AN EXAMINATION OF FIELD III, WITH A VIEW TO DETERMINING ITS FERTILITY TREND BY A STUDY OF A SEQUENCE OF CROP YIELDS AND SOIL CONDITIONS FROM A NUMBER OF CONTIGUOUS AND FIXED PLOTS.

SEASON 1939 - 40.

By

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Thesis submitted as part of the examination for The Associateship of The Imperial College of Tropical Agriculture.
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   (II.) Rainfall.
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I. INTRODUCTION.

In the past the experimentalist on the College Farm has been faced with the difficulty of finding a suitable site on which to lay down his trial. This is due to the variation in growth which occurs throughout the area on which the farm is situated. But uneven growth is not restricted to the College Farm. Uneven growth can be seen at the Cotton Station, on cultivated land all along the northern side of the Eastern Main Road as far as Arima, and many areas on Caroni Estate. This uneven growth was particularly pronounced during November and December, 1938, when the farm experienced heavy rains. These rains caused floods and waterlogging, and seriously interfered with experiments which were being carried out by students. Likan (1) noted that cowpea planted in a very wet seed bed in field III. germinated patchily following heavy rains. Brown (2) recorded irregular germination in field XXVII. due to waterlogging. Webb (3) working on sunflowers in field III commented on heterogeneity of soil and waterlogging in low patches. Finally Phillips (4) reported that lack of uniformity of soil spoilt his experimental results in field III.; and he concluded by saying that he did not recommend further experiments on the College Farm.

This lack of uniformity of the soil, which the experimentalist has to face has raised the question of policy on the farm. Shall the farm continue its field trials or shall it confine its activities to demonstrations?

Variation in fertility within fields is plain enough to the eye, and was recorded in field III. in the farm field sheets in 1928 by Wood (5). But no measurements of the actual variation have been taken; so a uniformity trial was laid down early in 1939, field III. being chosen as the site.

Two crops of Woolly Pyrol were grown and plot yields recorded between June and October. When the trial was handed
over to the writer towards the end of November, a maize crop was nearly half grown.

**Aim of Experiment.**

(1) Record the variation in growth on Field III.

(2) Find out whether any part of Field III is suitable for field experiments.

(3) Discover the factors causing variation within crop yields on Field III.

Where reference is made to plots and a letter and number are given in the following pages, this refers to plots as shown in the plan of the experimental lay out (page 17).
II. ORIGIN AND FORMATION OF SOIL IN FIELD III.

Field III. is situated on detritus which occurs along the southern base of the Northern Range, as fans of hill wash. As far as is at present known, the Northern Range is composed of rocks of Cretaceous age; these are all metamorphic except the exposure of igneous rock at Sans Souci Bay on the north coast. The metamorphic rocks near St. Augustine consist in the main of weathered micaceous schists, giving rise to soils of very low base status in all but a few of the more level fans. Small rivers cut grooves through these detrital fans on their way to the sea. During the rainy season they flow with great velocity down the slopes carrying large quantities of erosion products. Sand and gravel were deposited very soon after the Northern Plain was reached, but the clays and silts were carried to Caroni river and finally deposited in the Gulf of Paria. These rivers probably altered their courses many times, leaving unconsolidated patches of sand and gravel in their old beds, and these may have been subsequently covered up by further earthy material before the present relief was attained. Evidence of old stream beds is afforded by the presence of gravel patches, both on the surface and deep subsoil of Field III.
III. HISTORY OF FIELD III.

Before 1928.

During this investigation massive concrete foundations and decaying wood were found on plot G 19, lying in an easterly and westerly direction at a depth of 2 feet 6 inches. These foundations extended beyond the area exposed, but no further excavation was made because it would have seriously disturbed the uniformity trial. The presence of these foundations suggests that a building once stood on this site (on the side of the trace running East and West mentioned below). The soil was compact around the foundations, so these foundations have been submerged many years.

The earliest data giving information about Field III. was found on a plan* of St. Augustine Estate, dated 1888. The survey from which this was compiled was made by Amede de Verteuil, who was the recognised Surveyor to the Trinidad Government at that time, and it can be taken as a true record.

On this plan the position of Field III. has been approximately superimposed. In 1888 the area now known as Field III. was crossed by two traces. One ran North and South and the other East and West. The traces East and West came from the South East corner of the present swimming pool across Field III., and met the trace running North and South at about plot A 16. It is still possible to detect this trace, for bricks and boulders dot its former position. The second trace came over the Government Railway line, across the North West corner of Field III. No signs of this trace have been discovered; it was probably an earth trace without stone foundations. This trace crossed Field III. and was itself crossed by a third trace, which ran East and West across the centre of Field II.; the position of the latter trace can still be seen on the other side of the railway line.

No reliable information has yet been obtained which throws any light on this area before 1888. But an old Indian

(* For plans see appendix XIII. )
named Kisona, who has lived for the last fifty years at St. Gill, worked as a young man at the Sugar Factory (mentioned below) until it was dismantled in 1900. He can remember quite clearly, that all the land along the railway line, now Fields II. to IX., were pasture when he worked at the factory. This pasture was grazed by mules which carted cane for the factory.

Before 1900, St. Augustine Estate consisted of over 8,000 acres, and was owned by Bell Smythe. The estate manager was McInroy. A central sugar factory stood on the present position of the farm buildings. In 1900 Bell Smythe failed; and his estate was taken over by the Trinidad Government. The sugar factory was dismantled, and McInroy was appointed manager of the estate for the Government.

Under this new management most of the present College grounds were thrown open as public pasture (see plan II). The Principal’s residence, then known as St. Augustine House, the Yaws Hospital, now the Biology Building, and the Assistant Warden’s house were all fenced off. Stock of every description was sent to the pasture, and a small fee was charged for each grazing animal. The Government encouraged people to settle on the estate as owners or tenants. Plan II. shows the extent of this settlement in 1903.

In 1913 small holdings had spread from the South and East up as far as the present position of the farm buildings, but the almost all rest of the land between St. Augustine Circular Road and the Government Railway to San Fernando remained pasture. A wire fence ran West from the swimming pool along the line of the old trace across Field III. to the railway. The land on the Southern side of this fence was used by the local Public Works Department, to grow para grass, which they carted off the land. This para grass extended as far as the pond. The remainder of Field III. above the wire fence jutted into a strip of sugar cane. The para grass field was used until 1922 as a burial
ground for stock, which died on the public pasture. Graves remained as humps. The use of the para grass field as a burial ground for stock is said by some to be untrue, but men working on the farm and others have described how they saw horses and cows buried in this area when it was grass before the College took it over.

In 1920 the Government broke up the remainder of St. Augustine Estate, which had not been sold or let to tenants. The Department of Agriculture took over some; while the Department for Crown Lands managed the rest; this included the College grounds.

In 1922, the savannah, part of the Botany Department, and land around the Engineering Department were handed over to from the Imperial College of Tropical Agriculture. Later in the year further land was added to the College, and Field III. was included.

In 1924 the College closed the pasture from the public; and Fields J - O on plan III. were laid out. In 1931 Field K was re-named Field III.

As soon as these new lands had been laid out, trees were removed and the land ploughed. There were no Samén trees growing in Field III. but a few coconut trees, and a large Pomerae (Eugenia malacensis) in the N.W. corner of the field were cut down, and the roots of the latter excavated. The field was ploughed with two pairs of oxen and ploughs, borrowed from the Government Stock Farm. But this ploughing was shallow because the ground was hard; a tractor was therefore hired from Orange Grove Estate to re-plough the field to a greater depth. After ploughing the field it was levelled with a metal scoop, and as much as a foot of soil was removed to fill low places; this operation considerably reduced the hummocks and depressions.

In 1925 surface drains were dug 2 feet wide and 20 feet apart. The drains ran parallel to the Northern and Southern boundaries of the field, and joined larger surface drains at the
outside. Sugar Cane was planted in Field III., but a strip next Field II. was planted in maize. The cane remained until 1927.

