Our intention here is only to summarize the work so far completed and to draw what preliminary conclusions are possible.

Diagram 1 shows the arrangement of the plots both in sandy and in stiff fields. The big plots are each $\frac{1}{16}$ th of an acre in extent. The smaller plots in the first year (1918-19) were each six feet square and were isolated from the surrounding soil by a layer one foot broad and three feet deep of broken brick. These were, however, found to be too small and there were possibilities of considerable errors in the results. In the succeeding year 1919-20, therefore, each plot was made of 15 feet square and was isolated from its neighbour by means of a three feet strip of fallow land. In the bigger plots controls were situated alternately with the manured plots. But in the smaller plots there was one control for every green manured and artificial plot. Thus in taking yields the yield of a control is in fact the average yield of 3 plots taken together.

Before starting the experiment samples of soils 3 feet deep were taken from both sandy and stiff plots. Table I gives the mechanical analysis of these soils along with the moisture equivalent of the first foot of each

of them. As is clear from the analysis, the lighter soil is very sandy and itself is unable to grow a leguminous crop.

In the first year 1918-19, $\frac{1}{16}$ th of an acre of Guara * was cut from elsewhere and buried in plot No. 1 (Guara 1 crop of the sandy field). Plot No. 2 (Guara 2 crop) had $\frac{2}{16}$ th of an acre of Guara buried in it and so on for Guara 3 crop. Exactly similar was the case for the small plots and the stiff plots both small and big. In the year 1919-20, however, $\frac{1}{16}$ th of a normal crop of green Guara was cut and weighed and the additions to 2 and 3 crop plots were simply made by weighing out twice and thrice the amount of the one crop.

In cutting and weighing, precautions were taken not to take too much time over these operations in order to lose as little water as possible. The whole operation of cutting and weighing one bundle did not take more than five minutes. Care was taken to bury Guara in the plots on the same day that it was cut from the field.

A representative sample of the green Guara was taken, and its moisture and total nitrogen content determined. Regarding the method of sampling, holes 1' x 1' x 9" were dug at about six places in the field. The earth from all these holes was taken together and thoroughly mixed. A sample was then taken from this mixed earth.

In the first year of the experiment samples were taken from the plots before putting in the green manure, before sowing wheat, and after cutting wheat. In the succeeding year, however, the smaller plots were first analysed 3 weeks after burying in the green crops and afterwards they were analysed every fortnight till the time of sowing.

Table II shows the result of the analysis of the plots indicated on the dates shown. After each analysis the total available nitrogen content of the artificial plot was made up to the total available amount developed in the green manured plots, by the addition of the calculated amounts of sodium nitrate and ammonium sulphate dissolved in water distributed in a watering can. The figures with one or two exceptions now indicate that the artificial plots contain the same amount of total available nitrogen as was present in the green manured plots. It will therefore appear that we are justified in assuming that the treatment has rendered both plots comparable as regards the nitrogen content and that the differences of yields obtained must be due to some other factor. The results are given in Tables III and IV and are graphically presented in Diagram 2.

Before proceeding further to discuss the results obtained so far, it would be as well to draw attention to one or two points in connection with the effects of the season and wheat crop of 1919-20 on these plots.

* *Cyamopsis psoraloides*.

The season, as is well known, was a remarkably good one for wheat. It is to be expected therefore, as is shown later to be the case, that the results will not show such remarkable differences as would be obtained in a less favourable year. At an early stage of the development of the crop it was obvious that in the manured plots the growth was so luxuriant that it would be impossible to harvest the crop. It was consequently decided to prune the crop in the main area, and as control a fraction of the area was cut down to the ground. The weights of the material, green and dry, are shown in Table V. From this it will be seen that the amount of growth in the sandy plots is increased roughly in the ratio of 3, 10 to 13 by the corresponding applications of 1, 2 and 3 unit quantities of green manure. In the stiff plots, however, the yields are more uniform and roughly about 3 times the yields obtained in the control plots. Despite the pruning the crop lodged very badly in the more heavily manured plots and the differences are consequently not as great as would have been obtained if this had not taken place. This is to some extent due to an attack of white ants and the deficiency is estimated to be from 10 to 15 per cent.

The results which are presented in Table III for both the sandy and the stiff soils are enough to throw light on factors 1 and 2. As regards (d) factor (1) it may be said that results in which sand and Guara show a depressing action have been met, but while we may admit the possibility of this factor coming into play there is not yet sufficient data to throw light on the conditions which favour it.

