EFFECT OF GROWING COTTON IN ROTATION WITH DIFFERENT CROPS ON STRUCTURE OF BLACK COTTON SOIL

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IT has been observed that soils under the influence of different cropping systems undergo specific structural changes. Many studies have been made in different countries on the effect of various crops and cropping systems on soil structure. The outstanding investigations of W. R. Williams (1935) who developed the concept that soil structure was the key to fertility and that a grass-land system of agriculture was the means of achieving a desirable structure, are too well known. Relatively little work has been done on the effect of common rotational practices on the structure of the soil in this country in general and in Madhya Pradesh in particular. A rotational experiment is being conducted on the Experimental Farm, Akola, Madhya Pradesh, for over 20 years. Opportunity was, therefore, taken to study the effect of some common and suitable crop rotations of this tract on the structural condition of the soil and the investigation, reported in this communication, is an attempt to that end.

EXPERIMENTAL

The soil of the Farm is a heavy clay and is a representative of the typical black cotton soil of the tract. The soil profile shows uniform black colour upto 30 inches depth from the surface, then becoming greyish brown below that depth. Kankars are present throughout the profile, the amount increasing with depth. The mechanical composition of the soil is given in Table I.

TABLE I

Mechanical composition of the soil

(Per cent. on oven-dry basis)

Depth	Moisture	Carbonate	Coarse Sand	Fine Sand	Silt	Clay	pH
0–10″	8·34	4·97	5·81	12·00	20·47	49·80	7·8
10–26″	8·78	5·42	5·95	11·14	18·45	51·38	7·9
26–47″	8·56	7·32	4·12	10·51	17·91	53·32	8·2

A field experiment is in progress at the Farm since 1931–32 in which cotton, juar and groundnut are grown in different rotations. The experiment is a very comprehensive one involving the effect of seven different treatments on cotton crop. Out of these seven treatments, the following three were selected for our study.

Treatment A: Cotton grown year after year.

Treatment B: Cotton followed by juar in alternate year.

Treatment C: Three course rotation. First year cotton followed by juar in second year followed by groundnut in third year.

The field is divided into five blocks and each treatment is replicated in the five blocks in a random manner. The size of the plot is 1/20 of an acre and sufficient space between adjacent blocks and plots has been provided to facilitate cultural operations. All these plots did not receive any manurial treatment from 1931–32 to 1939–40. However, since 1940–41, they are receiving 40 lb. of Nitrogen once in three years, half in the form of F.Y.M. and half in the form of Ammonium Sulphate at sowing time. As is the usual practice with the cultivators of this tract, these plots were ploughed once in three years since the commencement of the experiment.

For investigating the structural changes, a composite soil sample for each plot was taken by mixing equal quantities of soil from ten different spots taken at random. Each block contains six plots under the three treatments studied. Thus thirty samples were collected for three treatments from all the five blocks from 0–6″ layer while for 6–12″ layer, the number of samples was twelve as they were taken from two blocks only. These samples were taken in the month of October 1953.

METHODS EMPLOYED

In the present study, the following methods have been used for evaluating the structural changes in the soil that might have been brought about as a result of different rotations.

(i) Water-stable aggregates.

(ii) Total porosity and volume weight.

(iii) Volume of large pores.

(iv) Dispersion coefficient.

(v) Permeability.

(i) *Water-stable aggregates*

Aggregate analyses were carried out by wet sieving, using an adaptation of the Bouyoucous (1935) method. The adaptation became necessary in order to obtain reasonably reproducible results. The method used finally is as follows:—

A sample of 50 gm. of air-dry soil consisting of 5–10 clods of nearly equal size was submerged in water for half-an-hour. The contents were then subjected to sieving analysis by hand as described by Bouyoucous. The quantity of aggregate material > 2 mm., > 1 mm., > ·5 mm. and over ·2 mm. was determined after removal of sand from the respective fractions. The aggregated silt and clay were determined by undispersed water suspension and the crumbs between 0·2 to ·02 mm. were found out by difference.

(ii) *Total Porosity and Volume Weight*

Total porosity and volume weight were determined in the usual way in the undisturbed soil core samples taken for permeability studies.