In October 1927 Professor R. C. Wood took over the directorship of the farm. He began by making drastic alterations. The surface drains of Field I., II. & III. were all destroyed; and every attempt was made to prevent water running off these fields. In subsequent years the Southern and Western part of Field III. would form a sheet of water after heavy rains. In some places the field flooded to a depth of 1 foot.
After 1927. Extracted from Farm Field Sheets.

**1928.**

Jan. - June: Whole field was savannah, ploughing, removing coconut trees, levelling, digging out stumps of trees, hauling and burning.

**1928 - 29.**

June 1928 - April 1929: 1.3 (a) Sugar Cane, variety trial, manure:
- 1 cwt. Superphosphate.
- 1 " Sulphate of Potash.
- 2 " Blood.
- 1 " Sulphate of Ammonia.

Sept. 1928 - May 1929: 1.05 (a) Tobacco, variety trial.
- 0.61 (b) Strips of Forage Crops.

Aug. 1928 - Dec. 1929: 0.6 (c) Soya Beans.

Manure:
- 1.8 cwts. Fish.
- 1.2 " Superphosphate.
- 0.6 " Sulphate of Potash.


**1929 - 1930.**

378 Yds.

<table>
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<th>Area</th>
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<tr>
<td>CASS</td>
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<tr>
<td>COWPEA</td>
<td>0.65 (a)</td>
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<td>WOLLY PYROL</td>
<td>0.167(a)</td>
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<td>50'</td>
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1930.

April:- Whole field received 28 tons of Limestone.
June 25 - Whole field (4.019(a)) Maize. A good crop.
Oct. 23:- 3,375 lbs. dry cwt. of corn p.a. Especially good in Southern part where onions had been grown: here good soft tilth; in centre lumpy. Southern half of field had very good growth because of previous year's dressing of dung. Western and central area of field had poor, yellow growth. Supplies failed as they never caught up with older plants.

Manure:- 12 cwts. Fish.
8 " Superphosphate.
8 " Sulphate of Potash.

1930 - 31.

Dec. 1, 1930 - ) Whole field (4.019 (a)) Cowpea.
Feb. 19, 1931: }

1931.

April 24th - June 29th: Whole Field,(4.00 (a)) Sunn Hemp.

Manure:-
2 cwts. Superphosphate.

Aug. 7th - Nov. 28th: Whole Field Maize.

It was a very poor crop. Manure:-
3 cwt. Fish p.a.

1931 - 32.

Dec. 23rd 1931 - March 21st 1932:- Whole Field (4.019 (a)): Black Eye Cowpea.

1932.

March 29th - June 2nd: Whole Field (4.13 (a)): Woolly Pyrol. removed from field and thrushed.

Aug. 20th - Oct. 15th: Whole field Sunn Hemp.
Ploughed in.
1932 - 33.

Manure:
2½ cwts. Murate of Potash.
2 cwts. Superphosphate.

1933.

Much weed, cut and turned in for following maize crop, as ground very wet.
Manure:
2 cwts. Nicifos.
2 cwts. Murate of Potash.

April 18th - Aug. 28th: Southern Half: Soya Bean.
On June 3th 32 lbs. Woolly Pyrol sown in crop. Irregular germination due to dry weather, cut and harvested.
Manure:
2 cwts. Nicifos.
2 cwts. Murate of Potash.

1933 - 34.

Manure:
3 cwts. Nicifos.
3 cwts. Murate of Potash.

Sept. 7th 1933 - Jan. 3 1934: Southern Half: same as above.
<table>
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<tr>
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<td>CHILLIES</td>
<td></td>
<td>0.07</td>
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<tr>
<td>WOOLLY FUR</td>
<td></td>
<td>2.0 (a)</td>
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Dec. 15th 1933 - May 1934: Tobacco.

Manure:-
- 185 lbs. Murate of Potash.
- 222 lbs. Blood Meal.
- 148 lbs. Superphosphate.
- 74 lbs. Sulphate of Ammonia.

Jan. 6th 1934 - June 1934: Tomato Experiment.

Manure:-
- 140 lbs. Nicifos.
- 175 lbs. Sulphate of Potash.
- 250 lbs. Superphosphate.

Dec. 1933 - May 1940: Chillies.

Manure:-
- 4 lbs. Nicifos.
- 7 lbs. Superphosphate.
- 5 lbs. Sulphate of Potash.

This northern half of the field received loads of synthetic manure.
Manure:-
3 cwts. Nicifos.
2½ cwts. Murate of Potash.
3 cwts. Blood Meal.

1934.
July - Oct.:
Whole field (4.13 (a)): Woolly Pyrol.
Had no manure, and was removed from field when harvested.

1934 - 35.

Oct. 24th 1934 - March 1935: Sweet potato variety trial I.
(0.82(a)).
Manure:-
5½ tons Compost.
250 lbs. Blood Meal.
112½ lbs. Murate of Potash.
42½ lbs. Nicifos.

II. (1.76(a))

**Manure:**
- 8.6 tons Pen Manure.
- 288 lbs. Fish Meal.
- 100 lbs. Nicifos.
- 100 lbs. Murate of Potash.

Oct. 29, 1934 - April 19, 1935: Sweet Potatoes (1.55(a)).

**Manure:**
- 98½ lbs. Fish Meal.
- 94 " Blood Meal.
- 153 " Nicifos.
- 78 " Murate of Potash.

**1935.**

May 20th-Sept. 6th: Whole field: Maize.

**Artificial Manures:**
- 4 cwts. Sulphate of Ammonia.
- 4 cwts. Murate of Potash.
- 8 cwts. Superphosphate.

Oct. 9th-Nov. 22nd: Whole field: (4.13(a)) Cow pea.

**Manure:**
- 2 cwts. Sulphate of Ammonia except first acre on Western side which had 4 cwts. p.a.

**1935-'36.**


**Crop taken for seed.**

**1936.**

Whole field grew cover crop.

- Sunn Hemp May 19th - Sept. 30th.
- Woolly Pyrol July 7th - Sept. 30th.
1936 - 37.

Nov. 10th '36 - March 15th 1937: Maize (1.88 a).

Manure:

- 2 cwts. No. 2 N.P.K. mixture.

Feb. 8th '37 - June 7th 1937: Songham (0.5 a)


Manure:

- 2 tons pen manure.
- 2 cwts. No. 2 N.P.K. mixture.

1937 - 38.


Manure:

- 10 tons F.V.M.
- 1/2 cwt. Sulphate of Potash.
- 1/2 cwt. Nicifos
- 1 cwt. Murate of Potash.

1938:


Manure:

- 2 cwts. Superphosphate.
- 1 cwt. Murate of Potash.

Crop was harvested and seed taken.


Crops were harvested and seed taken.

1938 - 1939.


Oct. 1938 - March 1939: Western Half (1.37 acres):

Post Graduate experiments with Sun flowers,
Cow pea and Soya Beans.
THE EFFECT OF THE PAST TREATMENT ON THE UNIFORMITY TRIAL.

There is not sufficient data on which to compare any relationship between the past history of Field III. and its present fertility variation. This comparison must be delayed until the mean of several crops is available.

The past history shows that Field III. has been under different treatments. In the last ten years it has been divided in half eight times, and these divisions were sometimes subdivided and grew different crops and received different manures. It is tentatively suggested that, assuming the maize yields of this year are a reliable indication of the fertility, the permanent fertility of the land overshadows past treatment, and the uniformity trial will in the future be little affected by the past treatments.
IV. Experimental Section.

(a) Lay out.

Field III. was laid out by the third-year Diploma Students in 1939 before the first crop of Woolly Pyrol was planted. Iron piping was driven into the ground round the sides of the field to mark the position of plots and discard areas. These marks were checked in March, 1940, and set in cement at ground level.

Plot size is 33 feet by 33 feet = \(\frac{1}{40}\)th acre.