From the results it is obvious that the yields in the sandy plots are not proportional to the amounts of available nitrogen developed or added to the soil. It is natural, therefore, to conclude that the improvement is not entirely due to the nitrogen present in the soil but rather to the improvement in the water holding power brought about by the addition of the organic matter. This will explain the fact that these differences are not observed in the heavy plots, since the addition of organic matter would not improve the water holding power of the already heavy soil.

This will be made more clear from Table VI which gives the results obtained by the Professor of Agriculture at Lyallpur. It will be seen that the plot in which the Guara is ploughed in gives roughly 10 maunds more yield than the one from which the above ground portion was removed for fodder. In this way all the nitrogen symbiotically fixed by the leguminous crops is supposed to have been left behind in the soil although the recent work of Wright, *Soil Science*, Vol. X, No. 4, page 259 (1920), shows that any nitrogen fixed symbiotically with the

leguminous crop will be found at harvest time in the above ground vegetation.

Looking at it from another point of view altogether, we find that the total amount of nitrogen contained in an average crop of Guara is 40 lb. per acre. Most of it is lost during decomposition, which is going on at a fairly high temperature in the hot weather of the Punjab. That which is left after decomposition is not all in the available form; therefore the available nitrogen added by the green manure comes to a nominal figure per acre. Tables VII and VIII which give the amounts of total nitrogen of the plots under the experiments at different times of the year also reveal the fact that it is very difficult to correlate the yields of wheat with the amounts of total nitrogen in the soil.

It is very difficult to estimate the improvement in the water holding power of a field, mostly on account of the fact that the crops borne by, for instance, the Guara plots, are as much as 3, 10 and 13 times that of the control and that, therefore, transpiration of water equivalent to the yield of green matter must have taken place before the field in question could be approached for taking samples to determine its moisture content. Hence it was decided to estimate in the laboratory the moisture holding capacity of the treated and the untreated plots. Whereas the addition of organic matter in the sandy soil has increased its moisture equivalent by about 2.75 per cent. over the control, in the stiff plots these differences are not noticeable. The results are shown in Tables I and IX.

Moreover, it must be understood that the improvement in the retention of moisture will be an improvement in the retention of soluble nutrients. This is clear from Table X which shows that in an untreated sandy soil drainage takes place very rapidly. In the year 1919-20, when the 6 feet plots were left out of experiment, an excessively heavy dose of the artificial manures was applied to some of these plots both in the sandy and stiff fields. From the Table it is clear that, after irrigation, whereas the nitrates have penetrated to a depth of 36 inches in the sandy plots, they have not been able to go beyond the first 9 inches of stiff soil.

This is supported by the work of Burt, Anstead, Russell, Fredrick, Joseph and Joshi.

These results led us to start experiments in the Barani tracts of the province where moisture is the chief controlling factor. In tracts where large amounts of green organic matter during the Kharif are available a very simple and inexpensive method presents itself.

In the Kharif of 1920, experiments were started with a non-leguminous crop, Bhang (*Cannabis sativa*), in the Barani lands of Gurdaspur

District on the same lines as at Lyallpur. Doubts have been expressed by agriculturists in Barani tracts as to whether fermentation of green manure takes place unless rain is received at a suitable time before the sowing of wheat. Experiments at Lyallpur, both under the Professor of Agriculture and under the Agricultural Chemist, have shown that the fermentation of a green manure is well secured without any further irrigation after the burying in of the stuff. On the contrary, green manuring experiments in square 11 and 12 at the Students' Farm have shown that irrigation after ploughing in of the green manure is not only not advantageous but in some cases exerts an actual depressing influence on the succeeding crop. It appears that this objection is raised on the basis of results obtained where a green manure has been grown and ploughed in on the same field, when it is probable that unless rain is received in September and October to compensate the losses of moisture which would otherwise have been conserved by fallow cultivation there may not be sufficient moisture left for the sowing in of Rabi crop. Later experiments have proved that this is quite true and that the green manure will have to be carted from elsewhere for these Barani soils.

The results of the application of green manure of a non-leguminous nature are presented in Table XI. In each case there is approximately a difference of about 100 per cent. in the yields of treated and control plots. This year (1920-21) was a very bad year for wheat and hence so great a difference. Usually, however, we get an increase of 50-75 per cent. over the controls. If we carefully examine the factors operative (in 1920-21), we will find that moisture was the chief limiting factor. Compared with this the wheat season of 1921-22 was an ideal one so far as the moisture conditions were concerned and the results show that the differences in the treated and untreated plots in the Barani areas are not so great as those of the previous year.