(iii) *Volume of large pores*

An indication of the distribution of pore space was obtained by taking measurements to show the division of total pore space into large and small pores, in other words, finding the so-called non-capillary and capillary porosities. The volume of pores drained when the pressure deficiency of the samples was increased from zero (saturation of sample) to 40 c.m. water (pF 1·6) was taken as the value for volume of large pores as suggested by Nelson and Baver (1940).

(iv) *Dispersion Coefficient*

Dispersion coefficient was calculated by determination of the silt and clay in the undispersed suspension by Puri's method (1930).

(v) *Permeability*

(*a*) *Permeability of undisturbed core samples.*—Permeability is measured quantitatively in terms of rate of percolation of water through a column of soil under specific conditions. The samples used for this study were the core samples 3″ in diameter and 3″ in height taken in metal cylinder with the least possible disturbance of natural structure and volume by using the core sampler and the rates of percolation through saturated samples have been determined as per procedure laid down by R. E. Uhland and A. M. O'Neal (1951).

(*b*) *Permeability of the disturbed samples.*—In determining the percolation rates through disturbed samples, the only difference was that instead of the metal cylinder being filled with soil in the natural condition, it was filled with soil clods of nearly equal size as were used in the aggregate analysis. The soil cylinder was submerged in water overnight, the swollen portion of the soil being chopped off clean the next day. The percolation rates were then measured exactly in similar manner as in the case of undisturbed cores.

RESULTS

The results presented in Tables II–VIII relate to the soil samples from 0–6″ layer.

TABLE II

Results of aggregate analyses

(Per cent. on oven-dry soil)

Sl. No.	Rotation	Cotton continuous A	Cotton followed by Juar B		Three Course Rotation Cotton-Juar-Groundnut C		
	Crop in the Plot · Particle size mm.	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
1	>2	0·49	0·31	0·50	0·27	0·60	0·35
2	2–1	1·39	1·01	1·09	0·87	0·91	0·56
3	1–·5	8·42	8·24	7·28	7·51	5·80	4·64
4	·5–·2	37·83	39·46	39·46	39·09	37·52	37·57
5	·2–·02	15·43	14·90	15·54	16·08	19·89	21·34
6	<·02	6·70	6·30	6·39	6·44	5·53	5·81
7	Degree of Aggregation. Mean for rotation	68·46	69·29		64·38		
8	Single value figure for surface area. Mean for rotation	595·7	589·3		587·6		

Statistical Analysis for Degree of Aggregation

C.D. at 5% level for A B .. 5·98
A C .. 5·66
B C .. 4·46
Result B A C

Statistical Analysis for single value figure for Surface Area

C.D. 5% for A B .. 62·81
A C .. 53·31
B C .. 41·87
Result A B C

Water-stable Aggregate Analysis

The results of aggregate analyses are presented in Table II. Each value is the mean of five replications, the analyses of each replicate being carried out in triplicate.

(i) *Degree of Aggregation*

The figures from Table II have been plotted in the form of summation curves with a logarithmic scale for particle diameters, and are shown in Fig. 1. For comparison, Fig. 1 also shows a mechanical analysis curve of