Discard areas between plots running North and South are 4 feet wide with a central discard area of 10 feet. Discards running East and West are 7 feet with one in the middle of 14 feet. Discards round the outside of the field vary in size and are shown in the plan of the lay out.

All tables of results and diagrams of this lay out that follow are shown without discard areas. Plot lettering and numbering are on the North and West side respectively. A block of plots is described by a single number across the field East and West and by a letter North and South.
PLAN OF LAYOUT ON FIELD III.

The field was ploughed in blocks from East to West so that it was ridged in the centre.

Field II.

Field IV.
B. CROPS.

1. Woolly Pyrol: (Phaseolus mungo).

(a) Procedure.

The field was ploughed in blocks from East to West so that each block was ridged in the centre.

A seed-bed was prepared with harrows. On 16th and 17th June, 1939, 225 lbs. of seed were broadcast; this was weighed out for each block and scattered with a fiddle. On 21st June 3/4 cwt. sulphate of Ammonia was broadcast per acre by hand from a pale; the quantity for each block was carefully weighed out, but the operation of broadcast was not supervised. During crop growth drains across the field between blocks were kept open, and large weeds were destroyed by hand hoeing.

The crop was harvested when the first flowers appeared. Discard areas were cut and removed on 27th July. From 1st to 4th August the crop was harvested; it was cut by hand and each plot yield was weighed on a spring scales suspended on a tripod, and the weight was recorded.

(b) Observations.

Ploughing was even and the conditions for seeding were remarkably good. Seed germinated well and came through evenly. During growth the crop became patchy, and by harvest the variation between plots was very pronounced. At this stage the Farm Overseer reported the crop "good on the whole."

The rainfall throughout the growing period was even; it was normal for the season (See Appendix XII.).
**Harvest Results.**

Table I. Woolly Pyrol: Plot yields in lbs, after correction.

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</tbody>
</table>

Standard Deviation: 59.
WEATHER CONDITIONS AND CORRECTIONS MADE.

1st - 2nd August.
12.15 a.m. - 1.0 a.m.
Cutting and weighing by moonlight.
Rain stopped work.

2nd - 3rd August.
9.0 p.m. - 2 a.m.
Cutting and weighing by moonlight.
Rain stopped work.

4th August.
7 a.m. - 11.30 a.m.
Crops wet, day over-cast.

G to K x 25, 26.
---
A to F x 25, 26.
and all plots in rows
21 - 24, and A, E x 1920 incl.

C to K 1920 (incl) rows
16, 17, 18, - 5 %
(d) Discussion.

It was thought that by harvesting the crop at night it would be possible to eliminate variations in crops moisture content which occur during the day, and obtain plot yields which would be comparable. But this attempt failed because rain upset work, and the last few plots had to be harvested during the morning two days after the second nights work. To reduce errors the yields from plots harvested during the day were reduced by 5%; further error may have been introduced when the crop was manured.

The results (Table I.) are certainly not accurate, but since there was a distinct variation in plot growth the broadest conclusions can be drawn. The Colour Diagram (Appendix I.) shows plot yield groups in colour - groups. An area of low yield extends from the centre to the North East and North West and as far as the edge of the field on the West. High yielding areas occurred in the four corners of the field and on the East and South.
2. **Woolly Pyrol**: (*Phaseolus mungo*).

(a) **Procedure.**

The field was cutlassed, ploughed and harrowed down to a seed bed. On 19th August 190 lbs. of seed were broadcast with a fiddle. The crop received no manure. During growth the weeds were removed by hand hoeing and the drains were kept open. On 6th October discard areas were cut and three days later the plots were cut and weighed by the same method used in harvest of the first crop. The whole crop was cut in one day.

(b) **Observations.**

The conditions for growth were very good; germination was even; but the rainfall, although higher, was less evenly distributed than the first crop. The crop developed most marked unevenness by harvest time.
(c) Harvest Results.

Table II. Woolly Pyrol: Plot yields in lb, after correction.

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WEATHER CONDITIONS AND CORRECTIONS MADE.

**a.m.**

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<td>Rows 25, 26 cut</td>
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<td>8.30 - 9.45</td>
<td>Crop dry</td>
<td>23, 24 cwt.</td>
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<td>Shower: Crop</td>
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<td>G 19, 20 cut</td>
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**d.m.**

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<td>H to K 19 20 cut</td>
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<td>Crop dry</td>
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<td>Heavy shower,</td>
<td>Plots G to K 17 (incl)</td>
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<td>crop very wet</td>
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(d) Discussion.

This crop was lighter than the first, and since it grew under similar conditions, but without artificial manure there is reason for the lighter yield. Error due to uneven distribution of manure was absent. During harvest dew in the morning and showers during the rest of the day introduced error into weighing. Corrections (see above) were estimated and applied to plot yields, and the final summary of results is shown in Table II.

Since these corrections are approximations the results for plot yields are only broadly comparable.

The Colour Diagram (Appendix II.) shows the fertility trend. There are definite areas of low and high yield, but these areas do not coincide with the first crop, low yields occurred in the North and East of the field and in the S.E. across the line of gravel between plots H 22 - E 25. Blocks H, J, and K and the Western end of blocks 21 to 26 gave high yields.
3. Maize:

(a) Procedure.

I. Preparation of seed-bed. Oct. 10th - 13th

The previous crop of Woolly Pyrol was spread after it had been cut and weighed. It was ploughed in as a green manure, and a seed bed was prepared with harrows.

II. Planting. Oct. 13th - 14th

73 lbs. of selected seed was sown by a planter in rows 3 feet apart. The width of plots inside the discard areas was 33 feet, so eleven rows of maize fell within the area to be recorded. These rows of maize ran the length of the blocks from the farm trace to the headland along the railway line. Seed was covered with a roller. This seed was selected Dent from a mixture of Flint and Dent types grown on the farm.

III. Artificial Manure.

The land was in good heart, and although the previous crop of Woolly Pyrol had been ploughed in as a green manure, a mixture of 200 lbs. of artificial manure were applied per acre to insure the maize a good start. Half the manure went on with the seed and the rest was applied by hand along the rows when the crop was thinned:-

93 lbs. Sulphate of ammonia.
60 lbs. Sulphate of Potash.
47 lbs. Superphosphate.
200 lbs.
IV. Supplies and Singling.

A week after planting blank spaces appeared in the rows, these were filled by hand sowing. On 3rd - 4th November the plants were singled by hand to intervals of 15 inches within rows.

V. After Cultivations.

Every attempt was made to treat the whole area alike. Cultivations were more extensive than usual in order to give the crop every chance of growing well. Weeds were constantly destroyed:

- 7th - 8th Nov. Hand hoeing.
- 9th Nov. Inter-row cultivation.
- 10th Nov. Hand hoeing weeds and cleaning drains.
- 20th Nov. Inter-row cultivation.
- 4th-6th Dec. Inter-row cultivation.

VI. Harvesting.

Discarded Areas were removed on 7th February. Those discards which ran across the rows of maize were marked out with pegs and string to insure accuracy. No pegs and string were necessary in discard areas along the line of maize rows as one clear row of maize was removed. Cobs were picked and stover cut down and carried off, leaving plants on the recorded area isolated.

Recorded Areas. The Southern half of the field was harvested on 8th February and the rest on the 9th.

The number of maize plants on the recorded area of each plot were counted.

A gang of eleven (men, women, and boys) picked and husked the cobs. Each labourer picked one row of maize and
the whole gang worked across a block together, throwing their cobs into the middle of the plot. This operation was carefully supervised and very few cobs were missed, except where Diploma students picked half a block. Cobs from each plot were picked up and counted into baskets and weighed; later they were carted to the drying floor at the farm buildings.

Three men followed the pickers cutting down and lumping up the stover; and Joseph with a gang of three boys weighed and recorded the stover from each plot. The stover was bulky and had to be weighed in a folding wire-netting frame which was lifted on to a spring scale suspended on a tripod. When harvest was over the stover was carted to the farm for stock bedding.
(b) Observations.