An examination of the nitrogen content of the Bhang plant also reveals the fact that this non-leguminous plant is in no way inferior to a leguminous plant such as Guara in its nitrogen content. The results obtained at Lyallpur and Gurdaspur therefore may be taken to indicate that in the case of a sandy soil, and it is in such a soil that green manuring is most beneficial, the increased yields brought about by green manure are not chiefly dependent on the nitrogen factor but are to be referred to the improvement in the physical texture of the soil.

The present work therefore leads us to believe that we are apt to attach too much importance to the application of leguminous green dressings. It must be remembered that the primary consideration of a green manure is quantity. Figures as to the amounts of the nitrogen fixed per acre

are very misleading and are of little use in formulating a manure programme; hence the great question when choosing a green manure crop is "which plant will give the greatest amount of organic matter at a lowest cost for a particular soil under treatment."

ECONOMICS OF THIS METHOD OF MANURING.

The method of carting large amounts of green organic matter from elsewhere and ploughing it in the sandy soils is not common practice with the agriculturists of this province, and consequently fears have been expressed by them that this method of reclaiming and enriching their sandy soils will be too expensive and will not ultimately pay. This is, no doubt, true if we take into consideration the effect of the green manure on one succeeding crop alone, but complete estimates of the beneficial effect of green manuring cannot be formed until the residual effect of the manure has been taken into account. In spite of the fact that the experiments at Lyallpur and at Gurdaspur were not designed to investigate the economics of this method of manuring, a glance at Tables XII and XIII will show that both in the irrigated and in the unirrigated tracts carting manure from elsewhere is profitable. This is particularly so in the Barani tracts where large amounts of green organic matter are available in the Kharif, and it is only in the excessively sandy soils of these Barani tracts that the use of these green dressings is advocated.

From the Tables we find that at Lyallpur after a period of 4 years Guara 1 crop shows a profit of Rs. 24 per acre, Guara 2 Rs. 104 per acre and Guara 3 crop Rs. 67 per acre, and yet even in the fourth year the increases over the controls are 5, 64 and 64 per cent. respectively. The above is true when wheat follows wheat every time. As we have said before, these experiments were started only to isolate the factors responsible for the reaction of the green manure and hence no regular rotation was adopted. Had some other crops been tried which make a greater demand on the soil the margin of profit would probably have been even higher.

As is clear from Table V it might be possible by selling wheat green to obtain 3, 10, 13 times more profit than would be obtained from untreated land, as compared with the increase of only 50-70 per cent. on the matured crop.

At Gurdaspur, however, where we have not to account for the price of the green manure other than the expense of cutting and carting, the margin of profit is much higher than in the case of the irrigated soils

of Lyallpur. From the Table it is clear that in the second year the profit per acre in units is 240 mds. of Bhang per acre. Bhang 1 unit is about Rs. 26, Bhang 2 unit Rs. 17, per acre, and Bhang 3 unit shows Re. 1-12.

It is rather remarkable that whereas the increases in yield at Lyallpur are in the same order as the quantity of the green stuff buried in, the increases at Gurdaspur are not so. This at present is difficult to explain, but work on this subject is being continued. In this connection it will not be out of place to mention the trial made by Khan Sahib Ch. Mohd. Bux of Bhaini Milwan, District Gurdaspur, who dug in Bhang (*Cannabis sativa*) at the rate of 240 mds. per acre in one of his sandy *tibbas* (uncommanded sandy area) which were lying barren before. His results are presented in Table XIV and show a profit of Rs. 10-7-0 even in the first year when Bhang is buried in at the rate of 240 mds. per acre.

SUMMARY.

1. The work presented in this paper covers a period of 5 years and gives the results secured both in the laboratory and in the field in a comparative test of artificial manures, leguminous green crops and non-leguminous green crops.
 2. No regular rotation was followed. Wheat followed wheat.
 3. Results on the whole show that the response to green manuring is much greater in sandy soils than in stiff soils.
 4. That in the sandy soils the increase in yield is much greater in the green manured plots than in the plots having received quantities of artificial manures equivalent to those developed by the green manured plots.
 5. That the main factor responsible for the increase in yield is the improvement in physical texture of soil due to the addition of the green manure.
 6. That when the above ground portion of a leguminous crop is removed the yield is diminished to a remarkable degree.
 7. That non-leguminous green dressings in the Barani areas are as effective as leguminous green dressings.
 8. That green manure carted from elsewhere is a paying concern.
- This opportunity is taken by the authors to express their obligations to Professors W. Roberts and H. R. Stewart, of the Agricultural College, Lyallpur, and M. Sultan Ali, Deputy Director of Agriculture, Gurdaspur, under whose supervision the agricultural work of the experiment was carried out at their respective farms.