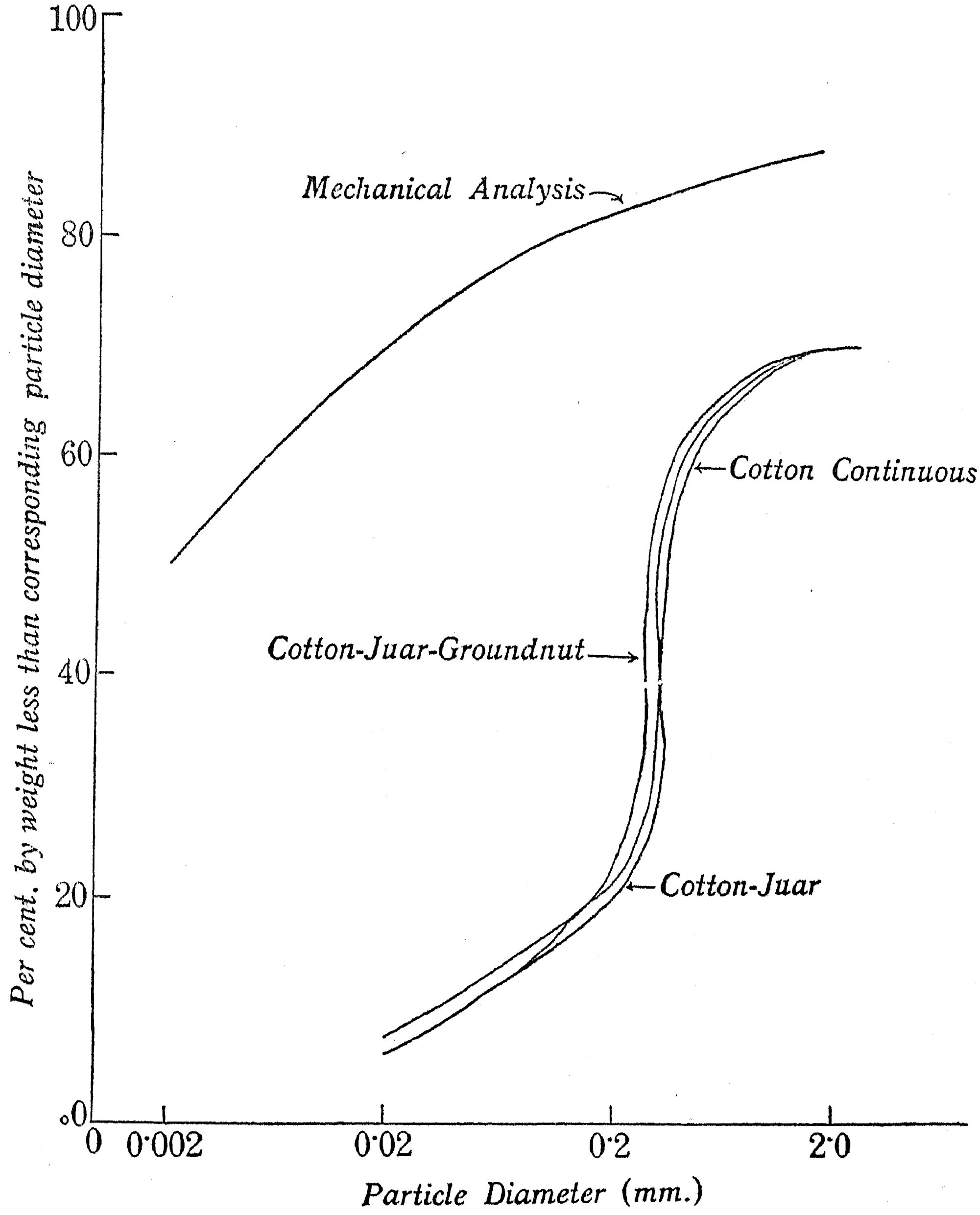

FIG. 1. Aggregate Analysis Summation Curves.

the Farm soil. It would be seen on examining Table II and Fig. 1 that the proportion of soil aggregates of different grades is of the same magnitude in all the three rotations.

In order to compress the data from an aggregate analysis into a single figure, it is customary to quote the degree of aggregation at a given minimum aggregate diameter. Though no two investigators have agreed on this limit, it is generally accepted that only those aggregates that are larger than 0·25 mm. in diameter are responsible for stable soil structure. However, in the present study, the diameter has been taken as ·2 mm. for calculation of the degree of aggregation. The mean values for the degree of aggregation (Table II) range from 64–69, the highest value being obtained in the case of Cotton-Juar rotation. In comparing the treatments, it may be noted that the difference between the Cotton-Juar over Cotton-Juar-Groundnut alone just exceeds the critical difference at 5% level. In general, therefore, there is no appreciable change in the proportion of silt and clay aggregated in crumbs > ·2 mm. under the different rotations.

(ii) *Relative Surface Area*

The structural condition of the soil can also be judged by the relative surface area as suggested by Cole (1939). In the present studies, however, a single value figure for the surface area contributed by all the soil aggregates has been worked out according to the procedure described by Basu and Kibe (1946).

Reference to row No. 8 of Table II shows that the average values for surface area differ very slightly from treatment to treatment. The critical difference for any two treatments exceeds many times the difference between the means for those treatments, thus indicating that rotations have hardly caused any difference in the structural condition of the soil. In this connection, it may be noted that Kibe and Basu (1952) used this value in order to bring out prominently the small differences in the structure of the soil which could not be brought out by the commonly used size distribution curve. Considering the fact that very slight changes in the finer fraction affect this value greatly, it will be evident that the aggregation of soil has not changed under the different rotations even on consideration of the soil crumbs of lower dimensions.