I. Development of unevenness.

The germination of seed was good, and the crop grew well from start. Seed supplied to blank spaces, a week after planting, never caught up with the rest of the crop. This was the first sign of unevenness and it was general throughout the crop; it cannot be contributed to the effect of soil on germination only, because the planter missed places and some seed was probably killed or removed by pests.

Within six weeks of planting further unevenness of growth appeared, and supplies had fallen further behind the rest of the crop. Areas of strong growth developed in the South and East of the field, and blocks 24 - 26 stood out above the rest of the field. By December the crop was shoulder high and was growing fast, and unevenness was more pronounced. Height and vigour of plants varied, this took the form of humps and waves of growth. The number of plants still surviving varied per plot.

Inter-row cultivation had been intense, and since the harmful effect of weeds had been eliminated the cause of poor growth was due to factors below the surface.

On 30th November, when the crop was half grown, an estimation was made comparing the unevenness of vegetative growth. Three students walked the field and awarded marks to each plot. The system of marking was arbitrary and the average of three estimations was taken. (Table III.):-
TABLE III. Estimation of difference in amount of vegetation at half growth.

(Low numbers represent poor growth.)

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A Colour Diagram (Appendix III.) shows that when the crop was half grown there was a distinct fertility trend. The North West corner was very poor and growth improved towards the South East. The diagram shows the fertility trend, but it does not show the variation in growth within plots; growth was generally best in the centre of the plot where drainage was better on account of the ridge.

II. Rainfall.

The season was very dry, and of the 16 inches of rain that fell while the crop was in the ground three-quarters fell in October and two weeks in December (Appendix XII.). It was during December that the ground became waterlogged. A dry November offered excellent opportunities for killing weeds, but the crop felt the dry period because when rain came in December there was a sudden increase in growth. The dry period from the end of December to harvest reduced opportunities for fungus attack and it hastened maturity.

When rain came, after the soil had been cultivated to a loose tilth, it beat the loose surface soil down to a solid mass of glittering sand and thus reduced variation. The intensity of this beating varied on plots and the photographs show the least and most affected areas:-

(See following page for photographs.)
Photograph I.
From Plot E 26. Showing that here the rain had little effect on beating down the soil.

Photograph II.
From Plot F 16. Showing soil surface beaten down.

Photograph III.
From Plot C 17. Showing soil surface beaten flat.
On 12th December, when rain had fallen on the last inter-row cultivations, three students made an estimation of the difference in the effect of rain beating down the soil surface, by awarding marks to each plot. Results are summarized in Table IV. This Table is reproduced in Colour (Appendix IV.) and it shows the general trend of the intensity of the beating. The soil surface of plots with dense vegetative growth and canopy were least beaten down; this can be seen by comparing the Colour Diagrams of Tables III. and IV. (Appendices III. and IV.)

**TABLE IV. Estimation of difference in the effect of rain beating down soil surface.**

(Low marks represent much beating.)

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III. Height of Plants.

As the crop matured the height of plants became more and more variable, although the whole field ripened off at the same time. Height records were taken on 29th January when the plants had finished growing. Six boys with offset rods took the readings; these were taken at 3 feet intervals in the rows in six out of the eleven rows in each plot. No readings were taken if the interval fell on a blank space. More than 1/5th of the plants per plot were measured, and from the results the average height of plants per plot was calculated (Table V.).

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TABLE V. Average Height of Plants in Feet.
The Colour Diagram of Table V. (Appendix V.) does not show the variation in height of plants within plots, but it shows there was considerable variation in height of plants between plots, and it shows the patchiness of this variation. The Southern half of the field grew taller plants than the Northern half and the highest plants occurred in blocks 24, 25 and 26.

IV. Wind.

Strong steady winds blew down many plants on the Eastern side of the field between the 3rd and 6th February; this damage hastened the decision to commence harvest.

V. Insect Pests.

The usual attack by larvae of the moth Laphygma frugiperda occurred throughout the field, and no preference to any one area was noticed. Young developing leaves showed the characteristic perforation as they grew out from the funnel of the plant. Vigorous growth made the damage insignificant. No attempt was made to kill the larvae. A week before harvest a small black unidentified weevil appeared in the cobs. During harvest this weevil was plentiful and was boring into cobs between grains. The attack was general.

VI. Root Studies.

After harvest some root systems were examined. A contrast was made between systems from high and low yielding areas. Roots were examined from high yielding areas on plots C 25 and J 25, and low yielding areas on plots B 20 and C 20. The ground was hard and it was impossible to study the finer roots. A trench 2 feet deep was dug on either side of rows
of stubble, and plants were removed separately and the soil removed by hand. Root systems from high yielding areas grew in soil containing more humus and better structure than those from low yielding areas; those from the high yielding areas were more uniform in shape, better developed, and were more numerous than those from low yielding areas. Roots were found to a depth of 20 inches, but there occurred in both areas contrasted. The study leaves no doubt that poor root systems coincided with poor yielding areas.

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**Standard Deviation:** 5c.

There were 200 plant plots on each plot, and the average number of plants was 310. Of the plant plots were occupied by natural plants. Only 50% of the plots were occupied in blocks 10, 17, and 30, respectively, in blocks 11 and 20. The detailed diagrams (Appendix VII) shows the differences.
(c) **Harvest Results.**

I. **Number of plants per plot.**

**TABLE VI.** Plant count made at harvest.

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**Standard Deviation:** 36.

There were 290 plant sites on each plot, and the average number of plants was 210, so 72% of the plants sites were occupied by mature plants. Only 66% of the sites were occupied in blocks 16, 17 and 18, compared to 84% in blocks 24, 25 and 26. The Colour Diagram (Appendix VI.) shows up this difference.
II. Number of Cobs per plot.

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Some plants grew two cobs while others grew none; and the average figure of 1.06 cobs per plant was not constant for all plots, since on the thinly populated plots there were more cobs per plant than on the plots with a large number of plants. Block 26 has been omitted in the Colour Diagram (Appendix VII), because it was counted by a man who afterwards proved himself incapable of counting accurately.
III. WEIGHT OF PLANTS AND COBS.

TABLE VIII. WEIGHT OF PLANTS (BLACK) & DRIED COBS (RED) IN LBS. PER PLOT.

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Standard Deviation of Weight of Plants: - 38.
Standard Deviation of Weight of Total: - 37.
The stover was dryer than the cobs at harvest. In order to arrive at a truer estimate of the total yield, it was decided to determine the loss of water when the cobs were dried, their water content after this drying being more approximate to that of the stover. Random samples of cobs were weighed, dried in a corn crib for ten days, shelled and re-weighed:

- Grain = 67%
- Loss by moisture = 18%
- Core = 15%

Cobs weights were reduced by 18%. These results together with the weights of the plants are summarized in Table VII; and the Colour Diagram (Appendix VIII) based on the sum of each plot yield, represents the fertility trend of the field.
(d) **Discussion.**

There is far less variation in cob weight than plant weight, consequently the ratio of cob weight to plant weight increases as the total plot yield decreases. In block 16 which is low yielding the cobs comprise 42% of the total plot yield compared to 34% in block 26 which is high yielding.

The total yield is closely correlated with the average height of mature plants, and the estimated development of the crop at half growth, but not so closely correlated with the number of plants, except that high yielding plots had high plant population. Therefore plant population was not always an indication of yield, but Colour Diagrams of the total yield, average height, and half growth are the most reliable indications of the field's fertility trend.
IV. Discussion of Results of Three Crops.

The Colour Diagrams (Appendix I., II. and VIII.) of the fertility trend of these three crops show little similarity. The variation between the two Woolly Pyrol crops may be attributed to:

(1) For three years prior to the first Woolly Pyrol crop the field had been divided into an Eastern and Western or a Northern and Southern half, and different crops grown with different manurial treatments in each half. This variation in treatment would have left behind a variation in fertility which had its greatest affect upon the first Woolly Pyrol crop.