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TABLE I.

Mechanical analysis (by the centrifugal method) of 6 samples of soil obtained from the Students' Farm, green manuring experimental plots.

No.	Sample	Fine gravel	Coarse sand	Fine sand	Silt	Fine silt	Clay	REMARKS
	<i>Stiff Soil.</i>							<i>Moisture equivalent.</i>
1	Square 12, field 23, 1st foot.	0.34	8.24	41.32	18.68	18.70	10.96	18.14 No. II.
2	Square 12, field 23, 2nd foot.	1.92	5.29	41.99	18.40	19.00	9.36	
3	Square 12, field 23, 3rd foot.	0.32	4.43	42.89	16.48	22.60	10.00	
	<i>Sandy Soil.</i>							
4	Square 12, field 21, 1st foot.	0.40	36.68	44.97	5.45	6.20	4.68	7.32 No. I.
5	Square 12, field 21, 2nd foot.	nil	28.79	47.52	7.00	8.40	5.62	
	Square 12, field 21, 3rd foot.	0.32	25.45	48.04	7.48	10.70	6.08	

TABLE II.
GREEN MANURING EXPERIMENTS, 1919-20.

Available nitrogen. 15 feet plots.

No.	Plot	AVAILABLE NITROGEN ON 23RD SEPTEMBER 1919			AVAILABLE NITROGEN ON 8TH OCTOBER 1919			AVAILABLE NITROGEN ON 27TH OCTOBER 1919		
		Nitrates	Nitrites	Ammonia	Nitrates	Nitrites	Ammonia	Nitrates	Nitrites	Ammonia
	<i>Sandy</i>			per cent.	on soil					
1	Guara 1 crop	0.000005	0.000440	0.00290	0.00240	0.000044	0.00200	0.00300	0.000020	0.000040
2	Artificial 1	0.00036	0.000011	0.00015	0.00150	0.000024	0.00210	0.00296	0.000038	0.000050
3	Guara 2 crop	0.00200	0.000058	0.00200	0.00180	0.000680	0.00250	0.00268	0.000032	0.001910
4	Artificial 2	0.00036	0.000011	0.00015	0.00260	0.000032	0.00160	0.00292	0.000032	0.001550
5	Guara 3 crop	0.00180	0.000038	0.00280	0.00230	0.000036	0.00260	0.00352	0.000064	0.003010
6	Artificial 3	0.00036	0.000011	0.00015	0.00410	0.000028	0.00230	0.00340	0.000064	0.002210
7	Control	0.00036	0.000011	0.00015	0.00056	0.000016	0.00037	0.00552	0.000012	0.000045
	<i>Stiff</i>									
8	Guara 1 crop	0.0049	0.000051	0.00079	0.0070	0.000052	0.00086	0.0042	0.000032	0.0000390
9	Artificial 1	0.0016	0.000022	0.00017	0.0046	0.000044	0.00091	0.0131	0.000080	0.000350
10	Guara 2 crop	0.0042	0.000036	0.00120	0.0053	0.000088	0.00210	0.0044	0.000052	0.001490
11	Artificial 2	0.0016	0.000022	0.00017	0.0064	0.000080	0.00100	0.0044	0.000088	0.000740
12	Guara 3 crop	0.0040	0.000076	0.00150	0.0080	0.000056	0.00100	0.0034	0.000064	0.001490
13	Artificial 3	0.0016	0.000022	0.00017	0.0046	0.000056	0.00110	0.0160	0.000104	0.001280
14	Control	0.0016	0.000022	0.00017	0.0012	0.000052	0.00035	0.0032	0.000032	0.000023