Dispersion Coefficient

Dispersion coefficient is the other value which is commonly taken as an index of soil aggregation. It indicates the proportion of silt and clay which is dispersed and remains suspended in water. As such, higher this ratio, lower will be the proportion of aggregated silt and clay. The values for the coefficient are presented in Table III below.

TABLE III

Dispersion coefficient

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No.						
I	11·10	12·60	12·46	10·85	10·39	7·75
II	10·67	10·42	9·46	11·85	7·58	7·54
III	6·44	10·77	7·15	8·51	8·36	7·12
IV	6·29	5·44	8·22	6·33	9·86	9·29
V	9·61	5·76	8·18	9·25	6·76	6·55
Mean for rotation ..	8·82	9·04			8·53	

Statistical Analysis.—S.E. % .. 9·0
C.D. for A B .. 2·017
A C .. 1·902 Result $\overline{\text{B A C}}$
B C .. 1·503

A scrutiny of the data in Table III reveals that practically the same percentage of silt and clay has remained unaggregated under the different rotations.

Volume Weight

Volume weight is another value which determines the structure of a soil as much as any other single factor. Granulation encourages a pluffy porous condition and hence a lower value for the volume weight indicates a better structure of the soil. In the present study, it was determined by taking undisturbed core samples and the values are recorded in Table IV.

It will be seen from the values given in Table IV that so far as volume weight is concerned, the physical condition of the soil has not undergone changes under the various rotations.

TABLE IV

Volume weight

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No.						
III	1·12	1·12	1·26	1·09	1·01	1·18
IV	1·22	1·15	1·06	1·10	1·04	1·12
V	1·08	1·08	1·02	1·12	1·02	1·26
Mean for rotation ..	1·14	1·11			1·11	

Statistical Analysis.—S.E. % .. 3·8

C.D. at 5% level A B .. ·2642
A C .. ·1085 Result $\overline{A\ B\ C}$
B C .. ·0858

TABLE V

Total pore Space

(% by Volume)

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No.						
III	60·77	57·62	55·80	59·15	65·61	58·61
IV	54·81	58·42	59·12	58·83	63·20	60·83
V	59·40	59·16	61·06	58·28	63·19	52·81
Mean for rotation ..	58·33	58·53			60·06	

Statistical Analysis.—S.E. % .. .. 2·6

C.D. at 5% level for A B .. 4·233
A C .. 3·993
B C .. 3·155 Result $\overline{C\ B}\ A$

Porosity

Total porosity and volume of large pores are listed in Tables V and VI respectively.

TABLE VI

Volume of large pores

(% by Volume)

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No.						
I	19·32	20·46	21·59	20·46	22·16	20·46
II	21·02	21·02	22·16	21·59	23·29	18·43
III	26·13	23·29	20·40	25·00	21·59	18·75
IV	21·59	18·43	23·86	19·08	17·11	21·05
V	19·73	20·46	21·02	18·43	17·76	17·11
Mean for rotation ..	21·56	21·27			20·15	

Statistical Analysis.—S.E. % .. .. .. 4·2

C.D. at 5% level for A B .. 2·2468

A C .. 2·1183 Result $\overline{A\ B\ C}$

B C .. 1·6748

The values for total porosity in Table V range between 58·33 to 60·06 and the differences are not statistically significant. Soils under the different rotations have practically, therefore, the same total pore space.

In heavy soils the total porosity is not so important for characterising structural properties as the relative distribution of the pore sizes. Because even though they contain large amount of total pore space, the movement of air and water will be restricted to a great extent if they do not contain a reasonable proportion of large pores. It is therefore necessary to examine this point further by taking into consideration the values for large pores recorded in Table VI. A scrutiny of this table will reveal that the percentage of large pores under all the rotations is more or less the same and when compared with the total pore space, their proportion works out to about the same magnitude in each case. It seems, therefore, that there is no structural variation under the different rotations even if the consideration of porosity is restricted to volume of large pores. As stated earlier, the volume of large pores is taken as the volume of pores drained at pF 1·6.

Permeability

The movement of water and air through soil which is the primary function of the structure, is related to the size and arrangement of the pores. A better approach for evaluation of the structure, therefore, should include a method which takes into account the movement of water through undisturbed arrangement of the soil particles. Measurement of aggregation and other laboratory tests are of assistance but they cannot be considered adequate to indicate the natural condition of the soil as they are carried out after disturbing the arrangement of soil particles. Once the natural arrangement is disturbed in the laboratory, there is no way of reconstructing it. It is mainly because of these considerations that the direct permeability measurements through undisturbed soil core samples have received widespread recognition in recent years.