(2) The first Woolly pyrol crop received manure, the second did not.

The fertility trend of the maize crop (Appendix VIII.) shows a gradual trend of increasing fertility from North to South compared to a general variation throughout both Woolly Pyrol crops. This difference between Woolly Pyrol and maize may be attributed to a difference in:

(1) Crop.
(2) Weather conditions.
(3) Manure.
(4) Length of growing period.

None of these three crops results above are considered representative of the fertility of the field; but a Colour Diagram (Appendix IX.) of the summary of these three crops shows that some areas gave consistently low yield and the others gave consistently high yields.

The standard deviation of the first and third crops was higher than the second which received no manure, suggesting that manuring increases the standard deviation. The yield
of the third crop was a little higher than the second as was its standard deviation, but neither were as high as the first crop, which is evidence that the variation in crop yield is decreased.
V. Some Factors Affecting Fertility of Soil.

(A) Erosion.

1. Introduction.

There is a good slope across Field III. and many humps and depressions occur. The soil has little natural crumb structure and improvement of this crumb structure by cultural methods is temporary. The absence of stability of soil structure, and the sloping nature of the land together provide suitable conditions for erosion, and suggest the probability that erosion has been going on during the past twelve years when the field was arable. A simple test was made in February at the end of the rainy season to prove that erosion was occurring; and the field gradient was measured.

2. Experimental.

(a) Erosion Test.

I. Procedure;

It was possible to distinguish between undisturbed soil and two types of material which had been transported by running water and deposited. Therefore three composite samples were taken and examined.

Sample I. This consisted of the small surface knobs of soil, picked up by hand, which had been under cover of the maize plants and were least beaten and washed by rain.

Sample II. This was taken from small flat patches of soil between the rows of maize, where the rain had washed the soil a few feet and deposited it. Spoonfulls of surface soil were scraped up.
Sample III. This consisted of material 1/4 inch thick, which had been deposited in large depressions where the water had accumulated after heavy rains. The water being unable to run off having subsequently seeped into the land.

As far as possible portions of each sample were taken at adjacent spots where all three types were to be found, to insure that all three samples should be equally representative of that heterogeneous field. Thus most of the Eastern half of the field was avoided, because there were no ponds in which Sample III. occurred.

Mechanical analysis of the soils were carried out by the Hydrometer Method (6).
II. Results of Mechanical Analysis of Soil Samples.

TABLE IX. Percentage fractions obtained by mechanical analysis of over-dried soil which passed through 2 m.m. sieve.

<table>
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<th></th>
<th>SAMPLE I.</th>
<th>SAMPLE II.</th>
<th>SAMPLE III.</th>
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<td>Clay</td>
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<td>Fine Clay</td>
<td>18.6</td>
<td>6.7</td>
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Another set of three samples were taken and analysed, and these gave results similar to those in Table IX.
(b) **Survey of Slope.**

**I. Procedure.**

The survey was carried out with a Dumpy Level. Four readings were taken on each plot, the position of the Levelling staff being approximately 4 feet in from the corners of the plot.

The level had to be set up at two station points because the glare of the sun made it impossible to take all the readings from one point.

From the station point on plot H 18 readings were taken for blocks 16 - 20, and "flying levels" were taken on the concrete base of the gate post in the hedge above the swimming bath, and on concrete bases of the two gate posts in the South East corner of the field. The remainder of the readings were taken from a station point on plot F 25, and "flying levels" were taken on the concrete base of the gate post in the South East and South West corners of the field; these "flying levels" connected up the two sets of readings from different stations, and also provided a check on the work.
## II. RESULTS.

### TABLE X. SUMMARY OF DUMPY LEVEL READINGS.

(All figures reduced to feet below zero.)

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"Flying Level" on concrete base of Gate Post.

"Flying Levels" on concrete base of Gate Post.
III. Discussion of Results.

Data shown in Table IX. demonstrates that considerable transportation of soil by water is occurring within the field, for it is well known that the extent to which transportation of soil particles can occur depends upon their size.

The Colour Map (Appendix X.) shows an average slope of 1:72 from the North East to the South West, across which sheet erosion would certainly occur. In addition to the general erosion across the field in the direction of the slope localized erosion and deposition probably occur owing to the occurrence of humps and depressions.
(B) **Soil Survey.**

1. **Introduction.**

A general soil survey of Field III was considered necessary because soil variation is likely to play an important part in yield variation; and in a uniformity trial this is always necessary because it is exceptional for a soil to be homogeneous even in one small plot. The importance of soil variation depends upon structure, which itself involves a knowledge of the constituents of soil fractions including percentage of humus, gravel, and colloidal matter. This affects the porosity of the soil and may vary from plot to plot. To this end a general soil survey of the area was made by a study of profile samples. The profile investigations were limited to their analysis based on appearance and feel in the hand, because mechanical analysis was too expensive for such a large number of samples and also because the drainage factor determined by structure was anticipated to be of greater practical importance than chemical analysis in "discovering the factors causing variation in yield."

2. **Experimental.**

(a) **Survey of Gravel on Surface.**

1. **Procedure.**

The surface of each plot was examined by eye and the incident of gravel recorded.
II. RESULTS.

1. Procedure.

A map of Surface Gravel was made throughout the field, and a record was kept of the type of material which came to the surface. Boring were made to a depth of 6 - 7 feet unless gravel or some other impervious object was met. Three pits were also dug in different parts of the field in order to make

MAP OF SURFACE GRAVEL.

16 17 18 19 20 21 22 23 24 25 26

A B C D E F G H J K

16
17
18
19
20
21
22
23
24
25
26

(1) Gravel.
(2) Sand.
(3) Hard rock.
(4) Clay.
(5) Clayey sand.

This area is influenced by a patch of pure gravel which comes to the surface on plots Y, S x 24, 25, and spreads out (Map, page 51) from here it extends below the surface to the north west. The area where the gravel is thickest on the surface has a low surface level.

Much gravel.

No gravel.
(b) **Soil Survey Below Surface.**

**I. Procedure.**

Auger borings were made throughout the field, and a record was kept of the type of material which came to the surface. Borings were made to a depth of 6 - 7 feet unless gravel or some other impenetrable object was met. Three pits were also dug in different parts of the field in order to make a full examination of the soil profile.

**II. Results.**

For detail of field notes see Appendix XIV.

The soil survey shows that there is marked variation in the soil profiles throughout the greater part of the field; and the chief factors which vary are:-

1. Gravel.
2. Humus.
3. Hard pans.
4. Sand.
5. Colour.

Some areas of the field show certain important points of similarity:-

(a) Plots E 25, 26; F 24 - 26; G 22 - 26; H 21 - 25; J 21 - 23. This area is influenced by a patch of pure gravel which comes to the surface on plots F, G x 24, 25, and spreads out (Map, page 51 ). From here it extends below the surface to the North West. The area where the gravel is thickest on the surface has a shallow layer of humus.
This area has a shallow humus layer. It is marked by almost complete absence of gravel, and the texture of the surface soil is heavier than the rest of the field.

(c) The boundary plots of the field (with the exception of E, F, G, H x 16 on the Northern side), and the southern quarter of the field (with the exception of the area mentioned in (a) above) exhibit a thick layer of humus.

(d) The distribution of gravel on the surface shown by the Map (page 51) is closely related to the distribution of gravel below the surface.

3. Discussion of Results of Both Surveys.

It is not possible to draw many conclusions by comparing the results of this survey to the fertility trend of the three crops already grown because:

(a) The variable factors of the soil are so intermingled.

(b) The weather conditions play such an important part in determining crop yield.

However, the maize which grew in the Southern quarter of the field yielded best and this area coincided with good drainage and the thickest humus layer.

The conditions under which the Woolly Ryol crops grew were similar, except for manuring; as a result the crop gave a fair yield over the gravel patch in the South East, when manured, but a very low yield when unmanured. This indicates that plant nutrients are the chief limiting factor in this area.
The variation in distribution of gravel, sand, and impervious hard pans which appear throughout the soil profiles of the field probably cause variation in level of the water-table.
plants cannot grow without a supply of air and water to their roots.