TABLE

Showing the yields obtained from the treated and the

No.	Plot and treatment	Quantity of green manure put in per acre	1918-19				1918-19		1919-20			
			Yield per acre				Per cent. increase over control		Yield per acre			
			Grain		Straw		Grain	Straw	Grain		Straw	
	<i>Sandy.</i>		Mds.	Srs.	Mds.	Srs.			Mds.	Srs.	Mds.	Srs.
1	Guara 1 crop	240 mds. per acre in 1918 and 1919.	13	5	17	30	58.0	71.10	20	1	42	10
2	Guara 2 crop	480 mds. per acre in 1918 and 1919.	18	20	24	10	123.0	134.00	27	20	64	20
3	Guara 3 crop	720 mds. per acre in 1918 and 1919.	21	10	35	0	156.0	237.00	25	15	71	30
4	Control	..	8	12	5	10	..	..	11	14	21	0
	<i>Stiff.</i>											
5	Guara 1 crop	240 mds. per acre	25	0	32	30	20.5	41.60	33	25	74	20
6	Guara 2 crop	480 mds. per acre	23	30	30	30	14.5	33.00	21	23	80	0
7	Guara 3 crop	720 mds. per acre	26	30	45	0	28.0	94.60	28	30	72	20
8	Control	..	20	30	23	5	..	..	28	1	50	20

III.

untreated plots (sandy and stiff) at Lyallpur.

1919-20		1920-21		1920-21		1921-22		1921-22	
Per cent. increase over control		Yield per acre		Per cent. increase over control		Yield per acre		Per cent. increase over control	
Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
		Mds. Srs.	Mds. Srs.			Mds. Srs.	Mds. Srs.		
76.44	101.2	12 20	20 20	28.20	53.24	8 10	20 0	4.78	27.00
142.30	207.2	18 0	37 30	84.60	96.10	12 35	20 5	63.50	84.00
123.60	241.7	24 10	46 20	148.70	141.50	12 35	30 25	63.50	94.50
..	..	9 30	10 10	..	..	7 35	15 30	..	..
19.98	47.5	22 0	42 20	18.92	37.10	23 0	52 0	15.00	38.70
12.67	58.4	23 0	47 20	24.32	53.20	23 20	38 20	17.50	2.70
2.50	43.6	30 30	57 0	66.21	83.90	24 20	46 20	22.50	24.00
..	..	8 20	31 0	..	..	20 0	37 20	..	..

TABLE IV.
GREEN MANURING EXPERIMENTS, 1919-20.
Yields, etc. 15 feet plots.

No.	Plot	Weight of green manures put in	Dry matter, organic or artificial manure		YIELD		Calculated amount of green manure in one acre	Dry matter, organic or artificial manure	YIELD PER ACRE		Proportion of grain to straw	PER CENT INCREASE ON CONTROL	
			Mds. Srs.	Grain	Straw	Grain	Mds. Srs.	Grain	Straw	Mds. Srs.	Grain	Straw	
1	Guara 1 crop	1 10	9 seers	6 6	11 6	6 6	240	43 maunds	30 34	55 2	1:1.78	72.34	110.5
2	Artificial 1	..	NaXO ₃ = 720 grams AmSO ₄ = 1,458 "	6 5½	10 0	6 5½	..	NaXO ₃ = 308 lb. AmSO ₄ = 624 "	30 29	48 16	1:1.57	71.64	85.1
3	Guara 2 crop	2 20	18 seers	8 9½	13 8½	8 9½	480	86 maunds	41 25	65 10	1:1.57	132.50	150.4
4	Artificial 2	..	NaXO ₃ = 1,295 grams AmSO ₄ = 1,373 "	5 14	8 5	5 14	..	NaXO ₃ = 534 lb. AmSO ₄ = 387 "	29 17½	40 9	1:1.41	53.80	53.8
5	Guara 3 crop	3 30	27 seers	6 4	13 11	6 4	720	129 maunds	30 10	66 12	1:2.19	69.00	153.5
6	Artificial 3	..	NaXO ₃ = 790 grams AmSO ₄ = 1,612 "	4 12	9 8	4 12	..	NaXO ₃ = 338 lb. AmSO ₄ = 690 "	23 0	45 39	1:2.00	28.40	75.8
7	Control, average of 3 plots.	..	..	3 11	8 6½	3 11	..	..	17 36	26 6	1:1.46	..	..
1	Guara 1 crop	1 10	9 seers	8 6½	13 3	8 6½	240	43 maunds	40 26	63 35	1:1.57	6.33	3.02
2	Artificial 1	..	NaXO ₃ = 2,326 grams AmSO ₄ = 329 "	6 6½	13 0	6 6½	..	NaXO ₃ = 995 lb. AmSO ₄ = 141 "	30 39½	62 37	1:2.03	-13.99	1.45
3	Guara 2 crop	2 20	18 seers	6 14	15 6	6 14	480	86 maunds	33 11	74 16	1:2.24	-12.93	20.00
4	Artificial 2	..	NaXO ₃ = 1,087 grams AmSO ₄ = 724 "	9 5	14 14	9 5	..	NaXO ₃ = 464 lb. AmSO ₄ = 310 "	45 3	71 39	1:1.60	17.86	16.09
5	Guara 3 crop	3 30	27 seers	7 4½	14 9	7 4½	720	129 maunds	35 13	70 18	1:1.99	-7.60	13.63
6	Artificial 3	..	NaXO ₃ = 2,691 grams AmSO ₄ = 745 "	6 14½	12 0	6 14½	..	NaXO ₃ = 1,151 lb. AmSO ₄ = 319 "	33 16	58 3	1:1.74	-12.65	-6.33
7	Control, average of 3 plots.	..	..	7 14½	12 13	7 14½	..	..	38 9	62 0	1:1.62	..	..