(*a*) *Rates of percolation through undisturbed core samples.*—The rates of percolation through the undisturbed core samples are recorded in Table VII.

TABLE VII

Rates of percolation through undisturbed soil core samples

(inches per hour)

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No. III	0·50	3·37	0·33	0·91	4·08	0·22
IV	0·03	2·29	5·49	2·68	3·54	0·25
V	5·19	1·21	10·88	2·59	5·10	0·28
Mean for rotation ..	1·90	3·92			2·13	

Statistical Analysis.—S.E.% .. .. .. 42·9

C.D. at 5% level for A B .. 2·529

A C .. 2·384 Result $\overline{B\ C\ A}$

B C .. 1·885

It will be observed from the mean values in Table VII that there is very little difference between the percolation rates in different rotations and statistically the difference is insignificant. Closer scrutiny of the table shows that there is a wide range of variation between the values for samples from different blocks, the percentage of standard error being as high as 42·9. Only one sample was taken from each plot. Uhland and O'Neal (1951) have, however, recommended that, due to a great variability in the values, at least a minimum of six determinations should be carried out for permeability studies. As the number of metal cylinders available was limited it was not possible to take more than one sample per plot.

(*b*) *Rates of percolation through disturbed soil samples.*—Percolation rates through disturbed core samples have also been studied. It is no doubt observed that permeability values obtained in the laboratory in general, do not agree, with the field percolation rates, yet the work of Fireman and others (1944), indicate that the disturbed soil samples can be used advantageously to study the relative changes in percolation rates, brought out by different treatments. They have further shown that because of its extreme sensitivity, soil permeability as determined in the laboratory may be one of the best, if not the best, criterion of soil structure available. In view of this, it was considered desirable to supplement the data regarding the rates of percolation through undisturbed soil samples by permeability values obtained in the laboratory. These values are recorded in Table VIII.

TABLE VIII

Rates of percolation through disturbed soil samples

(inches per hour)

Treatment	Cotton continuous A	Cotton followed by Juar B		Three course rotation Cotton-Juar-Groundnut C		
Crop in the Plot	Cotton	Cotton	Juar	Cotton	Juar	Groundnut
Block No.						
III	4·52	3·12	3·52	2·17	3·25	3·53
IV	2·26	2·78	2·32	2·41	2·63	2·39
V	1·90	2·70	2·25	2·54	3·18	3·27
Mean for rotation	2·89	2·78		2·82		

Statistical Analysis.—S.E. % .. .. .. 12·2

C.D. at 5% level for A B .. ·935

A C .. ·883 Result $\overline{ACB}$

B C .. ·697

The first point which the data in Table VIII brings out is that the variation in the values is much lower than what has been observed in Table VII. The percentage of standard error has been appreciably reduced, *i.e.*, from 42·9 to 12·2%. The mean values also indicate that there is no significant difference between the mean values for any two rotations. Thus laboratory tests of percolation also do not reveal the superiority of one rotation over the other.

Structural changes in 6–12″ layer

In order to investigate into the effects of different rotations in the lower layer, *i.e.*, 6–12″, determinations were also carried out in samples from two blocks and the results are presented in Table IX. For comparison the values for 0–6″ layer are also shown side by side in the table.

TABLE IX

Structural values for samples from 0–6″ and 6–12″ layers

Treatment	Continuous Cotton		Cotton-Juar Rotation		Three course rotation Cotton-Juar-Groundnut	
Depth	0–6″	6–12″	0–6″	6–12″	0–6″	6–12″
Values						
Degree of Aggregation	68·4	66·2	69·2	71·1	64·3	65·8
Single value for surface area ..	595·7	575·4	589·3	563·1	587·6	556·3
Dispersion Coefficient	8·8	7·0	9·0	8·8	8·5	7·5
Rate of Percolation through undisturbed core samples ..	1·9	0·9	3·9	2·0	2·1	1·5

Values recorded in Table IX show that there is not much difference between the mean values for 0–6″ and 6–12″ layers thus indicating that the structural condition of the soil does not vary in the 12″ surface layer.