When rain falls, some runs off the surface of the ground, some is intercepted by field drains and is taken off, and the rest enters the soil or evaporates. But when the rate of supply exceeds the rate of disposal the ground becomes waterlogged. This excess of water is harmful as it fills the pore-spaces and reduces the soil atmosphere and arrests soil breathing.

Plants must have water to grow, but they are unable to make use of all the water present in the soil surrounding their roots. The water which plants are unable to take up is held by forces exceeding those exerted by roots, this water is therefore unavailable. In dry soils the quantity of water available to plants may be small, and an uneven distribution of available water will produce marked variation in growth, because (other things being equal) the uptake of water corresponds closely with the amount of plant growth.

Air and water supply are closely related to one another in their association with plant growth, but are dealt with separately in the experimental section.

In both the experiments it is assumed that the distribution of rainfall was uniform over the whole field.
2. Experimental.

(a) Estimation of Waterlogging.

I. Procedure.

As a result of heavy rains in the middle of December (Appendix XII.) part of Field III. became saturated and water began to stand on the surface. During the morning of the 19th instant heavy rains came, and in the afternoon, while it was still raining, three students examined the water on the surface, and awarded marks to each plot by taking the average of their three estimates of the difference in amount of surface water present. One plot was selected as the standard, and the marks awarded it served as a basis for the estimation. The estimation was made as quickly as possible to avoid error caused by further rain, and because surface water was running off some plots on to others.
II. Results.

**TABLE XI. Estimation of difference in amount of Surface Water on plots after heavy rain.**

(High marks indicate good drainage.)

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Rain stopped at 3.30 p.m. and by 5.30 p.m. all surface water had gone, except on plots A, B, C, D, x 16, 17, 18, 19, 20, 21, and G 16 and J 16. Where water was draining during the estimation it was moving from East to West between the rows of maize, and in the surface drains between blocks.

III. Discussion.

The Colour Diagram (Appendix XI.) of Table XI. clearly illustrates the results of this estimation. The Northern half of the field was much wetter than the Southern half and the gravelly area in the Southern half of the field clearly assisted drainage. The colour trend of this estimation of drainage capacity of plots corresponds fairly well with the colour trend of the total yield of the maize crop (Appendix VIII.). This indicates that the yield of maize was influenced by the efficiency of drainage; and soil variation was the cause of growth variation.

If the growing period had been much wetter, it is probable that this demonstration would have been even more pronounced.
(b) **Determination of Available Water.**

I. Procedure.

Four areas each consisting of four plots were selected; two of these areas represented high yield and two low yield, and were chosen on the results of the two previous Woolly pyrol crops. From symmetrically-spaced spots twelve soil samples were taken in each area with an auger at 1" - 6" and at 6" - 12". Each set of twelve samples was bulked and mixed; and a sample was taken in a closed tin for the determination of grass moisture content to prevent error due to evaporation before it could be weighed in the Laboratory.

The Moisture Point of Stickiness, Sand, and Maximum Retaining Capacity were determined in the Laboratory for each area from the remainder of the bulked samples.

The areas were sampled on three different occasions and the various determinations made as follows:-

**Moisture Point of Stickiness:** By kneading the soil until it just stuck to the blade of a spatula; it was immediately weighed and dried in an oven, and the moisture expressed as a percentage of oven-dried soil. This determination was made because it is related to the Wilting Coefficient, which itself depends upon the colloidal matter in the soil. The colloidal matter of a soil is saturated at its Sticky Point, and, therefore, this determination is a direct measurement of the colloidality of the soil. Colloidal matter holds water from the plant to a greater degree than sand. The determination of the Moisture Point of Stickiness although not used in the calculation of the Wilting Coefficient endorsed the value for this coefficient.
Sand: by sedimentation. A sample of soil was treated with sodium carbonate solution in a measuring tube, water was added to make the height of the column in the tube up to 75 m.m., this was allowed to settle for 75 seconds before the suspended matter was poured off. This process was repeated until the water was clear. The sand remaining at the bottom of the tube was dried, weighed and expressed as a percentage of the oven-dried sample.

The sand fraction was determined for although it is not used in calculating the Wilting Coefficient, it bears relationship to the Wilting Coefficient.

Sandy soils are dryer, contain less colloidal matter and, therefore, a lower Wilting Coefficient.

Maximum Retaining Capacity: by packing soil into a brass cup with a perforated bottom on which rests a piece of blotting-paper which acts as a conductor. The cup was stood in water so its bottom was level with the water and it was left over night to soak up water. Next day the cup was removed, wiped free of water, weighed, and after drying in an oven the moisture was calculated on the oven-dry soil.

Gross Moisture: by weighing soil sample, drying this in an oven and calculating the moisture on the oven-dry soil.

Wilting Coefficient: by application of the values for the Maximum Retaining Capacity to Briggs - Shan formula:

\[
\text{Wilting Coefficient} = 0.34 (M-21).
\]
The Wilting Coefficient may be determined by direct measurement, i.e. growing a plant in the soil in a sealed container and measuring the moisture when the plant wilts, but this method is troublesome; and the Wilting Coefficient was therefore determined in the above way.
Available Water: by subtracting the Wilting Coefficient (which represents the "unavailable water") from the grass moisture. The values obtained (red figures Table XII) are based on the Wilting Coefficients, which when determined by Briggs-Shantz formula, are approximate; but they are considered comparable and show that the values for grass moisture of soils are valueless.

II. RESULTS.

(See following page.)
## II. RESULTS

### TABLE XII. DETERMINATION OF "AVAILABLE" WATER.

(ALL FIGURES PERCENTAGES OF OVEN-DRY SOIL.)

<table>
<thead>
<tr>
<th>SOIL SAMPLE</th>
<th>MOISTURE POINT OF STICKINESS %</th>
<th>SAND %</th>
<th>MAXIMUM RETAINING CAPACITY M. %</th>
<th>GROSS MOISTURE</th>
<th>WILTING COEFFICIENT W. %</th>
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<td>Feb. 29th %</td>
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A - Soil Sample from top 6".
B - Soil Sample from 6" - 12".
¥ - Means of Duplicates.
** - Maize Crop Harvested by 9th Feb.
III. Discussion.

The four areas from which samples I., II., III. and IV. were taken and analyzed were chosen to contrast the available water in low and high yielding areas of the maize crop.

**Samples I.** from plot D, E, x 16, 17, represent low yield in both Woolly Pyrol crops, and gave low yield with maize. The "available water" in this area was very low.

**Samples II.** from plot B, C, x 19, 20, also represented a low yield in both Woolly Pyrol crops and gave low yield with maize. The "available water" was much higher than in Samples I., but the variation between top and the next 6" was wide (see Fig. I.), because the lower zone did not dry as the season proceeded.

**Samples III.** from plots G, H, x 17, 18, represented high yield in both Woolly Pyrol crops, but low yield with maize. This area had the lowest "available water" of any area during the growing period of the maize; and had the maize still been in the ground when the last samples were taken, it would have been suffering seriously from lack of water, because the quantity in the top 6" had fallen below the Wilting Point and the next 6" was approaching Wilting Point.

**Samples IV.** from plots H, J, x 25, 26, represented a high yield in both Woolly Pyrol crops, and gave high yield with maize. The "available water" in this area was high compared with I. and II., and as the dry season approached the "available water" in both tops and second 6" fell off gradually and together, but this drop was far less than in the other three areas. It has been shown that this area drained well (Appendix XI.), and further proof of this is shown in Fig. I., for on December 11th this was the only area where the top 6" was dryer than the next 6".
III. Discussion of results from both experiments.