TABLE V.
GREEN MANURING EXPERIMENTS, 1919-20.
Weights of the material, green and dry.

No.	Plot	WHEAT CUT FROM NEAR THE BOTTOM, 5TH FEBRUARY 1920			WHEAT PRUNINGS			PRUNINGS FROM ONE ACRE (CALCULATED)		Ratio as compared with the control
		Area	Weight of green wheat	Weight of dry wheat, 24th February 1920	Area	Weight of green wheat	Weight of dry wheat	Weight of green crop	Weight of dry crop	
1	Guara 1 crop	215	11 12	1 14	3,655	0 19	3 ½	5 26	0 36	3.19: 2.73
2	Guara 2 crop	215	36 8	5 11	3,655	2 13	14 8	47 29	4 13	9.90: 8.30
3	Guara 3 crop	215	47 0	7 1	3,655	3 31	22 11	45 0	6 30	12.75: 10.30
4	Control, average of 3 plots.	215	3 11	0 11	..	..	..	..	..	..
1	Guara 1 crop	210	42 10	6 6	1,575	1 10	7 8	34 23	5 8	3.31: 2.76
2	Guara 2 crop	210	41 12	6 0	1,575	1 15	7 15	38 1	5 19	3.24: 2.59
3	Guara 3 crop	210	51 0	7 2	1,575	1 24	8 15	44 10	6 7	3.96: 3.08
4	Control, average of 3 plots.	210	12 14½	2 5	..	..	..	..	..	..

TABLE VI.

Showing the results obtained by the Professor of Agriculture by green manuring with wheat, Punjab Type 11, in tenants' area during Rabi 1919-20.

Treatment	Area		Actual outturn of grain		Outturn per acre of grain	
	Kanals	Marks	Mds.	Srs.	Mds.	Srs.
Guara ploughed in	8	16½	22	5	20	2
Guara removed	8	10	12	39	12	9

TABLE VII.

GREEN MANURING EXPERIMENTS, 1919-20.

Total nitrogen. Big plots.

No.	Plot	Before burying guara. 2nd September 1919	Before sowing wheat. 12th November 1919	After cutting wheat. 12th May 1920	REMARKS
<i>Sandy.</i>					
1	Guara 1 crop . . .	0-029	0-018	0-0181	
2	" 2 " . . .	0-011	0-023	0-0215	
3	" 3 " . . .	0-034	0-019	0-0247	
4	Control . . .	0-010	0-0183	0-0181	
<i>Stiff.</i>					
5	Guara 1 crop . . .	0-065	0-032	0-0425	
6	" 2 " . . .	0-052	0-050	0-0391	
7	" 3 " . . .	0-059	0-055	0-0374	
8	Control . . .	0-061	0-016	0-0340	

TABLE VIII.

GREEN MANURING EXPERIMENTS, 1919-20.

Total nitrogen. 15 feet plots.

No.	Plot	Total nitrogen before burying guara. 2nd September 1919	Total nitrogen before sowing wheat. 16th November 1919 and 17th November 1919	Total nitrogen after cutting wheat. 29th April 1920 and 2nd May 1920	REMARKS
<i>Sandy.</i>					
1	Guara 1 crop . . .	0-028	0-020	0-0167	
2	Artificial 1 . . .	0-028	0-019	0-0172	
3	Guara 2 crop . . .	0-028	0-023	0-0204	
4	Artificial 2 . . .	0-028	0-019	0-0174	
5	Guara 3 crop . . .	0-028	0-020	0-0194	
6	Artificial 3 . . .	0-028	0-019	0-0160	
7	Control . . .	0-028	0-017	0-0160	
<i>Stiff.</i>					
8	Guara 1 crop . . .	0-066	0-051	0-0410	
9	Artificial 1 . . .	0-066	0-052	0-0397	
10	Guara 2 crop . . .	0-066	0-060	0-0482	
11	Artificial 2 . . .	0-066	0-061	0-0487	
12	Guara 3 crop . . .	0-066	0-063	0-0506	
13	Artificial 3 . . .	0-066	0-056	0-0420	
14	Control . . .	0-066	0-048	0-0394	

TABLE IX.