Effect of Standing Crops on the Structure

So far the effect of rotation as a whole has been described. In this, the values for the different crops in the rotation have been averaged for calculating the mean value for the rotation.

TABLE X

Values of structural determinations for different crops

Treatment	Cotton-Juar			Cotton-Juar-Groundnut			
1 Crop	2 Cotton	3 Juar	4 C.D.	5 Cotton	6 Juar	7 Goundnut	8 C.D.
Values							
1. Degree of Aggr. ..	69·78	68·79	11·10	67·94	63·82	61·37	7·86
2. Surface area ..	594·40	584·10	183·80	590·60	573·20	598·80	69·15
3. Dispersion Coefficient	8·09	9·09	3·98	9·36	8·59	7·62	2·48
4. Volume weight ..	1·12	1·11	0·22	1·10	1·02	1·18	1·14
5. Total porosity ..	58·4	58·66	5·14	58·95	64·00	57·41	5·22
6. Volume of large pores	20·73	21·80	2·25	20·91	20·38	19·16	3·01
7. Rate of percolation through undisturbed samples ..	2·29	5·56	8·18	2·06	4·24	0·25	1·57
8. Rate of percolation through disturbed sample	2·87	2·69	1·19	2·37	3·02	3·06	1·12

It was also considered desirable to study the effect of standing individual crop in a rotation on soil structure. The rotations chosen are :—

(1) Cotton-Juar and
(2) Cotton-Juar-Groundnut

The mean values of various determinations for different crops in the cotton-juar and cotton-juar-groundnut three course rotation, with the respective critical differences are presented in Table X.

It will be seen from Table X that none of the differences in mean values for cotton and juar crops in cotton-juar rotation has reached the level of significance. When the differences in the mean values for cotton, juar and groundnut crops in the three course rotation are compared with their respective critical differences given (Column 8), it will be observed that out of the possible 24 comparisons, in two cases only, *i.e.*, total porosity and rate of percolation through undisturbed soil cores, juar crop is showing significantly higher values than groundnut. As has already been pointed out, those determinations could not be carried out on adequate number of samples, and as such, much emphasis cannot be placed on its significance. Taking into consideration the values for all determinations in the two rotations mentioned above, it appears that none of the standing crops of the year had any pronounced effect on the structure of the soil.

DISCUSSION

In this paper an effort has been made to have as complete a picture of the structural condition of the soil as possible by employing as many as eight different methods of evaluation, some of which are completely independent of each other. The foregoing results have clearly shown that the soil is in more or less the same structural condition under all the different rotations. These observations are of special interest when it is remembered that the experiment is in operation for more than 20 years and the effect of different cropping practices can, therefore, be considered as stabilised.

Several investigators in other countries [Heltzer (1934); Rostovzeva and Avaeva (1935); Williams (1935); Woodruff (1939); Lutz (1941); Johnston, Browning and Russell (1943); Elson (1944); Myers and Myers (1944); Gish and Browning (1949); Uhland (1950); Barel and Schaller (1951); Bolten and Webbin (1952)] have, however, observed that soil structure is materially influenced by the cropping system. Since the findings in the present investigation are at variance with those of the above workers, it will be of interest to examine certain factors which are likely to throw some light on these apparently dissimilar results.

It is interesting to note that in other countries, marked effect in the improvement of soil structure, as a result of cropping system, has been observed generally in case of those crop rotations which include grass as one of the rotational crops. Improvement in soil structure has also been noticed, though to a lesser extent due to close-growing legume crops. The beneficial effect of a grass crop in rotation will be obvious from the results of Wilson, Rogger, Gish and Browning (1947). The percentage of water stable aggregates $>$ 1 mm. in corn in rotation was 23·3 while in case of meadow in rotation it was as high as 42·2. Similarly, Doirenko (1933) reported that the non-capillary porosities of fields in permanent fallow, in flax in rotation without grass and in flax rotation with grass were 4·9, 5·2 and 19·7% respectively. It may specially be noted that the rotation did not materially affect the structure until grass had been included. The fact that no grass was included in any of the rotations studied in the present investigation may partly explain the uniformity maintained in the structural condition of the soil.