These values for "available water" do not supply the reason for the variation in yield of maize in each case, nor were they expected to do so. Available water although of primary importance is only one of the factors controlling plant growth. It has been shown (Appendix XI.) that the areas from which samples I, II, and III. came were all badly waterlogged, this may have partly contributed to the low yield in areas I. and III. But samplesII. came from an area which has given the lowest yields in the field for three consecutive crops and was the most waterlogged area in the field. Since the "available water" in this area was much higher than I. and III. it shows that waterlogging was probably the major factor contributing to low yield and not available water.

In conclusion, it is clear that from these results of an investigation into the water relationships of Field III. waterlogging and distribution of "available water" are of supreme importance in determining plant growth whether in a dry or wet season, and therefore the variation of these two factors in the field play an important part in variation of crop growth.
Fig. 1. Fluctuations in "Available Water" from four areas in Field III.
SUMMARY, CONCLUSIONS AND SUGGESTIONS.

(a) Fertility Trend.

The fertility trend of the three crops recorded was different in each case. The reason for this difference was partly due in the first crop - Woolly Pyrol - to previous treatment, in the second crop - Woolly Pyrol - to no manure, and in the third crop - Maize - to difference in crop, weather conditions and manurai treatment. No definite line of fertility has been established. However, a summary of the three crops shows that some plots have given consistently low and some consistently high yields.

(b) Patchiness of Crop.

Data shows that variation in growth occurred throughout the field in all three crops, but there is not sufficient information to show that any one area is more uniform than another. No part of the field is suitable for field trials. Patchiness appears to be increased by manuring.

(c) Factors causing Variation in Crop Growth.

(a) A study of the past history of the field gives no definite facts on which to base the cause of variation in growth. Both the effect of levelling the natural unevennesses of the land and the grave humps made by people burying animals must still be present; this will gradually be eliminated by cultivation.

(b) Erosion is taking place in the field. The top layer of soil which contains most of the valuable plant nutrients is being washed from parts of the field and lost. This is wasteful; and where it is occurring between plots it is indirectly one of the causes of uneven growth. It is suggested that by ploughing the field from North West to South East along the contour lines erosion could be reduced.
(c) Waterlogging is an important factor in limitation of plant growth; it is, therefore, one of the causes of patchy growth. Some areas of the field are waterlogged because the soil is impervious, in other areas depressions form local drainage centres and become waterlogged.

(d) From a soil survey it has been shown that the field exhibited great diversity of character. The main factors responsible for this diversity were:

(1) The distribution of gravel. This affects drainage and ground-water level.

(II) Depth of humus. This affects supply of available plant nutrients.

(III) Variation in texture of surface soil. This affects supply of available water.

FURTHER SUGGESTIONS.

It has been shown that there is variation in "available water" in the top twelve inches of soil, and this bears relation to crop yield. Evidence of this is slender and it is suggested that future workers pay special attention to the subject. A comparison of the fluctuations in available water should be made on half or quarter plot areas, this should begin prior to planting the crop and determinations made at weekly intervals throughout the growing period. The development of the crop should also be recorded in each area at weekly intervals throughout the growing period.
BIBLIOGRAPHY.


ACKNOWLEDGMENTS

Many persons have helped me in this study; to all of them I wish to offer my sincere thanks, but I especially wish to thank Mr. Lyndon Kerr who helped with the History of Field III, L. J. C. Evans for his co-operation in my field work, Professor E. Harrison for his valuable criticism and advice, and finally to Professor P. Hardy who was always willing to give his own and his Department's assistance.
Colour Diagram of plot yields of 1st Crop of Woolly Pyrol.
Colour Diagram of plot yields of 2nd Crop of Woolly Pyrol.
APPENDIX III.

Colour Diagram of Estimation of difference in amount of vegetation at Half Growth.
Colour Diagram of Estimation of difference in effect of rain beating down surface of soil.

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Much Beating.

Little Beating.
APPENDIX V.

Colour Diagram of Average Height of Plants per plot.

Shortest.

Tallest.

Many Plants.
APPENDIX VI.

Colour Diagram of Number of Plants per plot.

(Block is left out due to error in counting.)
APPENDIX VII.

Colour Diagram of Number of Cobs per plot.

(Block 26 left out due to error in counting.)
APPENDIX VIII.

Colour Diagram of Weight of Plants and Dried Cobs.
APPENDIX IX.

Colour Diagram of Summary of Tables I., II., & VIII.
APPENDIX XI.

Colour Diagram of Estimation of difference in amount of surface water on plots after heavy rain.
APPENDIX XIII.
PLAN II.
Plan of the Boundaries of St. Augustine Estate & Monta Grand Estate.
Surveyed December 1903, by H. Massy.
Scale: 6 Chains to 1 Inch.
APPENDIX XIII.
PLAN III

COPY OF PLAN
SHOWING
IMPERIAL COLLEGE OF AGRICULTURE
AND PART OF
GROUNDS ATTACHED
16-10-24

0 50 100 150 200 250
Scale of Feet.

RED LINES SHOW DEVELOPMENT OF FARM UP TO 1924
APPENDIX XIV.

Field Notes of Soil Survey below Surface.

(1) Humus zone to 1'6", transition to reddish brown at 2'6", no hard layer, fairly homogeneous from 2'6" to 7', but gradual change from silt to clean fine sand at the bottom, this sand same as sand of No. 42, but finer than sand between 7' - 10' in No. 25.

(2) Same as No. 1, but been previously disturbed to 3".

(3) Drilled through loose gravel and sandy soil to 3'6", here gravel rare and the profile more yellow than the usual reddish brown of No. 2.

(4) Humus zone to 1'6", transition to 1'9", here lighter reddish brown becoming sand at the bottom similar to sand of No. 1. Small layer of gravel at 4'.

(5) Humus zone to 1'3", less black than No. 4, very hard here, usual reddish brown silt with no transition, steady trend to sand as in No. 1.

(6) Humus zone to 1', sharp change here to sand: more clay; became lighter and more sand at 3'6", at 4'6" became darker brown and much coarser sand, then very fine gravel, same to 7', here gravel layer. This profile should drain well but probably masked by silt layer at 2' which sets very hard when dried after being wet.

(7) Humus zone to 11", short transition, light brown silt which set hard, when wet a dirty pale colour, gravel at 4'6" together with sand and silt: darker brown than above layers, at 5' silt sand and gravel and easier to bore, at 5'6" much more gravel.

(8) Humus zone to 1'10", soft and good texture little transition followed by clean, but reddish brown silt, traces of gravel between 2'10" and 3'1", 3'6" sand, at 4' clean reddish sand and very small gravel, sand here same as bottom of 11A.

(9) Same as 11A, but less gravel at 3'9", at 4' the sand was more clayish, bored to 7'.

(10) Same as 11A, but the gravel layer at 4' - 4'6" therefore wider, homogeneous sand, bored to 7'.

(11) Humus zone to 1'3", transition to 1'6", followed usual reddish brown, very hard from 8' - 4'6", here brown silt, 5' - 6' fine gravel mixed with sand, coarse sand from 6' - 6'6", like No. 11A and 13.

(11A) Pit in the middle of plot B 20. Humus zone to 11", deeper zone of humus on West side of pit where the surface slopes up, very hard between 2' - 3', this was light reddish brown silt, transition from humus to red between 1' - 2', followed by silt with more clay than Nos. 11, 13 and 14. 6" of gravel at 3', then compact red silt to 7', here a little gravel and lighter yellow.
(12) Humus zone to 1', transition to 1'6", very hard at 1' reddish brown silt from 1'6" onwards, at 3'6" sand and gravel, at 6' very light greenish brown, texture same as llA, at 6'6" marked patches of brick red (i.e. iron stains).

(13) Humus zone to 8", transition to 12", trunked, no hard pan, steady reddish brown silt to 6'6", small layer of gravel at 5'.

(14) Humus zone to 1', transition to 1'6", hard between 11" and 22", from 1'6" yellow brown silt with more clay than No. 23, no gravel, a little sandy at 3'6" and more sand at 7', like 11A.