GREEN MANURING EXPERIMENTS.

Moisture equivalents of the samples of soil obtained from the treated and untreated plot.

No.	Treatment	Moisture equivalent
<i>Sandy.</i>		
1	Guara 1 crop	9.96
2	Artificial 1	7.38
3	Guara 2 crop	10.60
4	Artificial 2	7.56
5	Guara 3 crop	10.03
6	Artificial 3	7.38
7	Control	6.47
<i>Stiff.</i>		
1	Guara 1 crop	16.11
2	Artificial 1	20.61
3	Guara 2 crop	22.54
4	Artificial 2	21.12
5	Guara 3 crop	21.82
6	Artificial 3	21.82
7	Control	19.29

TABLE X.

GREEN MANURING EXPERIMENTS, 1919-20.

Estimation of nitrates in 6 feet plots which had received 10 times the dose of artificial manures.

Plot	Nitrogen per cent. in soil
<i>Sandy.</i>	
Artificial 1, 1st 9 in	0.0440
„ 1, 2nd „	0.0019
„ 1, 3rd „	0.0010
„ 1, 4th „	0.0034
„ 2, 1st „	0.1000
„ 2, 2nd „	0.0060
„ 2, 3rd „	0.1017
„ 2, 4th „	0.0004
„ 3, 1st „	0.0132
„ 3, 2nd „	0.0200
„ 3, 3rd „	0.0047
„ 3, 4th „	0.0011
<i>Stiff.</i>	
Artificial 1, 1st 9 in	0.0570
„ 1, 2nd „	0.0008
„ 1, 3rd „	0.00048
„ 1, 4th „	nil

TABLE XIII.
Showing the economics of carting a non-leguminous crop for green manuring from elsewhere in the Barani tracts of Gurdaspur.

No.	Treatment	1920-21				1921-22				TOTAL INCREASE				VALUE OF PRODUCE				Cost of dig- ging in Bhang per acre				REMARKS			
		Increase of yields over controls per acre																							
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
		Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.	Rs. As.
1	Bhang 1 (240 mds. per acre)	2	17	6	17	2	35	8	30	5	12	15	7	31	13	11	6	43	3	17	0	26	3	Wheat selling at Rs. 6 per md. Straw selling at As. 12 per md.	
2	Bhang 2 (480 mds. per acre)	3	6	7	33	3	0	3	15	6	6	16	2	36	15	12	3	49	2	32	0	17	2		
3	Bhang 3 (720 mds. per acre)	3	26	8	29	2	0	12	15	5	26	21	4	33	15	15	13	49	12	48	0	1	12		
		Cost of digging in Bhang per acre.										Rs. As.													
		Carting :										4 0													
		Ploughing in :										5 0													
		Cutting :										5 0													
		Miscellaneous :										3 0													
		TOTAL										17 0												per acre.	

TABLE XIV.
Showing the results obtained by Khan Sahib Ch. Mohammad Bux of Bhaini Milwan, District Gurdaspur, by digging in Bhang in his sandy soil.

No.	Treatment	Area in acres	YIELD		YIELD PER ACRE		INCREASE OVER CONTROL		VALUE OF THE EXTRA STUFF		Total value	Cost of digging in Bhang per acre	Profit per acre	REMARKS				
			Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw								
1	Bhang at 240 mds. per acre .	1	2	16	7	0	6	16	18	27	3	23	9	17	0	11	9	This plot was very badly damaged by rats.
2	Without any addition of Bhang .	1	2	4	7	0	2	33	9	8	..	..	..	..	..	..	..	The damage was very little.

Note. Wheat selling at Rs. 6 per maund. Straw selling at As. 12 per maund.

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Diagram 1.