As regards the favourable effects of a leguminous crop on soil structure, it may be effective when it developes a deep large fibrous root system or when maximum portion of the plant material, in the green stage or as crop residues, is returned to the soil. Beneficial effect on soil structure has been observed by Woodruff (1939) and Lutz (1941) by growing a leguminous green manure crop and by Uhland (1950) by including such close growing crops with deep large roots like lucerne and Kudzu. Myers and Myers (1944) have also observed that about 50% higher total aggregation was found in samples taken from plots which were under a rotation including lucerne or sweet clover than in samples similarly taken in a rotation from which the legume was omitted. It is true, that one of the rotations in the present case does include a leguminous crop, *i.e.*, groundnut but it is not used as a green manure. Moreover, since it is a short duration crop, it is not likely to develop a deep extensive root system. Besides, as is the practice in this tract, all the above ground portion of the crop along with some underground portion is removed from the soil when the crop is harvested. This might explain why the inclusion of groundnut crop in rotation did not bring out the beneficial effect on soil structure.

In the formation of stable soil structure, the length of time the soil remains undisturbed, is also an important factor. Russian workers (1940) who followed the effect of pasture on the structure of the soil found that two or three years were necessary to produce any noticeable improvement. The crops grown in the rotations studied, do not remain in the soil for more than one season. Moreover, the soil is ploughed once in three years, two bukherings are given every year at the time of preparing the seed bed and two or three hoeings are given when the crop is standing in the soil. Assuming, therefore, that the growing crop affects the structure of soil, directly or indirectly, the effects caused by crops like cotton, juar and groundnut, are either not so vivid as will come within the measurable limits of the different methods of evaluation, or the differences might have been obscured by the various cultural operations carried out from time to time thus bringing the soil to a uniform level, of structural condition.

There is another important point in respect of black cotton soil. It has been said of this soil that " it ploughs itself". The formation of deep and large cracks, as the soil dries after the end of the monsoon rains and the filling of those cracks when the next rains begin together with the tremendous volume changes when the soils wet and dry, must result in breaking up the soil clods and thus mixing of the soil material both vertically and horizontally. Evidently, this characteristic cracking and mixing is more conducive towards bringing the soil to a uniform structural condition.

Determinations for evaluation of the structure when carried out separately on 0–6″ and 6–12″ layers did not reveal any difference in the aggregation thus indicating that physical properties of the soil in the surface 0–12″ layer under the different rotations, are more or less similar.

Comparison of plots having different crops under the same rotation also showed that there was no significant difference in the structural condition of the soil under cotton, juar and goundnut crops. In this connection reference is made to the work of Basu and Sirur (1943). These workers in their study of soils of the Deccan canals evaluated the structure by determination of a single value index for soil tilth and dispersion coefficient. They found that the soil tilth, on the basis of this index, did not differ significantly after taking cotton, juar and groundnut crops and the dispersion coefficient also showed the same trend. Recently, Kibe and Basu (1952) studied the effect on soil structure of continuous growing of certain *kharif* crops over ten years and have found that the overall effect of growing cotton, groundnut and juar on the structure of the soil is practically of the same magnitude.

The results obtained in the present investigation regarding the effect of *kharif* crops namely, cotton, juar and groundnut on the structure of the soil, are thus in agreement with these workers.

SUMMARY

Results of an investigation carried out to study the effect of growing cotton in rotation with juar and groundnut on the structure of black cotton soil are presented and discussed.

The rotations studied were:—

(*a*) Cotton grown continuously year after year;
(*b*) Cotton and juar grown in alternate years; and
(*c*) Cotton-juar-groundnut in three course rotation.

Determinations made for evaluation of structure and the ranges of values obtained were:—

(i) Degree of aggregation	64·4– 69·3
(ii) Single value figure for surface area ..	587·6–595·7
(iii) Dispersion coefficient	8·5– 9·0
(iv) Volume weight	1·11– 1·14
(v) Total pore space	58·3– 60·1%
(vi) Volume of large pores	20·2– 21·6%
(vii) Rate of percolation through undisturbed soil core samples	1·9– 3·9 inch per hr.
(viii) Rate of percolation through disturbed soil samples	2·7– 2·9 inch per hr.

No significant differences in the structural condition of the soil were observed in plots under the three different rotations, both in 0–6″ and 6–12″ layers.

The lower 6–12″ layer did not show any structural difference from the surface 0–6″ layer.

None of the standing crops of the year, *i.e.*, cotton, juar and groundnut showed any pronounced effect on the structure of the soil.

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