(15) Humus zone to 1'3", transition to 3'6", texture intermediate, at 3'6" still some humus penetration brown colour and 3" layer of gravel, very hard from 1' - 3', after this profile was yellower and very hard.

(16) Humus zone to 1'3", then same as No. 17, gravel at 4' - 5'3", brick red and yellow patches at 6'.

(17) Humus zone to 2', transition next 3", very hard from 8" - 17", at 2'3" became easy to bore and silt light brown colour, gravel at 3'6", from here yellow silt to 6', here brick red and black streaks in yellow silt.

(18) Humus zone to 1'9", transition to 3', very hard between 1' - 2', very deep humus penetration, this soil good crumb structure, little gravel between 3' and 4', at 4'6" brownish yellow soil at 6' a little redder.

(19) Very black humus zone to 13", transition to 2', from 2' reddish brown silt and sand zone and easy to bore, 2" of gravel at 5', then yellow brown silt.

(20) Humus zone to 2', here soil texture is lighter than before, stopped boring because could not penetrate the gravel, this is possibly the edge of the gravel patch, but it does not come to the surface, should be fertile here.

(21) Humus zone to 9", transition to 18", hard from 8" - 19", from 1'6" reddish brown sandy soil, gravel at 2'9" and more at 3', stopped boring at 4'6" due to gravel.

(22) Humus zone to 2', hard at 1'6", transition difficult to define, gravel and sand between 3' - 4', more fine gravel at 4'6", little gravel at 5' but easy to bore.

(23) Humus zone to 1'6", transition at 2', little gravel here, pale brown silt to 3'7" where gravel traces appear, gravel increased to 4'9", change, at 5' gravel and coarse gravel, same at 6' but redder in colour.
Humus zone to 1', transition to 1'6", here dark yellow due to humus penetration, texture sandy silt, became redder and sand increased as depth increased, signs of gravel at 3'6", at 5' coarse gravel and fine sand of dark colour like sand of No. 25 at 6'6".

Pit in plot G 24, in what appeared to be the middle of gravel patch, surface to 1' humus zone and gravel, 1' - 2" brown silt, sand, and gravel, 2' - 7' a mixture of silt sand and gravel, becoming more gravel and larger particles as depth increased, 7' - 10' dark dirty coloured coarse sand quite wet and easy to work. Hard at 1'6" but at 7' the gravel loose.

Humus zone to 9", transition to 1', followed by brown sand and silt, redness increased, gravel at 2' which stopped boring.

Stopped at 10" by gravel.

Humus zone to 1', transition to 1'6", very hard at 1', little gravel here and water would not seep away, (iron pans seem to be associated with gravel close to surface), difficult to work at 4'6", brown silt, here gravel stopped work, this soil much lighter than on Western side of field.

Humus zone to 10", transition to 1'7", hard from 1' - 1'6", brown and sandy to 2'9" with traces of gravel, gravel increased to 4'6" and stopped boring.

Humus zone to 1'6", transition to 2', gravel at 2'3", dirty brown silt to 3'6", here little gravel and more at 4'6", at 5'6" coarse sand and fine gravel same at 6' but becoming coarse red sand.

Humus zone to 1', transition to 1'6", here dirty brown silt due to humus penetration, more sand as depth increased, little gravel at 3'6", dark brown sand, coarse sand and gravel at 5', like No. 25 at 8'.

Humus zone to 1', transition to 1'3", here orange brown silt becoming lighter and more sandy at 6', here sand and little gravel, 6" of gravel at 3', all easy to bore especially at 5'-where there were black marks of organic matter indicating past disturbance.

Humus zone to 1'1", transition to 2', here light brown sand and silt, little humus penetration, good texture, little gravel and reddish brown at 4', then grey sand to 6', easy, possibly something buried here in the past.

Humus zone to 1', transition to 1'3", here dark brown soil and a very little gravel, redder than No. 28, at 4' very red and immediately gravel stopped boring, top soil hard to 18", but here the texture good.

(It is possible that local unevenness of crop is due to cemented zones which restrict moisture and air penetration.)
(35) Humus to 1'8" and very black, transition to 2', good texture and easy to work, from 2' homogeneous light brown silt, easy, more sandy at 7', humus may have penetrated deeper than 2', this profile should drain well; it is characteristic of this corner of the field.

(36) Humus zone to 1', transition to 2', here reddish brown soil at 2'6" gravel stopped boring.

(37) Humus zone to 1'3", transition to 1'6", here reddish brown silt which was hard to work, little gravel at 2", more at 3' and bad to stop boring.

(38) Humus to 2', transition to 2'6", here quite brown and hard, little gravel at 4'6", at 6' sand as in No. 42.

(39) Humus zone to 1'3", transition to 1'8", good texture, bright brown and good texture to 2'6", from here gravel and sand to 3'3" become greyer with more gravel and sand at 5'6", here stopped by more gravel, this gravel and sand should relate to that at bottom of No. 25.

(40) Same as No. 43, but not so hard.

(41) Humus zone to 5", then immediately to very light brown soil, this was the silt which cements when wet, 2'3" little gravel, stopped by more gravel at 3'3", this profile like No. 42.

(42) Pit on plot G 19, Humus zone to 1', transition to 1'3" very hard from 1' - 5'6", from 1'3" orange brown sand and silt to 3'9", here gravel and stones to 4'9", here to 5'9" small gravel, 5'9" - 8'3" homogeneous brown sand not compacted, but easy to work. When digging this pit concrete foundations were found lying East and West, and decayed sections of wood 5" x 7", these together with rusting iron, bricks and china, may at some time have been part of a building concrete 12" thick. The gravel in this profile lies horizontal, but varies in its distance from the surface because the pit is on a slope.

(43) Humus zone to 1'5", transition to 1'9", very hard from 10" to 3'6", gravel at 3' and more at 3'6", like No. 42.

(44) Humus zone to 1'6", transition to 1'9", hard from 6" - 2', light reddish brown silt and sand below 1'9", at 2' a little gravel, more at 3' and solid gravel at 3'5".

(45) Humus zone to 1'9", transition to 2'6", hard from 6" - 15", below 2'6" pale greyish yellow, the humus had been leached down, light in texture, stopped by rock at 3', probably same as No. 47.

(46) Deep black humus zone to 1', transition to 1'9", easy to bore till here then hard to 3'9", here gravel stopped boring, like No. 47.

(47) Deep black humus zone to 1'3", transition to 2', here uniform, light textured, brown, silt and sand, at 3'9" more sand, 4'6" coarse sand, 5' signs of gravel, much more gravel at 6'.
(48) Humus zone to 1'3", transition to 2', here brown sand which turned into gravel at 2'8", gravel stopped boring at 3'.

(49) Humus to 1'3", transition to 1'9", here brown sand easy to work, uniform to 4'6" here a little gravel, more gravel and much harder at 5'6", top brown sand set up when wet and dried but crumbled up more easily than those soils tested at Nos. 10 and 11.

(50) Humus zone to 1'3", transition to 1'6", here pale sand and gravel, at 2' pale brown silt and sand, at 3' stopped by gravel.

(51) Humus zone to 1'9", transition to 2'3", here solid light brown silt and sand and very small gravel, pure brown sand at 3'3", hard and stopped by rock.

(52) Humus zone to 1', transition to 1'3", here light brown sand and gravel, coarse sand at 2'3", gravel stopped boring at 3'4".

(53) Humus zone to 1', transition undefined, gravel at 1' hard at 1'3", at 1'9" dark brown coarse sand and fine gravel, at 2' signs of reddish brown silt, but at 2'6" nearly black, 2'9" uniform red sand and traces of gravel, 3'6" still a little gravel, from 5' - 6' coarse sand.

(54) Humus zone to 1'6", transition to 2'3", here brown silt and sand, easy to bore, silt gone at 5', at 6' little gravel, 6'3" solid gravel.
Key to position of Pits and Auger Borings of Soil Survey.

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- **Key to position of Pits and Auger Boring.**

- **Position of Pit.**

- **Position of Auger Boring.**