G u a						r a 1 Crop		
C o						n t r o l		
G u a						r a 2 Crop		
C o n						t r o l		
G u a						r a 3 Crop		
C o						n t r o l		
G I	A I	C o n	G II	A II	C o n	G 3	A 3	C o n

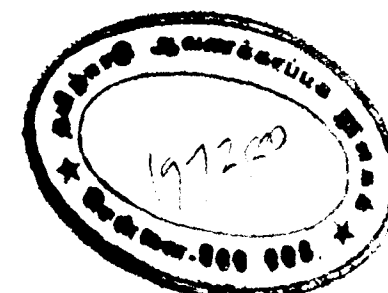
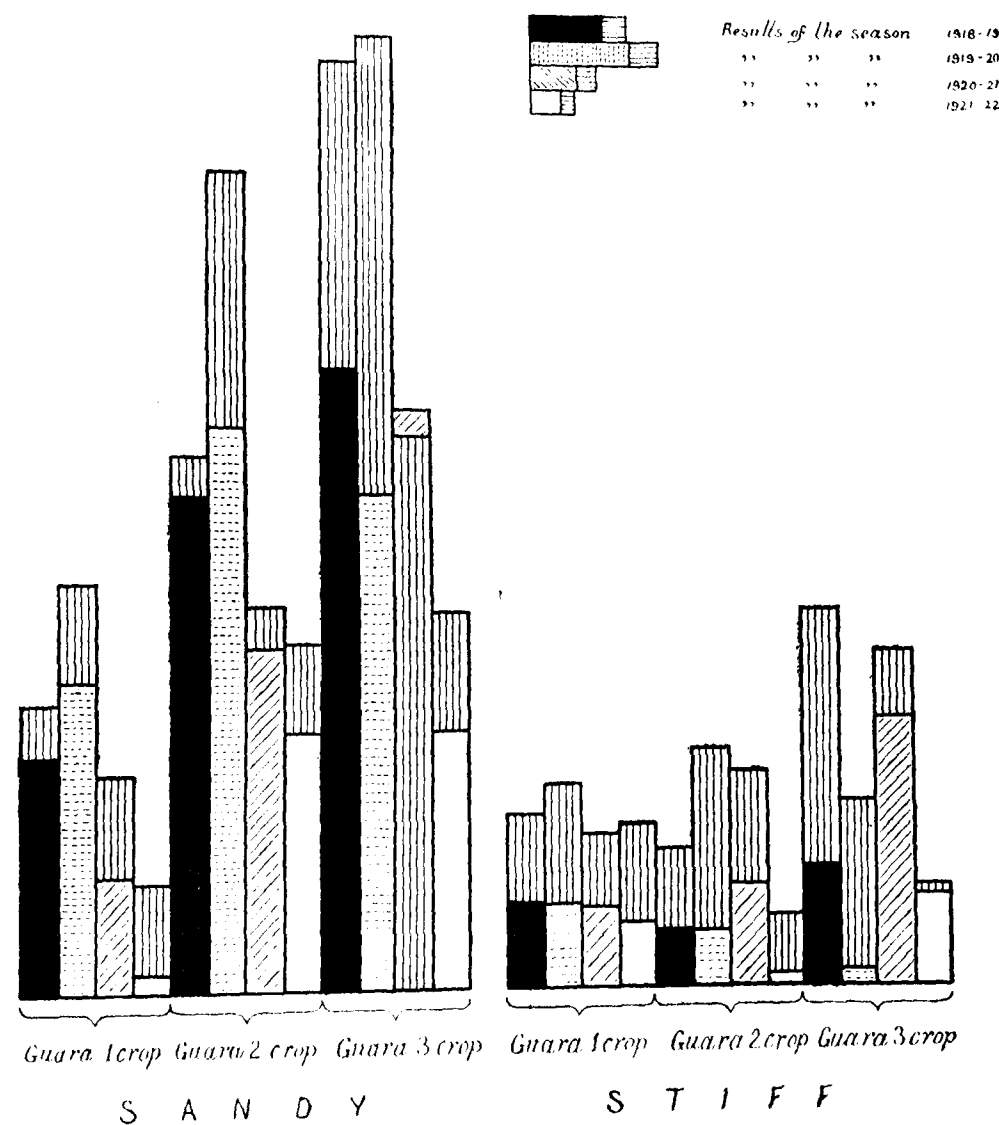


Diagram 2

Explanation. The full shaded columns are proportional to percentage increases in grain and straw above the control plots, the striped areas being proportional to excess increase in yield of straw



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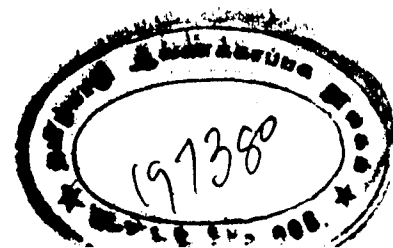
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